Online ISSN : 2249-4596
Print ISSN : 0975-5861

Global Journal of Researches in Engineering: A

Mechanical & Mechanics Engineering

Highlights

- Design for Rooftop of Metro
- Parametric Control for Machining
- Review of Modelling Techniques
- Evaluation of Machinability Index

Discovering Thoughts, Inventing Future

VOLUME 15 ISSUE 1 VERSION 1.0

Global Journal of Researches in Engineering: A
Mechanical and Mechanics Engineering

Global Journal of Researches in Engineering: A
Mechanical and Mechanics Engineering

Volume 15 Issue 1 (Ver. 1.0)

Open Association of Research Society

Incorporation No.: 0423089
License No.: 42125/022010/1186
Registration No.: 430374
Import-Export Code: 1109007027
Employer Identification Number (EIN): USA Tax ID: 98-0673427

Global Journals Inc.

*(A Delaware USA Incorporation with "Good Standing"; **Reg. Number: 0423089**)*

Sponsors: Open Association of Research Society
Open Scientific Standards

Publisher's Headquarters office

Global Journals Headquarters
301st Edgewater Place Suite, 100 Edgewater Dr.-Pl,
Wakefield MASSACHUSETTS, Pin: 01880,
United States of America
USA Toll Free: +001-888-839-7392
USA Toll Free Fax: +001-888-839-7392

Offset Typesetting

Global Journals Incorporated
2nd, Lansdowne, Lansdowne Rd., Croydon-Surrey,
Pin: CR9 2ER, United Kingdom

Packaging & Continental Dispatching

Global Journals
E-3130 Sudama Nagar, Near Gopur Square,
Indore, M.P., Pin:452009, India

Find a correspondence nodal officer near you

To find nodal officer of your country, please email us at *local@globaljournals.org*

eContacts

Press Inquiries: *press@globaljournals.org*
Investor Inquiries: *investors@globaljournals.org*
Technical Support: *technology@globaljournals.org*
Media & Releases: *media@globaljournals.org*

Pricing (Including by Air Parcel Charges):

For Authors:
22 USD (B/W) & 50 USD (Color)
Yearly Subscription (Personal & Institutional):
200 USD (B/W) & 250 USD (Color)

Integrated Editorial Board
(Computer Science, Engineering, Medical, Management, Natural Science, Social Science)

Dr. Bart Lambrecht
Director of Research in Accounting and FinanceProfessor of Finance
Lancaster University Management School
BA (Antwerp); MPhil, MA, PhD (Cambridge)

Dr. Carlos García Pont
Associate Professor of Marketing
IESE Business School, University of Navarra
Doctor of Philosophy (Management), Massachusetts Institute of Technology (MIT)
Master in Business Administration, IESE, University of Navarra
Degree in Industrial Engineering, Universitat Politècnica de Catalunya

Dr. Fotini Labropulu
Mathematics - Luther College
University of ReginaPh.D., M.Sc. in Mathematics
B.A. (Honors) in Mathematics
University of Windso

Dr. Lynn Lim
Reader in Business and Marketing
Roehampton University, London
BCom, PGDip, MBA (Distinction), PhD, FHEA

Dr. Mihaly Mezei
ASSOCIATE PROFESSOR
Department of Structural and Chemical Biology, Mount Sinai School of Medical Center
Ph.D., Etvs Lornd University
Postdoctoral Training,
New York University

Dr. Söhnke M. Bartram
Department of Accounting and FinanceLancaster University Management SchoolPh.D. (WHU Koblenz)
MBA/BBA (University of Saarbrücken)

Dr. Miguel Angel Ariño
Professor of Decision Sciences
IESE Business School
Barcelona, Spain (Universidad de Navarra)
CEIBS (China Europe International Business School).
Beijing, Shanghai and Shenzhen
Ph.D. in Mathematics
University of Barcelona
BA in Mathematics (Licenciatura)
University of Barcelona

Philip G. Moscoso
Technology and Operations Management
IESE Business School, University of Navarra
Ph.D in Industrial Engineering and Management, ETH Zurich
M.Sc. in Chemical Engineering, ETH Zurich

Dr. Sanjay Dixit, M.D.
Director, EP Laboratories, Philadelphia VA Medical Center
Cardiovascular Medicine - Cardiac Arrhythmia
Univ of Penn School of Medicine

Dr. Han-Xiang Deng
MD., Ph.D
Associate Professor and Research Department Division of Neuromuscular Medicine
Davee Department of Neurology and Clinical NeuroscienceNorthwestern University
Feinberg School of Medicine

Contents of the Issue

Global Journal of Researches in Engineering : A
Mechanical and Mechanics Engineering
Volume 15 Issue 1 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN:2249-4596 Print ISSN:0975-5861

Fixture Design for Rooftop of Metro

By Prof. S. N. Shinde, Siddharthkshirsagar, Aniruddhapatil, Tejasparge & Riteshlomte

Savitribai Phule Pune University, India

Abstract- Researching the possibilities for fixture design aided by computers has been in the sphere of interest of a number of authors worldwide for a longer period. Research results have led to the precise and systematised knowledge on the possibilities offered by computer application in fixture design process. The paper emphasises the importance of fixture design automation. It presents a general structure of the automated design system with a special highlight on the fixture design systems and their main characteristics. It also shows a structure and a part of output results of the automated modular fixture design system. Finally, the reached conclusions are presented with the expected directions of future researches. In industrial ergonomics a manipulator is a lift assist device used to help workers lift, maneuver and place articles in process that are too heavy, too hot, large or otherwise too difficult for a single worker to manually handle.

Keywords: welding, fixture, manipulators, solidworks, plc.

GJRE-A Classification : FOR Code: 091399

FIXTUREDESIGNFORROOFTOPOFMETRO

Strictly as per the compliance and regulations of:

Fixture Design for Rooftop of Metro

Prof. S. N.Shinde [α], Siddharthkshirsagar [σ], Aniruddhapatil [ρ], Tejasparge [ω] & Riteshlomte[¥]

Abstract- Researching the possibilities for fixture design aided by computers has been in the sphere of interest of a number of authors worldwide for a longer period. Research results have led to the precise and systematised knowledge on the possibilities offered by computer application in fixture design process. The paper emphasises the importance of fixture design automation. It presents a general structure of the automated design system with a special highlight on the fixture design systems and their main characteristics. It also shows a structure and a part of output results of the automated modular fixture design system. Finally, the reached conclusions are presented with the expected directions of future researches. In industrial ergonomics a manipulator is a lift assist device used to help workers lift, maneuver and place articles in process that are too heavy, too hot, large or otherwise too difficult for a single worker to manually handle.

Keywords: welding, fixture, manipulators, solidworks, plc.

I. Introduction

Fixture design is typically a setup cost function, making it very valuable in flow time and indirect cost calculations. Due to the rapid response required in many applications, the fixture design principles must be integrated and properly detailed so as to facilitate the fast design development of a fixture. Frequent checking, positioning, individual marking and non-uniform quality in manufacturing process are eliminated by fixture. This increase productivity and reduce operation time. Welding fixtures are normally designed to hold and support the various components (workpieces) to be welded. Fixture is a device for locating, holding and supporting a work piece during a manufacturing industry [2]. It is necessary to support them in a proper location which is capable of preventing distortions in workpieces during welding. For this the locating elements need to be placed carefully, clamping has to be light but firm, placement of clamping elements has to be clear of the welding area and the fixture has to be quite stable and rigid to withstand the welding stresses. With the aid of manipulator the welding fixture on which the rooftop will be placed is rotated for welding purpose. After necessary welding operations being performed, the fixture is rotated back to its original position. Then the rooftop is unclamped and unscrewed from its fixture in order to get lifted by the crane to be placed on the train top. For carrying out these operations appropriate design and functioning of this mechanism is of prime concern.As a result of complex alignment and positioning equipment are important as they are required in nearly all research andmanufacturing processes[1].

Figure 1 : Rooftop of railway

Current production systems in manufacturing industry are characterized by product range extension, high frequency in changing production programs, demands for constant product quality improvement, shortenings in production time, constant need for increasing technological level of products and decreasing their manufacturing costs.In industries it is however, with the availability of 64 digit computers and refined FE tools, welding engineers around the world are

Author α: SKNCOE Pune Survey No 44/, Sinhgad Road, Vadgaon(Budruk), Pune. e-mail: snshinde24@ gmail.com
Author σ: SKNCOE Pune Flat No. 602, Pinnacle Brookside, Bavdhan, Pune. e-mail: sidksh7 @gmail.com
Author ρ: SKNCOE Pune16, 15/D, Siddharth Nagar Phase-2, Aundh, Pune. e-mail: anirudh.patil1 @gmail.com
Author ω: SKNCOE Pune92, MangalwarPeth, PargeChowk, Barne Road, Pune. e-mail: tejas_parge48@yahoo.co.in
Author ¥: SKNCOE Pune Flat No. 7, Shreeya Apt., Bharatkunj Erandwane, Pune. e-mail: lomteritesh@yahoo.in

more biased towards the computer simulations of complex welding phenomenon instead of the conventional trial and error approach on the shop floor is the most common practice nowadays [5]. With such market demands, and intensive development of science, technique and information technologies, the level and the trend of further development of technological machining processes in metal manufacturing industry depend on all the composing factors, those being the following: type of blank, machining process, order of operations, machinery, operation and sequence concentration, tools, fixtures, measurements, etc

II. Materials and Components

Out of many types of steel used for manufactring we have choosen plain carbon steel while designing and manufacturing as it is robust, cheaper than other steels and easily available.

i. The fabrication System mounted on the base is made up of mild steel.

ii. For hard parts which are prone to inducing friction is made up of alloy steel grade EN-19 having high tensile strength, good ductility and shock resisting properties.

iii. Pins are made up of 20MnCr5 which are toughened and case hardened for smooth operation.

Jigs and Fixtures are made of variety of materials, some of which can be hardened to resist wear. Materials generally used: -

- High speed Steel: Cutting tools like drills, reamers and milling cutters.
- Carbon steels: Used for standard cutting tools.
- Non shrinking tool steels: High carbon or high chromium.
  - Very little distortion during heat treatment.
  - Used widely for fine, intricate press tools.
- Nickel chrome steels: Used for gears.
- High tensile steels: Used for fasteners like high tensile screws
- Mild steel: Used in most part of Jigs and Fixtures Cheapest material contains less than 0.3% carbon
- Cast Iron: Used for odd shapes to some machining and laborious fabrication
  - CI usage requires a pattern for casting.
  - Contains more than 2% carbon.
  - Has self-lubricating properties.

Our finalized design is a product of the several different ideas and components originally created in the design phase.

a) *Manipulator:*- In industrial ergonomics a manipulator is a lift assist device used to help workers lift, maneuver and place articles in process that are too heavy, too hot, too large or otherwise too difficult for a single worker to manually handle. As opposed to simply vertical lift assists (cranes, hoists, etc.) manipulators have the ability to reach in to tight spaces and remove workpieces.

Figure 2 : Manipulator

b) *Gears:*- Gears used are spur gears or straight-cut gears are the simplest type of gear. They consist of a cylinder or disk with the teeth projecting radially, and although they are not straight-sided in form (they are usually of special form to achieve constant drive ratio, mainly involute), the edge of each tooth is straight and aligned parallel to the axis of rotation. These gears can be meshed together correctly only if they are fitted to parallel shafts.

Figure 3 : Spur Gear

c) *Brake Motor:*- A Motor is a device that creates motion. It usually refers to an engine of some kind. It may also specifically refer to Electric motor, a machine that converts electricity into a mechanical motion. Brake motor consists of an induction motor coupled to a disk brake, forming an integrated compact and robust unit. The brake used is sturdy with few moving parts and minimum of maintenance. This type of motor is mainly used in applications requiring quick stop and positive action and stand still like conveyors, gear reducers, machine tools etc. The motor used in our project is

Global Journal of Researches in Engineering (A) Volume XV Issue I Version I Year 2015

1.5 HP with a rotational speed of 0.5 rpm as per our application.

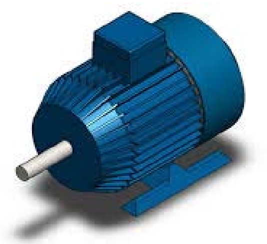


Figure 4 : Brake Motor

d) *Gear Box:*-The gear box used in our project work is a BOX type 5 inch worm and worm wheel gear box. It comprises of series of worm gear units made with die cast aluminium housing from size 25 upto 90 and cast iron for the size 110, 130, & 150. Two taper roller bearings are mounted on the worm shaft improving the mechanical resistance to the axial thrust generated by the worm wheel. The housing has been designed using parametric 3-D CAD software supported by symmetric analysis of the thermal dissipation capacity and structural resistance to deformation under the effect of working loads. The housing has been optimized to maximize the draining of water or liquid in the event of gear box being subjected to splashing or washing, thanks to the adoption of auto lubricated bearings on the output gear.

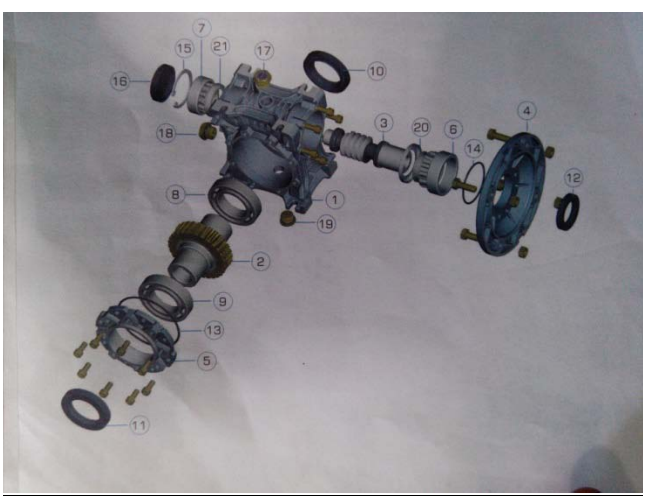


Figure 5 : *Exploded view of Gear Box*

e) *Bearing :-* Bearing is a machine element that constraints relative motion and reduces friction between moving parts to only the design motion. The design of bearing provides free linear of the moving part or free rotation aroung the fixed axis. Bearing used in our project is single deep groove bearing no. 6206 having a basic static capacity of 1000 Kgf and basic dynamic capacity of 1.30 Kgf. The maximum rotational speed for the bearing is 13000 rpm.

f) *PLC :-* The main concept of this research is implementation of a control system, by using an intelligent device, which controls the fixture so that manipulation of job becomes easy.A Programmable Logic Controller, PLC, is an electronic device used for Automation of industrial processes, control of machines and automation of factory assembly lines implying that PLC is an industrial computer which has multi-purpose use in order to handle complex parts and processes safely [3].

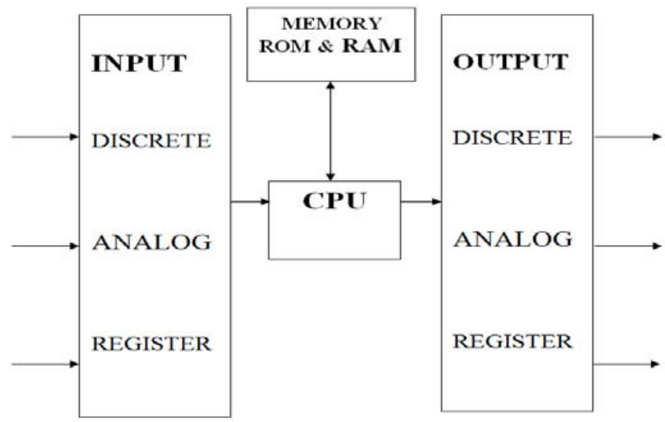


Figure 6: PLC

g) *Drive unit:* - The entire unit including the gear box, brake motor, shaft and the bearing mounting with the shaft is called drive unit. This entire unit is used to rotate the shaft with the help of gear mechanism according to our requirements. In order to improve the efficiency of the drive it needs to be regularly maintained.

Global Journal of Researches in Engineering (A) Volume XV Issue I Version I Year 2015

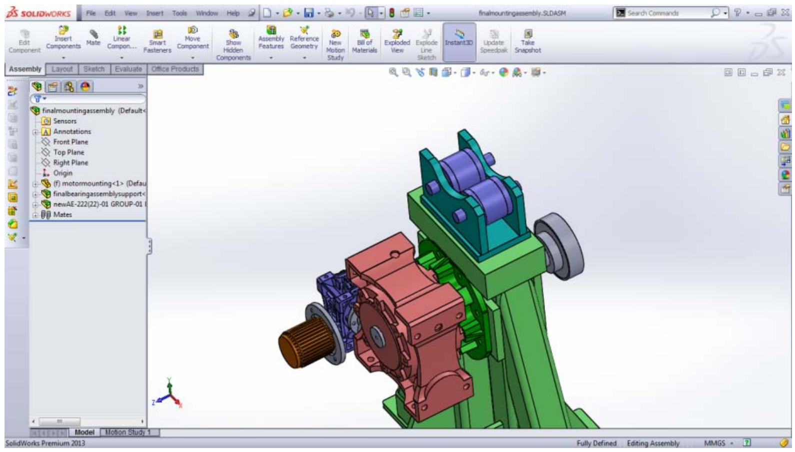


Figure 7 : Drive Unit

f) *Motor mounting:* - The entire drive unit is place on this mounting. Its unique design plays a crucial role in reducing the weight of entire assembly. The roller support is mounted on the mounting assembly and the drive unit is attached to its side.

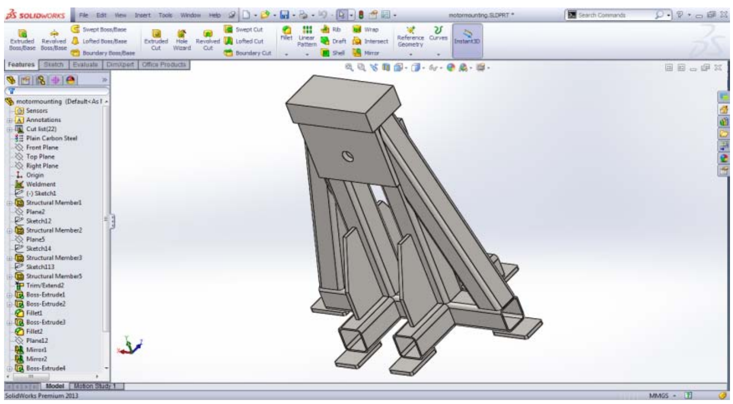


Figure 8 : CAD Model of Motor mounting

Figure 9 : Motor mounting

g) *Shaft support:* - For frictionless shaft rotation there is a specially designed shaft support. It mainly consists of use of bearings. This results into point contact between the shaft and the bearings, thus maintaining a firm support for the shaft movement. Mostly, temporary support is not adopted, while in others it becomes essential to protect the crew and equipment from any side fall.

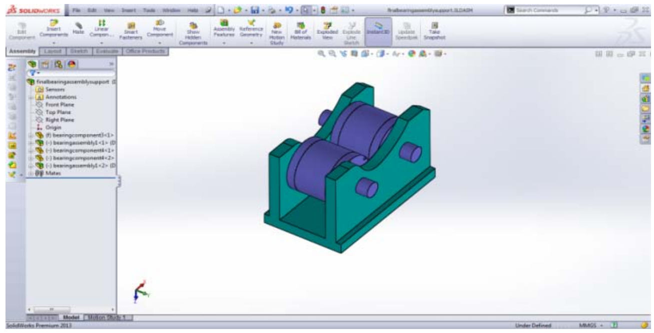


Figure 10 : Shaft Support

h) *Duct:* - In order to carry the electrical wires and other appliances for purposes of lighting specially designed pair of duct is used as a protective covering. The duct size is 300x200x6 mm which is assembled four in a number.

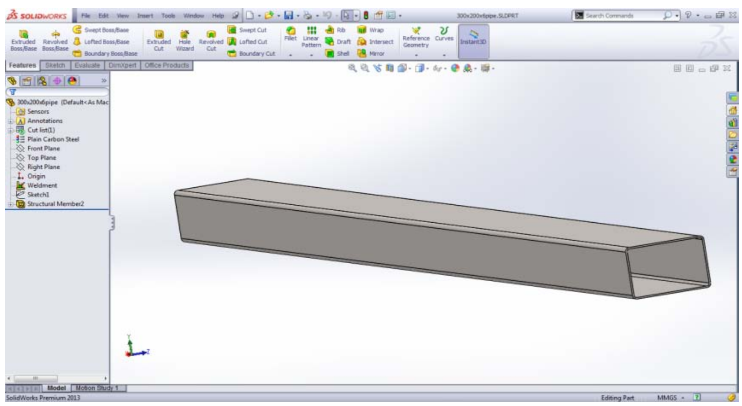


Figure 11 : Duct

i) *Supporting Components:* - These components are not considered as the main parts of the design but still they play a very important role in avoiding the falling of the main component that is the rooftop. When the entire assembly is turned by the manipulator, the rooftop is supported by these components so that welding operation can be carried out easily and safely.

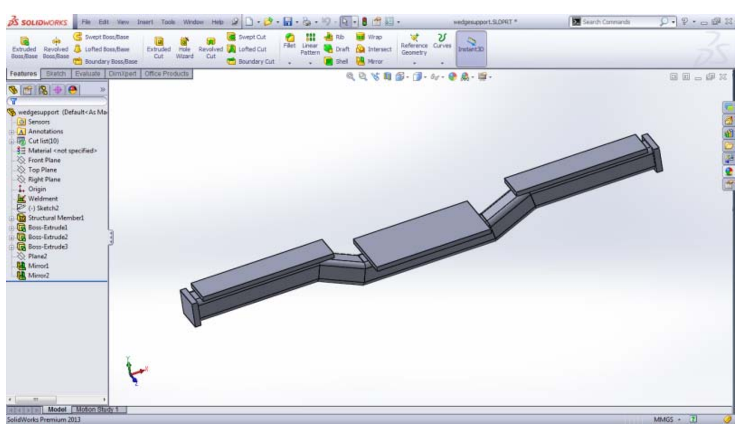


Figure 12 : Duct Supporting Component

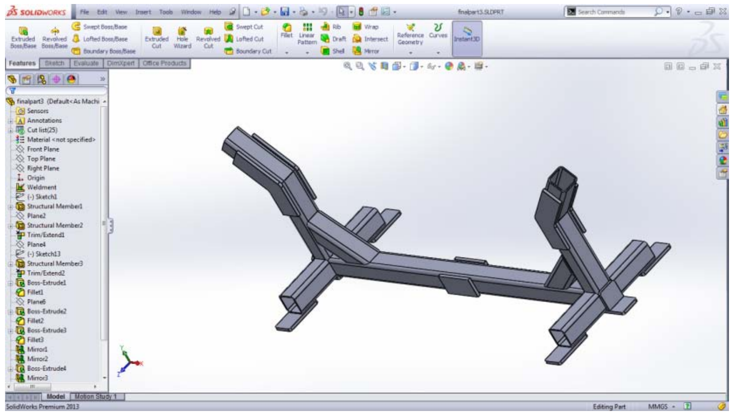


Figure 13 : *Duct Supporting Assembly*

j) *Actual rooftop:* - It basically consists of four components each having a specific dimension which is altogether assembled as one part of the entire rooftop assembly. Another pair of the rooftop is similar but having different dimensions. Though the design is complicated, error while manufacturing will not be tolerated.

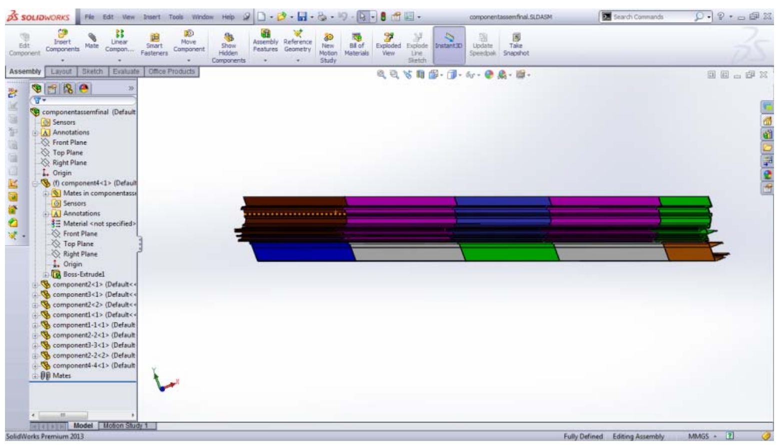


Figure 14 : CAD Model of a Rooftop

k) *Final Assembly:* - Based on the above design of the components, various components are assembled together in order to design the entire assembly which is further used for manufacturing.

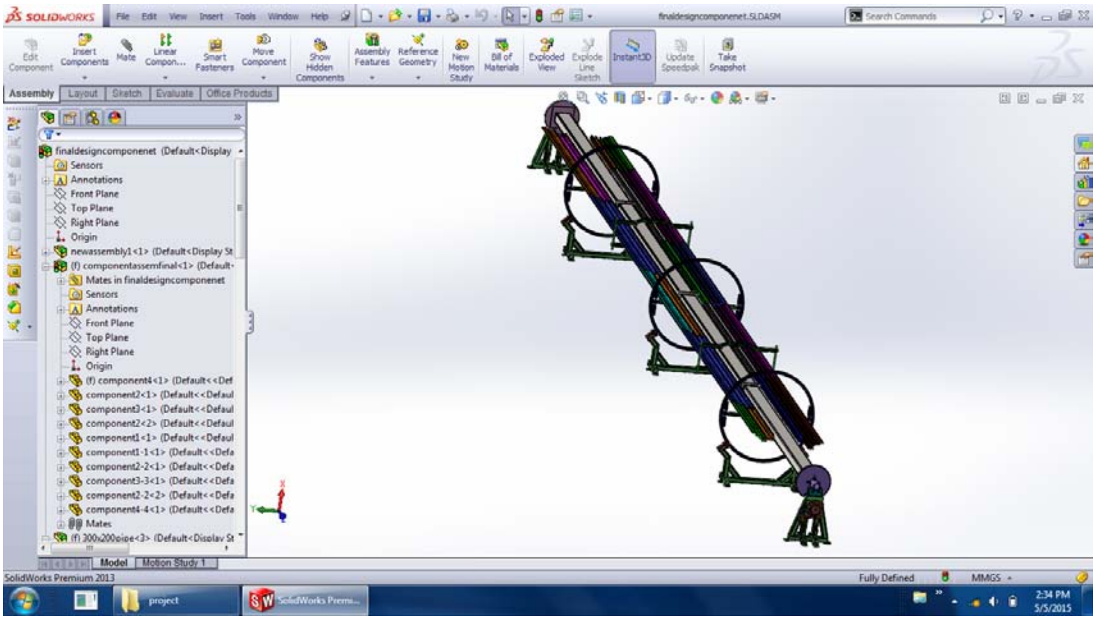


Figure 15 : CAD Model of assembly

III. Design Procedure

Before starting with the designing of the component there are rules which we followed which are:-

1. Compare the cost of production of work with present tools with the expected cost of production, using the tool to be made and see that the cost of buildings is not in excess of expected gain.
2. Decide upon locating points and outline clamping arrangement Make all clamping and binding devices as quick acting as possible
3. Make the jig fool proof Make some locating points adjustable Avoid complicated clamping arrangements
4. Round all corners
5. Provide handles wherever these will make handling easy
6. Provide abundant clearance
7. Provide holes on escapes for chips Locate clamps so that they will be in best position to resist the pressure of the cutting tool when at work
8. Place all clamps as nearly as possible opposite some bearing point of the work to avoid springing action Before using in the shop, test all jigs as soon as made

The complete planning, design and documentation process for a fixture can be carried out systematically in 3 phases based on application which are design pre planning, fixture design, and design approval[4].

The steps considered during designing are as follows:-

- Analytical design for fixture.
- 3 - D Modeling in SOLIDWORKS Wildfire 5.0
- Fixture assembly.

a) Analytical design for fixture

It includes the design of base plate, base vblock, threaded block, supporting v-block, clamp, hexagonal bolt with washer, supporting pin.

b) 3D Modelling in SOLIDWORDS

It includes generation of 3D models of all part details of the fixture like base plate, blade, shim, spacer, bolts, riser, etc.

c) Fixture assembly

It includes assembly of all the parts of the fixture step by step.

IV. Design Calculations

a) Theoretical design calculation of duct

To calculate defleciton of duct having rectangular cross section when subjected to full loading condition :

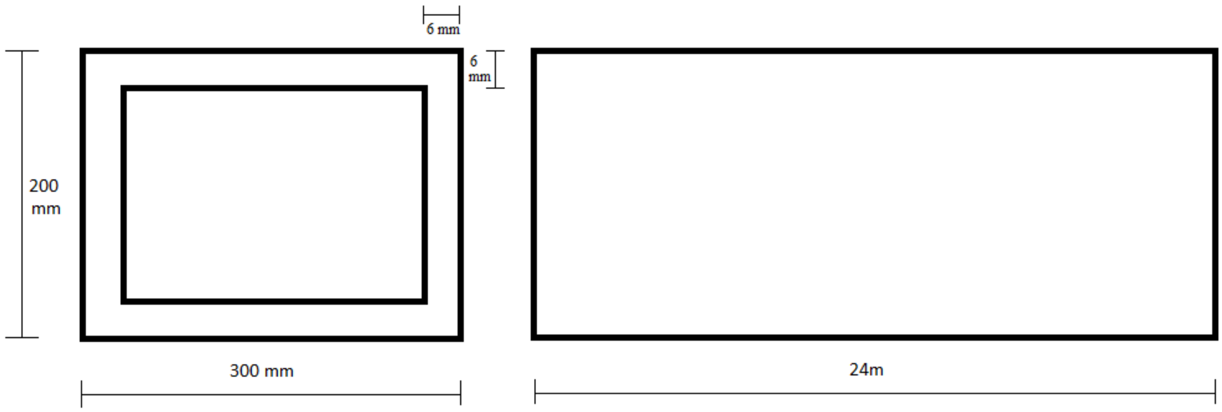


Figure 16 : Rectangular Cross Section of duct

For Figure 24,
Moment of Inertia can be determined by,

$$I_{yy} = (b_1 h_1^3 - b_2 h_2^3) / 12$$

From Figure 24,

$b_1 = 200$ mm ; $h_1 = 300$ mm

$b_2 = (200 - 12) = 188$ mm ; $h_2 = (300 - 12) = 288$mm

Substituting above values in moment of inertia formula,

$$I_{yy} = [b_1 h_1^3 - b_2 h_2^3] / 12$$

$$= [(200 * 300^3) - (188 * 288^3)] / 12$$

$$= 75756672 \text{ mm}^4$$

$$= 7.57 * 10^{-5} \text{ m}^4$$

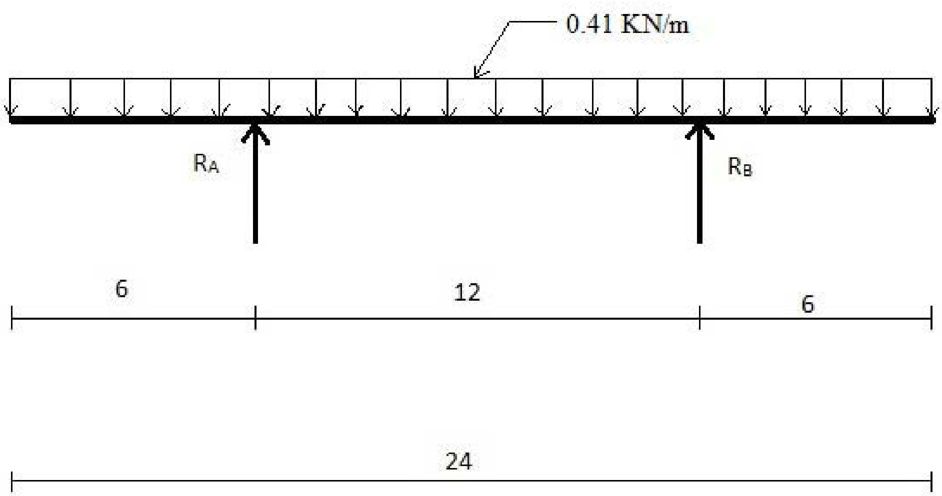


Figure 17 : FBD of Duct of 24 m

Total weight on the duct = 1000 kg = 1000 * 9.81 = 9810 N

Considering it as UDL over the span of 24 m length = 9810 / 24 = 0.41 KN/m

From Figure 25,

Considering Forces in x and y directions, we get,

$$R_A = R_B = 9.81/2 = 4.9 \text{ KN}$$

By Macaulay's method,

$$M = EI\, D^2y/Dx^2$$

$$\Rightarrow EI\, D^2y/Dx^2 = 4.9\,(x) - 0.41\,(x)\,(x/2)$$

Integrating and solving the equation, we get,

$$EI\, y = 4.9\,(x^3/6) - 0.41\,(x^4/24) + C_1 x + C_2$$

Boundary Conditions,

At $x = 0$; $y = 0$

$x = 12$; $y = 0$

Now Substituting the following boundary conditions in the above equation and solving it, we get,

$C_1 = -88.08$; $C_2 = 0$

So, the final equation becomes,

$EI\, y = 0.8166\, x^3 - 0.017\, x^4 - 88.08\, x$

Where, $E = 210 * 10^9\ N/m^2$

$I = 7.57 * 10^{-5}\ m^4$

Therefore,

Deflection, $y = 23.5$ mm (downward)

b) Verification of calculation in Ansys

In order to verify the calculations, analysis of duct is carried out in Ansys so that the deflection calculated is finalized or changed based on the difference between two values. Two conditions are considered based on which analysis is done which are:-

i. *Undeformed condition*

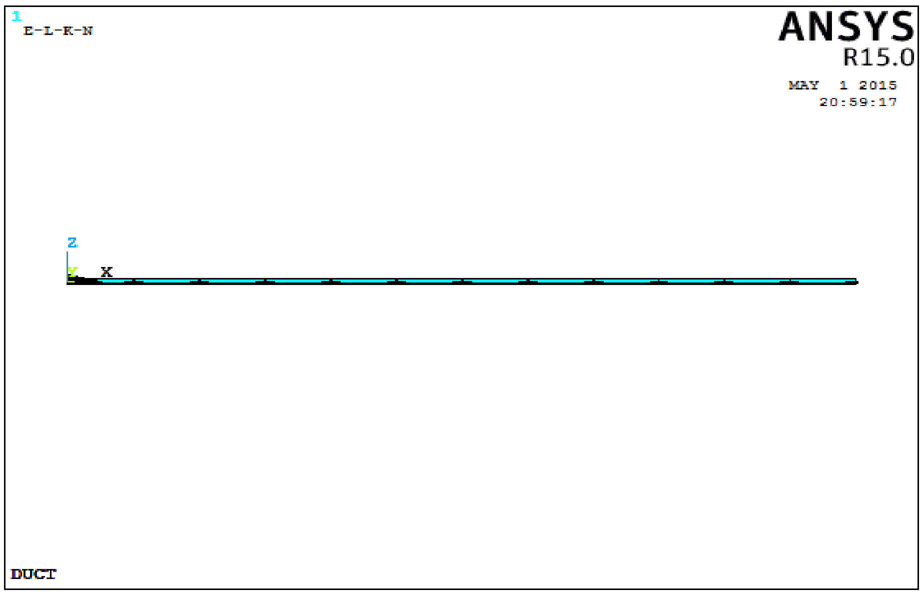


Figure 18 : Undeformed Duct without forces

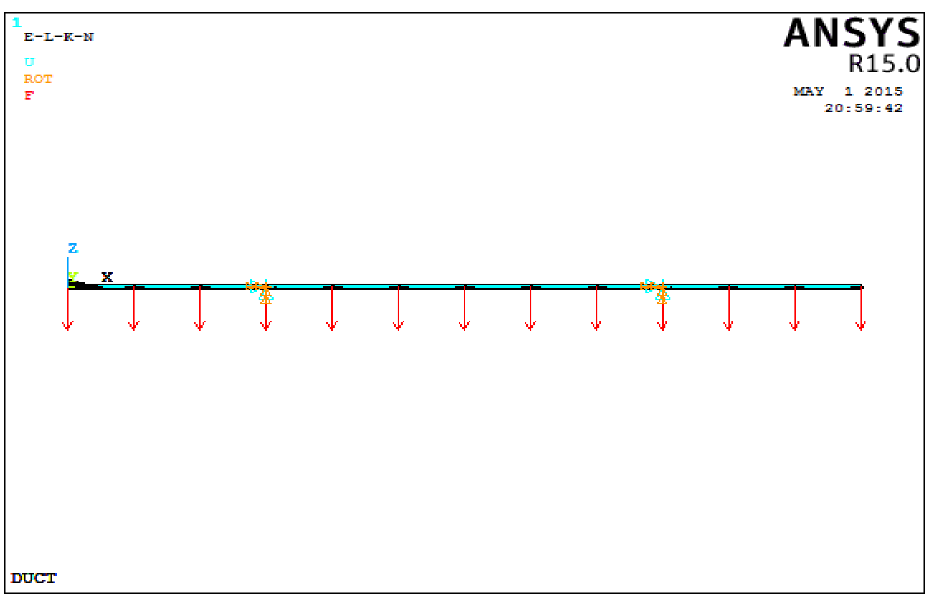


Figure 19 : Undeformed Duct with forces

ii. *Deformed Condition*

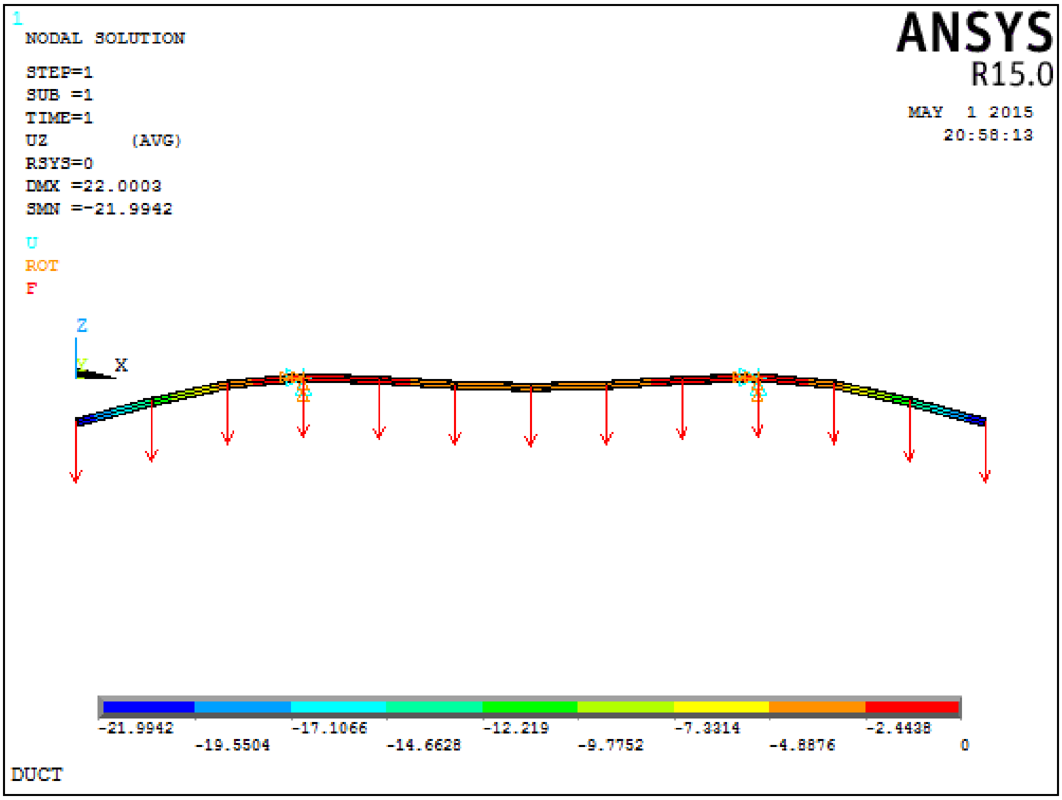


Figure 20 : Deformed Duct

Maximum deflection of duct = 21.9942 (Downward)

c) *Calculations of Spur gear*

For the given pair of spur gear,

Pitch Circle Diameter (P.C.D.) of pinion, d_p = 150mm

Pitch Circle Diameter (P.C.D.) of gear, d_g = 700mm

Based on standard selections, Standard Module, m = 6mm for gear pair

From the above information we can calculate the following parameters : -

1) Width (b) = 10m = 10 * 6 = 60mm
2) Teeth of pinion (Z_p) = d_p / m = 150/6 = 25
3) Teeth of gear (Z_g) = d_g / m = 700/6 = 117
4) Center distance (C.D) = (d_p+d_g) / 2= (700+150) / 2 = 425mm
5) Addendum (h_a) = 1m = 1 * 6 = 6mm
6) Dedendum (h_f) = 1.25m = 1.25 * 6 = 7.5mm

Now, Check whether Pinion or Gear is weaker

Ultimate tensile strength for Pinion, $(S_{ut})_p$ = 600 MPa

for Gear, $(S_{ut})_p g$ = 300 MPa

Deformation Factor (c) = 11000 N/mm^2 ;

Power P = 7.5 KW;

Factor of safety, FOS = 2.5;

Sum of errors between meshing teeth (e) = 7.3 microns;

Velocity factor = 6 / (6+V) ; Lewis factor = 0.484 – 2.87 / z ;

Thus,

$(\sigma_b)_p = (S_{ut})_p / 3$ = 600 / 3 = 200 MPa

$(\sigma_b)_g = (S_{ut})_g / 3 = 300 / 3 = 100$ MPa

Lewis form factor is

$Y_p = 0.484 - 2.87 / 25 = 0.3692$

$Y_g = 0.484 - 2.87 / 117 = 0.46$

Now,

$(\sigma_b)_p * Y_p = 200 * 0.3692 = 73.84$ MPa

$(\sigma_b)_g * Y_g = 100 * 0.46 = 46$ MPa

As $(\sigma_b)_p * Y_p < (\sigma_b)_g * Y_g$, gear is weaker than pinion in bending. So, the design is required based on gear.

Beam Strength of gear, $F_b = (\sigma_b)_g * Y_g * b * m = 46 * 60 * 6 = 16560$ N

Effective load on gear pair, $F_{eff} = (K_a * K_m * F_t) / K_v$

As $V = \pi d_p N_p / 60 = (\pi * m * Z_p * N_p) / 60$

$= (3.14 * 6 * 25 * 1440) / (60 * 10^3)$

$= 11.304$ m/sec

Tensile Force, $F_t = P / V = 7500 / 11.304 = 663.48$ N

$K_v = 6 / (6+V) = 6 / (6+11.304) = 0.3467$

$K_a = 1.56$ and $K_m = 1$ (assume)

Therefore,

$F_{eff} = (K_a * K_m * F_t) / K_v = (1.56 * 1 * 663.48) / 0.3467 = 2985.373$ N

Dynamic Load by Buckingham's Equation : -

$F_d = [21V(Ceb + F_t)] / [21V + (Ceb + F_t)^{(1/2)}]$

⇨ $F_d = [21 * 11.304(11000 * 7.3*10^{-3} * 60 + 663.48)] / [21 * 11.304 + (11000 * 7.3*10^{-3} * 60 + 663.48)^{(1/2)}]$

⇨ $F_d = 3631.97$ N

Design safety : -

$F_{eff} = (F_t)_{max} + F_d = K_a * K_m * F_t + F_d$

⇨ $F_{eff} = 1.56 * 1 * 663.48 + 3631.97$

⇨ $F_{eff} = 4667$ N

Therefore, FOS $= F_b / Feff = 16560 / 4667 = 3.5483$

As available FOS of gear pair is higher than the required FOS; Design of gear pair is safe.

Surface Hardness, $F_w = d_p * b * Q * K$

But, $d_p = 150$ mm ; $b = 60$ mm

$Q = 2Zg / (Z_g + Z_p) = (2 * 117) / (25 + 117) = 1.648$

Assume, $K = 0.16 * (BHN / 100)^2$

$F_w = 150 * 60 * 1.648 * 0.16 * (BHN / 100)^2$

But, $F_w = FOS * F_{eff}$

Hence, $2373.12 * (BHN / 100)^2 = 2.5 * 4667$

$BHN = 221.7322$

V. Various Processes and Machines used for our Component

- *Gas cutting:* - Oxy-fuel cutting is a process that uses fuel gases and oxygen to weld and cut metals, respectively. Pure oxygen, instead of air, is used to increase the flame temperature to allow localized melting of the workpiece material (e.g. steel) in a room environment. A common propane/air flame burns at about 2,000 °C (3,630 °F), a propane/oxygen flame burns at about 2,500 °C (4,530 °F), and an acetylene/oxygen flame burns at about 3,500 °C (6,330 °F).

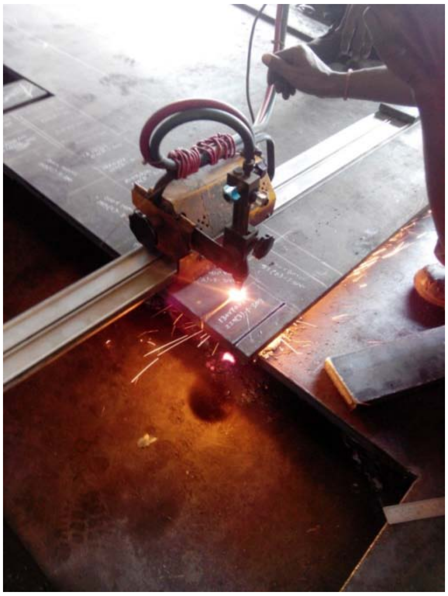


Figure 21 : Gas Cutting Process

- *Arc welding:* -Arc welding is a type of welding that uses a welding power supply to create an electric arc between an electrode and the base material to melt the metals at the welding point. They can use either direct (DC) or alternating (AC) current, and consumable or non-consumable electrodes. Each weld on any component is welded using a specific welding process with the aid of highly focused electrode shielding gas, largedegree of control the welder has over the heat intensity leads to production of very strong and consistent welds [6].
- *Special purpose machine:* -Special purpose machines are designed to perform some specific applications which cannot be carried out using conventional machines. In our company the SPM is of the company SCHARMANN is used mainly for job setting and machining the components using operations like sizing, drilling, rimming, boring, finishing etc.

Figure 22 : Special Purpose Machine

- *Vertical machining center:* - VMC used in our company is of the Hartford Company. It is very costly but serves its purpose to the fullest. Being economical it is widely used for large scale production of components. It is basically constituted of three components- the monitor where program is fed, keypad for feeding the program and the control panel for controlling the feed rate, RPM, start and stop of machine. For the machining purpose following are the codes which are written:-

a) *Drilling*

Figure 23 : G-code for Drilling

b) *Interpolation*

Figure 24 : G-code for Interpolation

c) *Milling*

Figure 25 : G-code for Milling

VI. Manufacturing Procedure

The actual manufacturing phase which plays a very important role is mainly classified into three categories:-

- *Fabrication:* Metal fabrication is the building of metal structures by cutting, bending, and assembling processes. This stage plays a very simple but a crucial role. Fabrication shops and machine shops have overlapping capabilities, but fabrication shops generally concentrate on metal preparation and assembly as described above. By comparison, machine shops also cut metal, but they are more concerned with the machining of parts on machine tools.
- *Machining:* Machining is any of various processes in which a piece of raw material is cut into a desired final shape and size by a controlled material-removal process. The three principal machining processes are classified as turning, drilling and milling. Other operations falling into miscellaneous categories include shaping, planning, boring, broaching and sawing
- *Assembly:* Component or end item comprising of a number of parts or subassemblies put together to perform a specific function, and capable of disassembly without destruction. It is the last stage of manufacturing but very difficult requiring high precision and accuracy. Successful fixture designs begin with a logical and systematic plan. With a complete analysis of the fixture's functional requirements, very few design problems occur. When they do, chances are some design requirements were forgotten or underestimated. The workpiece, processing, tooling and available machine tools may affect the extent of planning needed. Preliminary analysis may take from a few hours up to several days for more complicated fixture designs. Fixture design is a five step problem-solving process.

The manufacturing process which we selected must be an economical balance of materials, manpower, product design, tooling and manpower, plant space, and many other equipment factors influencing cost and practicality.

a) *Our Basic Aim for Manufacturing the Assigned Fixture was*

1. Using Materials More Economically
2. Eliminating Operations
3. Selection of Proper Tooling
4. Minimum Cost Analysis

In minimum cost studies, it is found that when changes occur in a common variable (In this case it is operational speed), the change may modify other cost aspects of the problem in such a way that the combined problem effect produces a minimum value.

Figure 26 : Milling Machine

b) *Component Fabrication*

Precision cutting and forming of sheet metal is utilised for manufacture of superstructures including drivers cab engine hoods, and compartments for housing electrical equipment. All activities connected with pipes like pickling, bending, cutting, forming and threading of pipes of various sizes are undertaken in another well-equipped work area.

All electrical equipment is assembled in the fabricated control compartments and driver's control stands are done in another work area.

c) *Under frame Fabrication*

Under frames are fabricated with due care to ensure designed weld strength. Requisite camber to the under frame is provided during fabrication itself. Critical welds are tested radio-graphically. Welder training and their technical competence are periodically reviewed.

Global Journal of Researches in Engineering (A) Volume XV Issue I Version I Year 2015

High Horse Power (HHP) under frame is fabricated using heavy fixtures, positioners to ensure down hand welding.

VII. Results

From the above design calculations the type of gear which we have chosen is spur gear because it has proportional Brinell hardness number, high power transmission efficiency, highly reliable and unlike belt drives have no slip condition.

From the above bending condition the design of duct is not suitable, so it is required to take a plain rectangular duct with square cross section in order to reduce the bending below 10mm. By changing the cross section the inertia will change leading to decrease in the deflection. Thus it is advisable to design a duct 100*100mm with 8mm thickness and 6mm chamfer.

Bearing selection also plays a very important role and based on our application it is highly recommended to select single row deep grove ball bearing as they can sustain some axial load in either direction as well as radial loads, and the two raceway cross-sections are simple circular arcs which can be very precisely finished so that the bearings have low friction and very little noise or vibration. Several different cage designs are available with different characteristics and the choice depends upon the individual application.

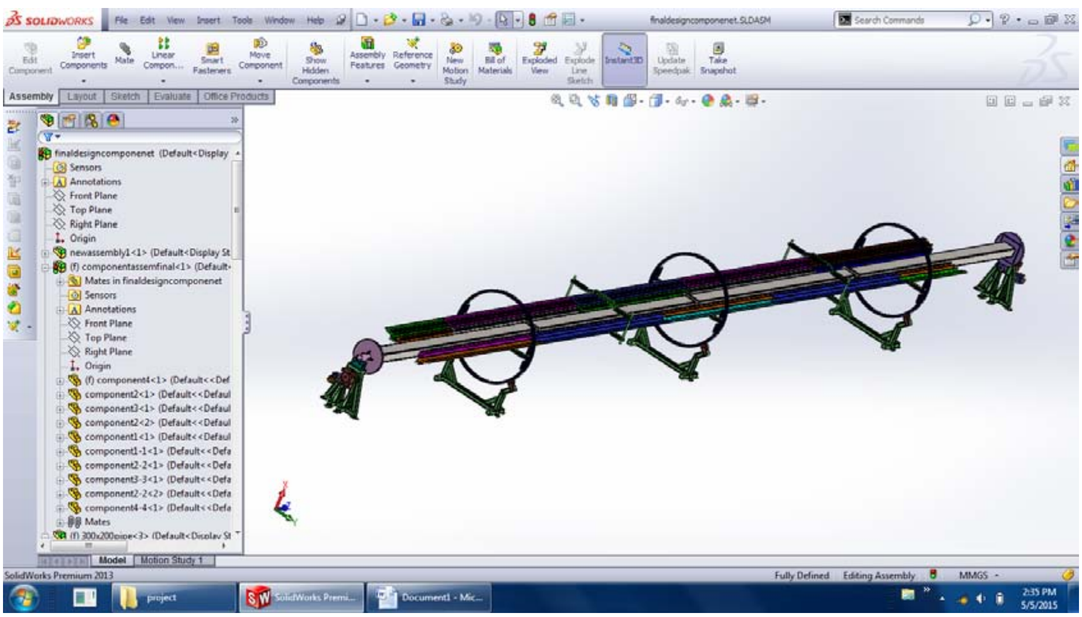


Figure 27 : Final assembly of fixture

VIII. Acknowledgement

Inspiration and guidance are invaluable in every aspects of life, especially in the fields of academics, which we have receivedfrom our company. We would like to thank them as they are responsible for the complete presentation of our project and also for the endless contribution of time, effort valuable guidance and encouragement given by professor S.N.Shindeto project work.

IX. Conclusion

Conclusion is drawn on the basis of the information collected on each aspect of our project. It leads to a belief that if applied will create an even better machine than we have designed. The process of conducting operations related to welding fixtures and positioners helps in gaining a deeper understanding as well as effective project process. From finding a resource for research material to design updates of the part causes the task of accurately prototyping the real design difficult. It is important that the design satisfies all of the functional requirements and design parameters which were outlined at the start of the project. In order to meet the requirements of the fixture customization is done by making the clamping system very practical for various sizes and geometries. By also knowing the material selection a cost benefit analysis could be conducted to determine how cost effective the product is.

Design data handbooks detail mechanical component design analysis with sufficient information provided regarding material specification, properties, requirements for design, etc. This facilitates designers to apply their exact requirements and choose from available resources. Also, verification with the design data books allows one to confirm that correct procedures are being followed. Similarly, the idea behind the preparation of a guide for fixturing as undertaken in this project is to develop a guide that could be used as a ready reference while designing jigs and fixtures. This project represents the first phase of designing a comprehensive roadmap for fixture design, to assist Tinker Engineers, designers and shop supervisors alike, as well as sub-contractors.

References Références Referencias

1. "Design of a Hybrid Positioner-Fixture for Six-Axis Nano positioning And Precision Fixturing", Martin. L. Culpepper, MIT Dept. Of Mechanical Engineering, Massachusetts Avenue.
2. "Analytical Report on the Design and Simulation of a Weld Fixture", SampathRao, P. , Mechanical Dept. VREC, Nizamabad.
3. "Plc Based Control System Applied To Industrial Automated Fixture with Category 4 Safety", S.P. Jagtap,ENTC Dept.PCCOE/University of Pune, India.
4. "Jigs and Fixture Design Manual",Erik K. Henriksen, Fellow of the ASME.
5. "Analysis Of Residual Stresses And Distortions In Girth-Welded Carbon Steel Pipe", Prabhat Kumar Sinha, International Journal Of Recent Technology and Engineering (IJRTE), May 2013.
6. "Design and Optimization of A Formula Sae Race Car Chassis and Suspension", Reid. F. Allen, Massachusetts Institute of Technology, June 2009.

This page is intentionally left blank

Global Journal of Researches in Engineering : A
Mechanical and Mechanics Engineering
Volume 15 Issue 1 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN:2249-4596 Print ISSN:0975-5861

Evaluation of Parametric Control for Machining with WEDM and Machinability Index

By Perla Sreenivasa Rao & Dr. K. Ravindra
SV University, India

Abstract- The present research work is intended to optimize the machining parameters for achieving high dimensional accuracy in wire electric discharge machining (WEDM). Experiments were designed and carried out to evaluate the best parametric setting which gives parameters like power, spark gap and corner radius using Inconel X-750 as workpiece material. These parameters are determined for a wide range of job thickness and mathematical correlations were developed for the parameters such as power and spark gap. Analysis of variance (ANOVA) is also performed to study the fitness. This procedure eliminates the need for repeated experiments which saves time and material unlike conventional machining process. The primary objective of the study is to find out the important and combination of one or more factors that influence the machining process in order to achieve the best power setting in turn machining current. Also, Machinability index of various materials which can be machined by WEDM is evaluated by referring to the present research work and literature review.

Keywords: wire electrical discharge machining, ferrous and non-ferrous materials, aviation materials, parameters, machinability index.

GJRE-A Classification : *FOR Code: 290501*

Evaluation of Parametric Control for Machining with WEDM and Machinability Index

Perla Sreenivasa Rao [α] & Dr. K. Ravindra [σ]

Abstract- The present research work is intended to optimize the machining parameters for achieving high dimensional accuracy in wire electric discharge machining (WEDM). Experiments were designed and carried out to evaluate the best parametric setting which gives parameters like power, spark gap and corner radius using Inconel X-750 as workpiece material. These parameters are determined for a wide range of job thickness and mathematical correlations were developed for the parameters such as power and spark gap. Analysis of variance (ANOVA) is also performed to study the fitness. This procedure eliminates the need for repeated experiments which saves time and material unlike conventional machining process. The primary objective of the study is to find out the important and combination of one or more factors that influence the machining process in order to achieve the best power setting in turn machining current. Also, Machinability index of various materials which can be machined by WEDM is evaluated by referring to the present research work and literature review. The index may be useful to the fraternities like industry and academia in determining the best cutting parameters that are to be set on the machine. The best parameters evaluated out of this study, will be useful while setting up the machine which avoids trial and error method and also aids in process planning.

Keywords: wire electrical discharge machining, ferrous and non-ferrous materials, aviation materials, parameters, machinability index.

I. Introduction

Worldwide industry acceptance has brought revolutionary changes in bringing the Wire electrical discharge machines (WEDM) into the shop floors which is an unconventional production process thus manufacturing the components with a complex geometry.

The material is removed from a workpiece by creating a series of rapidly recurring electric current discharge (thousands of sparks) between the cutting tool and workpiece, immersed in a non-conductive fluid called dielectric.

The wire used for machining is also called as a tool/electrode and is made of copper, brass, tungsten or brass coated of diameter varying from 0.03 to 0.30mm.

A constantly moving wire fed from a spool is subjected to a high tension with the help of an advanced tension servo control mechanism shall results in producing precision components of extremely complex shape and desired profile.

The WEDM can be deployed to machine the materials that are hard to machine such as high strength and temperature resistive materials (HSTR). Also, the components manufactured out of Wire EDM would be free from the geometrical changes as there won't be any mechanical stresses developed during the machining. The dimensional accuracy can be achieved even in the case of machining the heat treated materials regardless of the hardness. Hard or difficult to machine materials are also can be machined using the WEDM.

The mechanical stresses that are developed during the machining process would be eliminated as there would not be any direct contact between workpiece and the tool. It may be observed that the material is eroded ahead of the wire travel.

The first commercially NC machine was built and introduced to the manufacturing industry in the late 1960s. The WEDM process was developed as a result of quest of a technique to replace the machined EDM electrode. D.H. Dulebohn has automated the WEDM process and controlled the shape of the machined components with the help of optical-line follower technique in 1974. The process has become very popular by the year 1975 and by then the industry has good understanding and knowledge about various capabilities of WEDM. Later, it was observed that there was rapid growth in deploying the WEDM machines in the manufacturing segment.

The first CNC EDM was fabricated in late 1970s which has brought a major evaluation of the machining processes.

As a result, the wide range of capabilities of the WEDM process were significantly implemented for any

Author α: Graduated in Mechanical Engineering, Post graduated from Osmania University, Hyderabad, A.P, India and pursuing Ph.D. from Shri Venkateswara University, Meerut, U.P, India
e-mail: anjupsrao@gmail.com
Author σ: Graduated in Mechanical engineering, Post graduated in Machine Design, Ph.D. from Andhra University, Visakhapatnam, A.P, India. Working as a Professor and HOD in RVR & JC College of Engg., Guntur, A.P. India.
e-mail: ravindra.kom@gmail.com

through hole machining owing to the wire, which has to pass through the component to be machined. The WEDM applications includes Prototype production, die making, closed loop manufacturing, metal disintegration machining, Extrusion Dies, Fixtures and Gauges, Form tools and inserts, Bio-Medical applications, Aerospace, defense and electronic parts. Limited varieties of composites and ceramics also can be machined using WEDM. Fig.1. shows the schematic view of the process.

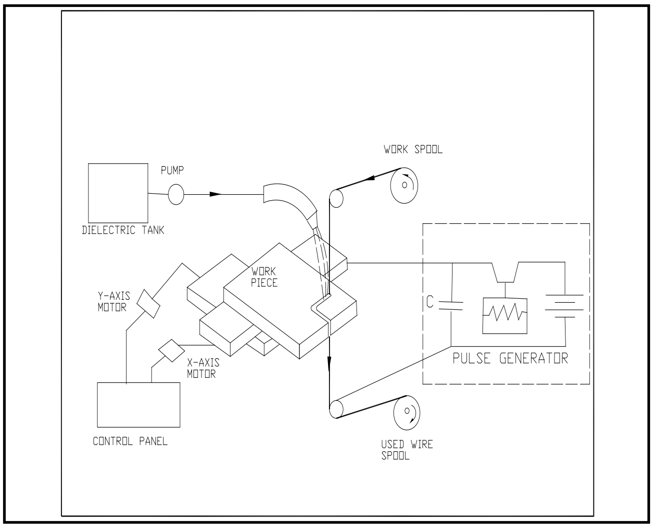


Figure1 : Wire electrical discharge machining Process

WEDM removes material with the help of a storage capacitor by releasing a series of discrete electrical discharges (transient sparks over a shorter duration). The erosion takes place when the capacitor starts discharging an electrical current through an accurately positioned and constantly moving wire (tool/electrode) and the workpiece (anode). A narrow gap is maintained between the tool and cathode through an insulated medium (dielectric fluid). A microprocessor embedded with the WEDM machine maintains a constant narrow gap varying from 25 to 50 microns between the electrode and workpiece.

When the wire approaches close to the workpiece, the controlled electrical discharges creates a concentrated spark that helps melting down the required portion of material into vaporized tiny particles during the erosion process.

The workpiece is totally submerged in dielectric fluid which would help in maintaining constant temperature and also flushes away the debris after erosion. Flushing mechanism plays a vital role when there is a change in thickness of the workpiece.

The flushing mechanism even aids in cooling down the workpiece after erosion and surrounding environment handling huge temperature range of 10000°C. The volume of the material removed per spark may be 10-6 mm3 approximately.

WEDM does not require customized form or a shaped electrode as there is only a wire used as a tool which saves investment of resources like cost, time and money. Unlike traditional machining, the WEDM process eliminates use of different electrodes for rough and finish operations. Sometimes, the finish operation may demand multiple passes along the profile/shape to be created.

WEDM can achieve exceptionally high dimensional accuracy as it uses a thin and continuous wire feeding through the workpiece and enables the production of parts particularly a complex shape.

Surface finish quality depends on the amount of electrical discharge energy and also relates to the intensity and duration of the spark plasma. Decrease in both pulse duration and discharge current may influence Surface finish, cutting speed and MRR.

Machining Parameters influencing the WEDM process Discharge Current, Gap Voltage, Pulse parameters like pulse frequency and duration, Conductivity, flow rate and flushing pressure of dielectric fluid, dielectric flushing pressure, wire size, material, speed and tension, thickness, melting point, material of workpiece etc.,

a) Experimental Set-Up

The experimental studies were performed on a Wire EDM machine of make ULTRACUT 334.

A brass wire of 250 microns diameter is used as a tool-electrode with a wire tension of 70N at a velocity of 3.4 m/min. Inconel X-750 is used as a workpiece material for conducting the experimentation. As per DIN 160 standards, the preferred mechanical strength of the brass alloy wire opted for the experimentation is of 900 N/mm2 with a composition of CuZn36.

Deionized water with a dielectric conductivity of a value of 38 mhos is used as a Dielectric medium for the present study. A range of 30 to 90 Volts has been set as a gap voltage. The optimum values were obtained at 80 Volts.

Experimental investigation was done to find out the influence of the current with respect to the parameters like varying workpiece thickness, spark gap and the geometry. Workpiece thickness of Inconel X-750 material used was varying from 5 to 80mm material.

As shown in Fig.2, an "L" shaped cut was performed to measure the corner radius with respect to the current value and also another slot of 30mm length has been cut to measure the slot width. Series of experiments were carried out varying the workpiece thickness starting from 5 to 80 mm with an increment of 2.5mm or 5mm as convenient. A total of 20 experiments were conducted in the present research work.

Necessary care was taken to achieve high cutting speed with respect to varying current with a least wire breakage.

Figure 2 : Shape of the slots machined

The instrument, Nikon OPTOMECH-Rapid-optical microscope with a 100X magnification is used for measuring the workpiece after cutting. Necessary parameters related to corner geometry were recorded and tabulated for quick reference.

The spark gap can be derived using the equation W = d + 2 * Sg Where W= Slot width, d = Wire diameter and Sg = Spark gap

The variation of power, spark gap and corner radius with respect to change in thickness of workpiece is discussed in this article to derive the best fit curve. Origin 8.0 software tool is being used for the study. The mathematical equations are derived and statistical analysis ANOVA is also performed to calculate the co-efficient of variance, R2 and standard deviation in order to determine the fitness of the curve.

b) Results and Discussions

Fig.3. describes the effect of variation in thickness with respect to the power. The increase in workpiece thickness causes variation in power. It is also observed that the increase in workpiece thickness causes increase in machining current for a specific set of machining conditions.

This phenomenon reveals that the high amount of energy required to machine higher workpiece thickness, the machining can be performed only when the current is increased which involves high amount of power. However, the rate of power change is found decreasing with increasing thickness. This may be due to the limitation of current carrying capacity of the wire electrode.

The plot is useful to determine suitable values like the minimum power required for machining the INCONEL X- 750 workpiece at given thickness with in working range of the select machine.

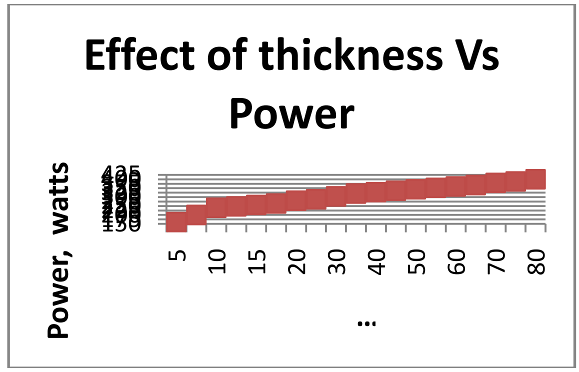


Figure 3 : Effect of Thickness on Power

The power required in turn the machining current can be selected from the plot for a given thickness of the job.

By regression and correlation of the available data, the mathematical expression for the best fit curve is derived as given below.

Power (P) = 400.16 - [80 x 5107.31 / (1 + exponential of {(T+223.8) / 26.3 })] Eqn. (1)

Fig.4 depicts the trend of variation in spark gap with the increase in workpiece thickness. The plot shows that the spark gap increases with increment in workpiece thickness. The increase in gap may be due to the spark jumping longer because of high energy generated at high current values, is required to machine the job of higher thickness, though the rate of change is proportionate with respect to the job thickness. The best fit curve is plotted and is carried out the statistical analysis (ANOVA).

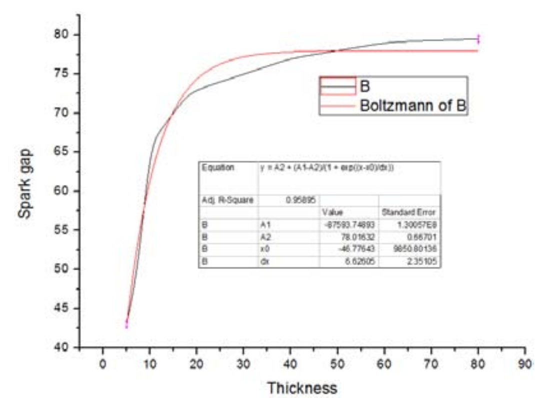


Figure 4 : Effect of Thickness Vs Spark gap

The mathematical relation can be expressed as

Spark gap (Sg) = 78.016 - [87671.75 / { 1 + exponential of { (T+46.77) / 6.63} }] Eqn. (2)

Where Sg in micrometers.

The outcome of statistical analysis gives the value of R-Squared and standard deviation as 0.9657 and 0.2557 respectively. This is useful in finding the spark gap i.e., the cutting width to compute the MRR and determine the wire offset used while generating a CNC part program and hence high accuracy can be achieved.

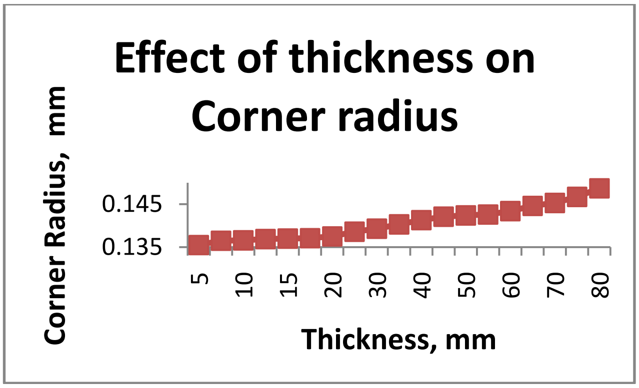


Figure 5 : Effect of workpiece thickness on corner radius

Fig.5. shows the variation in corner radius with the increase in thickness of workpiece. The curve shows an increasing trend in corner radius with increase in thickness of the workpiece. The plot shows that the spark gap increases with increment in workpiece thickness. The increase in gap may be due to the spark jumping longer because of high energy generated at high current values, is required to machine the job of higher thickness causing deeper cutting, though the rate of change is proportionate with respect to the job thickness. The profile geometry/contour of the corner radius generated can be similar to that of cross-section of the wire used for machining. From the plot, corner radius that can be achieved can be predicted while machining a particular workpiece thickness at optimum cutting parameters. The parameters can be set even for the required corner radius on a given job thickness from the database built while optimizing the parameters.

c) Machinability Index

The data for machining 5mm thick workpieces of Mild steel, HSS, HC-HCr steel, En24 steel, Stainless steel, Copper, Brass, Graphite, Tungsten-carbide and Titanium are adopted from the literature[4, 5, 10-12], and Inconel X-750 are considered from the present research work. The machinability index is calculated for all these materials and tabulated as below.

Table 1: Machinability Index

S.No.	Material, (5mm thickness)	Cutting speed, (mm/min)	Machinability Index
1	Mild steel	3.10	1.000
2	HSS	3.44	1.207
3	HC-HCr steel	2.20	0.752
4	EN24 steel	2.67	0.827
5	Stainless steel	3.00	0.985
6	Copper	2.80	1.253
7	Brass	7.80	2.560
8	Graphite	1.60	0.616
9	Tungsten carbide	1.40	0.474
10	Titanium	4.11	1.412
11	Inconel X-750	3.84	1.324

II. Conclusion

The influence of machining parameters like Current and Workpiece thickness with respect to the accuracy criterion such as cutting speed and spark gap are determined. A better control on machining accuracy can be achieved in comparison with earlier researchers by controlling the primary parameter “current” in turn Power. The results are useful in setting up the parameters required for accurate cuts on Inconel X-750 workpieces of any size ranging between 5 and 80mm. The appropriate machining parameters can be chosen depends on the availability of wire-electrodes. The mathematical relation developed and the plots are much more beneficial in estimating the spark gap and also to achieve high cutting accuracy for any given workpiece thickness within the working range of the select machine. The modern industrial applications like tool and die manufacturing units may make use of these results in order to optimize the use of Wire EDM resources in more efficient manner than the past.

Student fraternity, Researchers, Manufacturing industry can refer the machinability index developed out of this research to have an overall understanding about various challenges like the degree of difficulty or ease while dealing with the machining of different materials.

The findings of the present work will open up new insights into the fundamental and applied researchers in the WEDM area for better understanding of the technology, and also useful to the manufacturing industry and tool rooms for taking up a quantum leap from the present day needs of machining of the conductive materials irrespective of their metallurgical properties.

III. Acknowledgements

The authors would like to express their sincere appreciation to Purnodaya CNC facility, Hyderabad for permitting the experimentation work.

References Références Referencias

1. S V Subrahmanyam, M. M. M. Sarcar. (March 2013). Evaluation of Optimal Parameters for machining with Wire-cut EDM Using Grey-Taguchi Method. *International Journal of Scientific and Research Publications,* Volume 3, Issue 3, ISSN 2250-3153.
2. J.A. Sanchez, J.L. Rodil, A. Herrero, L.N. Lopez de Lacalle, A. Lamikiz. (2007). On the influence of cutting speed limitation on the accuracy of wire-EDM corner-cutting. *Journal of material processing technology, Elsevier,* 182, 574-579.
3. S.SivaNaga Malleswara rao, CH.V.S.Parameswara rao. (Feb 2013). Parametric analysis for machining HSS by WEDM-development of Mathematical Correlations and statistical analysis. *IJ-ETA-ETS,* pp 96-100.
4. S.Sivanaga Malleswara Rao, Ch.V.S. Parameswara Rao. (April 2013). Parametric Evaluation for Machining Die-Steel with WEDM. *International Journal of Scientific and Research Publications,* Volume 3, Issue 4, ISSN 2250-3153, pp 1-5.
5. Ch.V.S.Parameswara Rao, MMM Sarcar. (Jan-2009). Evaluation of Optimal Parameters for machining Brass with Wire-cut EDM. *Journal of Scientific and Industrial Research,* ISSN 0022-4456, Volume 68, Number 1, pp 32-35.
6. K. Bonny & P. De Baets & J. Vleugels & A. Salehi & O. Van der Biest & B. Lauwers & W. Liu. (2009). EDM machinability and frictional behavior of ZrO2-WC composites. *International Journal of Advances Manufacturing Technology, Springer,* 41: 1085-1093.
7. Goswami Amitesh, Kumar Jatinder. (January-March, 2012). An investigation into the machining characteristics of Nimonic 80A using CNC WIRE-EDM. *International Journal of Advanced Engineering Technology,* E-ISSN 0976-3945 IJAET/Vol.III/ Issue I/ /170-174.
8. D.K. Aspinwall, S.L. Soo, A.E. Berrisford, G. Walder. (2008). Workpiece surface roughness and integrity after WEDM of Ti–6Al–4V and Inconel 718 using minimum damage generator technology. *CIRP Annals-Manufacturing Technology, Elsevier,* 57, 187-190.
9. Marina Kousoulidou, Athanasios Dimaratos. (2014). Optimizing the machining characteristics of Nimonic 80A using wire-cut EDM. *Rev. Téc. Ing. Univ. Zulia,* Vol. 37, N2, 16 - 24, 16.
10. P.Srinivasa Rao, Dr.ChVS Parameshwara Rao, Dr.K.Ravindra. (May-2014). Experimental studies on parametric influence on machining of Titanium with WEDM. *IJETR edition,* ISSN:2321-0869, Volume 2, Issue-5, pp 230-233.
11. Kamal Jangra & Sandeep Grover & Felix T. S. Chan & Aman Aggarwal. (February 2011). Digraph and matrix method to evaluate the machinability of tungsten carbide composite with wire EDM. *Int J Adv Manuf Technol DOI 10.1007/s00170-011-3234-5, Springer-Verlag London Limited.*
12. Levy.G.N. and Maggi. F. (January 1990). WEDM Machinability Comparison of Different steel grades. *Annals of CIRP.*

This page is intentionally left blank

Global Journal of Researches in Engineering : A
Mechanical and Mechanics Engineering
Volume 15 Issue 1 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN:2249-4596 Print ISSN:0975-5861

A Review of Modelling Techniques for Loading Problems in Flexible Manufacturing System

By Ranbir Singh, Rajender Singh & B.K. Khan
DCRUST Murthal, India

Abstract- Though flexible manufacturing systems have promised wide range of benefits but the implementation of FMS has fraught with difficulty as a result of which the implementation rate of FMS is much lower than has been expected. To bridge the gap efforts at global level are carried out widely in today's global and informative world. In the progress, modelling plays a vital role in the design, planning, implementation and operation of FMSs. Models are used widely to provide insight into how the FMS system and its components interact. With time new optimization problems arises in FMS, thus new modelling methods and techniques and updation of the existing needs to be developed time to time. Since the publication of the first articles on the planning problems of FMS's (Stecke Kathryn E. and Solberg James J., 1981)(Stecke, 1983b), much research has been devoted to the solution of these types of problems. The aim of this paper is to review the approaches to model FMS and the solution approaches. A review paper provides basis and direction for future research directions.

Keywords: flexible manufacturing system (fms), loading in fms, modelling of fms, mathematical modelling of fms, artificial intelligence in FMS.

GJRE-A Classification : FOR Code: 091399p

AREVIEWOFMODELLINGTECHNIQUESFORLOADINGPROBLEMSINFLEXIBLEMANUFACTURINGSYSTEM

Strictly as per the compliance and regulations of:

A Review of Modelling Techniques for Loading Problems in Flexible Manufacturing System

Ranbir Singh [α], Rajender Singh [σ] & B.K. Khan [ρ]

Abstract- Though flexible manufacturing systems have promised wide range of benefits but the implementation of FMS has fraught with difficulty as a result of which the implementation rate of FMS is much lower than has been expected. To bridge the gap efforts at global level are carried out widely in today's global and informative world. In the progress, modelling plays a vital role in the design, planning, implementation and operation of FMSs. Models are used widely to provide insight into how the FMS system and its components interact. With time new optimization problems arises in FMS, thus new modelling methods and techniques and updation of the existing needs to be developed time to time. Since the publication of the first articles on the planning problems of FMS's (Stecke Kathryn E. and Solberg James J., 1981)(Stecke, 1983b), much research has been devoted to the solution of these types of problems. The aim of this paper is to review the approaches to model FMS and the solution approaches. A review paper provides basis and direction for future research directions. The modelling approaches and techniques in the paper are classified into three categories; hierarchical approach, mathematical modelling and artificial approaches. The solution approaches used are discussed with the modelling approaches respectively. A majority of research paper modelled FMS's, production planning problems, loading problem of FMS as mathematical model. This paper provides insight of different modelling approaches proposed in the literature to tackle the FMS problems during the last few decades.

Keywords: flexible manufacturing system (fms), loading in fms, modelling of fms, mathematical modelling of fms, artificial intelligence in FMS.

I. Introduction

To satisfy rapidly changing global market and requirements of customer demand, systems needs to be designed to increase flexibility. Flexible manufacturing is the answer to the problem. FMS are as flexible as job shop and as efficient as production lines. Thus FMS are complex and combinational problem, where arises a wide range of problems with its exploration. Prior to start of manufacturing, production planning problems is one among them. FMS planning problems is to decide which cutting tools are to be placed in which tool magazine, to decide when and which part to be produced and in what quantity, how pooling of the machines and tools has to be done, number and types of fixtures and pallets required and available, number and type of cutting tools available and required, type of operations that can be performed etc. These decisions are to be made before the start of manufacturing. The scheduling problem needs next to be addressed. The five production planning problems mentioned by Kathryn E. Stecke (Stecke, 1983a, 1983b) needs to be solved before solving scheduling problem. Solution of production planning problem is the pre-requisite to solve the scheduling problem. Scheduling is the time table for the machines set up for prescribed production target. Production planning problem needs to be solved to reach the shop floor and scheduling need to be done for actual production to begun.

Depending on the type of the manufacturing problem objectives are defined for problem formulation and optimal solution. The type and number of objective function depends on the type and nature of a particular manufacturing system. One or more objective may be desirable at one or more stage of FMS life cycle, i.e. from FMS conception, design, to scheduling. For handling large number of objectives the weightage factor for each objective needs to be defined to solve the problem. Various modelling techniques for different objectives have been identified and different solution techniques were targeted in the literature.

II. Literature Review of Modelling for FMS Loading Problem

A model is a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. A model enables the analyst to predict the effect of changes to the system. A model should be a close approximation to the real system and should incorporate most of its salient features and, it should not be so complex to understand and experiment with. A good model is a judicious trade-off between realism and simplicity. Simulation practitioners recommends for increasing the complexity of a model iteratively. An important issue in modelling is model validity. According to Maria model validation techniques include simulating the model under known input conditions and comparing model output with system output (Maria, 1997). Mathematical programming models, Heuristic

Author α: Research Scholar, Deptt. of Mech. Engg., SonipatDCRUST Murthal, (Hry) Haryana. e-mail: ranbirsheorans@gmail.com
Author σ: Professor Deptt. of Mech. Engg, DCRUST Murthal Sonipat Sonipat (Hry). e-mail: rajender1958@yahoo.com
Author ρ: Director MSIT Jagdishpur Sonipat (Hry)

approaches, Queuing network models, Simulation models etc. have been utilized for modelling various types of complex problems of FMS's. Different modelling methods and approaches used for modelling FMS's, particularly the loading problem of FMS's have been identified and classified pearly reviewed as under.

a) Artificial Intelligence (AI)

AI covers techniques like fuzzy logic, neural networks, and immune algorithms. AI is potentially suitable for complex and ill-defined problem (Kempf, 1985)(Lu, 1986). Loading problems in FMS has been modelled with fuzzy *logic by* Vidyarthi and Tiwari *in 2001* (Vidyarthi & Tiwari, 2001)*,* Chan and Swarnkar *in 2006* (Chan & Swarnkar, 2006)*,* Petrovic and Akoz *in 2008* (Petrovic & Akoz, 2008) *and Rai et al. in 2012* (Rai, Kameshwaran, & Tiwari, 2002), with *neural and a fuzzy Petri net* by Kumar et al. in 2004 (R. R. Kumar, Singh, & Tiwari, 2004), with *artificial immune algorithm* by Prakash et al. in 2008 (Prakash, Khilwani, Tiwari, & Cohen, 2008) and with *artificial neural network* by Kant and Vaishya in 2013 (Kant & Vaishya, 2013).

The FMS problems modelled with AI techniques have been solved with application of *fuzzy-logic* by Vidyarthi and Tiwari in 2001 (Vidyarthi & Tiwari, 2001), Kumar et al. in 2004 (R. R. Kumar et al., 2004) and Petrovic and Akoz in 2008 (Petrovic & Akoz, 2008), with application of *GA by Rai et al. in 2002* (Rai et al., 2002), with application of *Ant Colony Optimization (ACO*) by Chan and Swarnkar in 2006 (Chan & Swarnkar, 2006), with application of *Artificial Immune Algorithm* by Prakash et al. in 2008 (Prakash et al., 2008) and with application of *Artificial Neural Network (ANN) by* Kant and Vaishya *in 2013* (Kant & Vaishya, 2013).

b) Branch and Backtrack Approach

Branch and backtrack and Heuristic procedure for modelling the loading problem has been used by Shankar and Srinivasulu in 1989 (Shankar & Srinivasulu, 1989).

c) Branch and Bound Approach

The method was first described by Land and Doig in 1960 (Land & Doig, 1960). Branch and bound algorithm works by enumerating possible combinations of the variables in a branch and bound tree. A few integer variables are fixed to have zero or one value and others are allowed to have any value in the range between zero and one. The root of the tree is the original problem. A leaf node is selected from the tree and the algorithm is solved. In each iteration the descendents of feasible solutions are selected for further branching, and descendents of infeasible solutions are ignored.

Branch and bound approach for formulation of loading problem of FMS has been discussed by Kim and Yano in 1987 and 1989 (Y.-D. Kim & Yano, 1987)(Y.-D. Kim & Yano, 1989). The loading problem formulated by branch and bond methods has been solved with application of *branch and bound approach* by Kim and Yano in 1987 and 1989 (Y.-D. Kim & Yano, 1987)(Y.-D. Kim & Yano, 1989).

d) Heuristic Approaches

Heuristics was the name of a certain branch of study, not very clearly circumscribed, belonging to logic, or to philosophy or to psychology often outlined, seldom presented in detail.

The aim of heuristic is to study the methods and rules of discovery and invention. A few traces of such study may be found in the commentators of Euclid; a passage of Pappus is particularly interesting in this respect. The most famous attempts to build up a system of heuristic are due to Descartes and to Leibnitz, both great mathematicians and philosophers. Bernard Bolzano presented a notable detailed account of heuristic. The present booklet is an attempt to revive heuristic in a modern and modest form. Heuristic reasoning is reasoning not regarded as final and strict but as provisional and plausible only, whose purpose is to discover the solution of the present problem. We shall attain complete certainty when we shall have obtained the complete solution, but before obtaining certainty we must often be satisfied with a more or less plausible guess. We may need the provisional before we attain the final. We need heuristic reasoning when we construct a strict proof as we need scaffolding when we erect a building.

Heuristic reasoning is often based on induction, or on analogy. Provisional, merely plausible heuristic reasoning is important in discovering the solution, but you should not take it for a proof; you must guess, but also examine your guess (Polya, 1945).

Heuristic is a program, rule, piece of knowledge, etc., which one is not entirely confident to be useful in providing a practical solution, but has reason to believe to be useful, and which is added to a problem-solving system in expectation that an average the performance will improve (Romanycia & Pelletier, 1985).

Heuristics are defined as the set of rules that provides optimal or non-optimal solution to the problem with less computational work (Greene & Sadowski, 1986). For different manufacturing enterprises a wide range of heuristics procedures have been developed. *Heuristics* for FMS in 1987 ((Werra, 1987), **and** Petri net modelling combined with *heuristic* for FMS in 1994 (D. Y. Lee & DiCesare, 1994) has been developed. Heuristic model for the FMS capacity planning problem was presented in 1989 (Mazzola, 1989).

The loading problems of FMS has been modelled with simple heuristics *by* Stecke and Talbot *in 1983*(Stecke & Talbot, 1983)*,* Stecke and Talbot (Stecke & Talbot, 1985), Ammons et al. (Ammons, Lofgren, & McGinnis, 1985) and, Shankar and Tzen (Shankar & Tzen, 1985) in *1985,* Rajagopalan in 198*6*(Rajagopalan, 1986), *Kim and Yano in 1987* (Kim Yeong-Dae and Yano Candace A., 1987), Tang *and* Denardo in *1988* (Tang & Denardo, 1988), Shankar *and* Srinivasulu *in 1989* (Shankar & Srinivasulu, 1989), *Kim and Yano in 1991* (Y. D. Kim & Yano, 1991), Mukhopadhyay et al. in 1992 (Mukhopadhyay, Midha, & Murlikrishna, 1992), Oba and Hashimot in *1993* (Kato, Oba, & Hashimot, 1993), *Roh and Kim* (Roh H.-K. and Kim Yeon-D., 1997) and, Hsu and De-Matta (Hsu & De-Matta, 1997) in 1997, Farkas et al. in *1999* (Farkas, Koltai, & Stecke, 1999), Rahimifard and Newman (Rahimifard & Newman, 2000) *and,* Tiwari and Vidyarthi (M. K. Tiwari & Vidyarthi, 2000) in *2000,* Tiwari *et al. in 2007* (M K Tiwari, Saha, & Mukhopadhyay, 2007) *and,* Biswas *and* Mahapatra *in 2009* (Biswas & Mahapatra, 2009); sequential *heuristic* by Shankar and Tzen in 1985 (Shankar & Tzen, 1985); and branch and backtrack with *heuristics by* Shankar and Srinivasulu in 1989 (Shankar & Srinivasulu, 1989).

The solution to the heuristics modelled loading problems were discussed with application of heuristics by Stecke and Talbot *in 1983*(Stecke & Talbot, 1983), *Kim and Yano in 1987* (Y.-D. Kim & Yano, 1987), Shankar and Srinivasulu in 1989 (Shankar & Srinivasulu, 1989), Mukhopadhyay et al. in 1992 (Mukhopadhyay et al., 1992), Hsu and De-Matta (Hsu & De-Matta, 1997) and, Roh and Kim (Roh H.-K. and Kim Yeon-D., 1997) in 1997, Farkas et al. in 1999 (Farkas et al., 1999) and, Rahimifard and Newman in 2000 (Rahimifard & Newman, 2000); with application of *branch & bound, and branch & backtrack method* by Kato et al. in 1993 (Kato et al., 1993); with application of *GA by Tiwari and Vidyarthi in 2000* (M. K. Tiwari & Vidyarthi, 2000) *and Tiwari in 2007* (M K Tiwari et al., 2007); with application of *meta hybrid PSO* by Biswas & Mahapatra in 2009 (Biswas & Mahapatra, 2009); and software *simulation by* Shankar & Tzen *in 1985* (Shankar & Tzen, 1985).

e) Hierarchical Model

Hierarchy modelling method is amongst the oldest modelling methods, dating from 1960's. This method processes data efficiently at faster rate but it is less flexible for optimization. The system is classified according to its hierarchy and its network tree is formulated. All links from one to many networks, from parent to child are specified. The system at higher level is parent to its lower level hierarchy.

Modelling of FMS by Buzacott and Shanthikumar in 1980 (Buzacott & Shanthikumar, 1980), modelling of automated manufacturing system by Simpson et al. in 1982 (Simpson, Hocken, & Albus, 1982) and modelling of loading and some other FMS problems by Bell and Bilalis in 1982 (Bell & Bilalis, 1982), Eversheim and Fromm in 1983 (Eversheim & Fromm, 1983) , Stecke in 1983a (Stecke, 1983a) and 1983b (Stecke, 1983b), CAM-I in 1984 (CAM-I, 1984), O'Grady et al. in 1987 (O'Grady, Bao, & Lee, 1987) and O'Grady in 1987 (O'Grady, 1987) has been carried out using hierarchical approach. A hierarchical model for integration of FMS production planning into a closed-loop material requirements planning (MRP) environment was proposed by Mazzola in 1989 (Mazzola, 1989).

f) Markov Chains

A Markov chain is a model consisting of a group of states and specified transitions between the states. A Markov chain can have a finite or infinite number of states. In a discrete time Markov chain (DTMC) each state change takes place at a fixed decision point and the time between changes is constant. In a continuous time Markov chain (CTMC), changes can happen at any instant. Transitions in a Markov chain depend on only the current state, and not on any history of previous states.

Markov chains have been used to model FMS by Vishwanadham et al. in 1992 (Vishwanadham, Narahari, & Johnson, 1992) and loading problems of FMS by Aldaihani and Savsar in 2005 (Aldaihani & Savsar, 2005).

g) Mathematical Modelling

Mathematics has been the language of science. Mathematics is used to solve many real-world problems of industry, physical sciences, economics, social and human sciences, engineering and technology (Stecke, 2005a). A mathematical model can be deterministic (input and output variables are fixed values) or stochastic (at least one of the input or output variables is probabilistic); static (time is not taken into account) or dynamic (time-varying interactions among variables are taken into account). In a mathematical model usually, some of the decision variables are restricted to integer values and some are continuous. Usually the optimization problems are formulated with zero-ones to encode choices from a small set of available options to a decision, usually in binary form of zero and one. Use of mathematics and simple mathematical models to solve problems in industry were discussed in detail by Stecke in 2005 (Stecke, 2005b). Mathematical programming models have been applied widely to solve the production planning problems. Mathematical programming requires high degree of accuracy and the solution approach requires efficient computational help. Integer programming (IP), mixed integer programming (MIP) and linear integer programming (LIP) has been widely utilized for mathematical modelling.

Stecke applied 0-1 nonlinear MIP for formulation of mathematical model of grouping and loading problems during 1981-83 (Stecke, 1981)(Stecke, 1982)(Stecke, 1983b) and mathematical program for FMS in 1983 (Stecke, 1983b). 0-1 nonlinear MIP formulation of the manufacturing systems was utilized in 1984 by Chatterjee et al. (Chatterjee, Cohen, Maxwell, & Miller, 1984). MIP formulation of the routing mix problem was carried out by Chatterjee et al. in 1984 (Chatterjee et al., 1984). Ammons et al. formulated IP model of loading problems in assembly lines in 1985 (Ammons et al., 1985) and Hwang developed IP model of FMS problems in 1986 (Hwang, 1986). Equivalent IP formulation for the process planning problem of FMS was carried out by Kusiak and Finke in 1988 (Kusiak & Finke, 1988).

Kimemia in 1982 (Kimemia, 1982) and Kimemia and Gershwin in 1983 (Kimemia & Gershwin, 1983) used dynamic programming; Kimemia in 1982 (Kimemia, 1982), Kusiak in 1983 (Kusiak, 1983), Lee et al. in 1997 (D.-H. Lee, Lira, Lee, Jun, & Kim, 1997) and Kim et al. in 2012 (H. Kim et al., 2012) utilized LIP formulation; Stecke in 1983 and 1986 (Stecke, 1983b)(Stecke, 1986) discussed non-linear IP formulation; Wilson in 1992 (Wilson J. M., 1992), Lee and Kim in 1998 (D.-H. Lee & Kim, 1998), Sawik in 2000 (Sawik, 2000) and Dobson and Nambimadom in 2001 (Dobson & Nambimadom, 2001) adopted IP formulation; Taboun & Ulger in 1992 (Taboun & Ulger, 1992), Swarnkar & Tiwari in 2004 (Swarnkar & Tiwari, 2004) and Sujono & Lashkari in 2007 (Sujono & Lashkari, 2007) utilized 0–1 IP formulation; and Jahromi & Tavakkoli-Moghaddam in 2012 (Jahromi & Tavakkoli-Moghaddam, 2012) discussed 0-1 LIP formulation for modelling the loading problems of FMS.

Sarin and Chen in 1987 (Sarin & Chen, 1987), Rajamani and Adil in 1996 (Rajamani & Adil, 1996), Ozdamarl and Barbarosoglu in 1999 (Ozdamarl & Barbarosoglu, 1999), Chen and Ho in 2005 (Chen & Ho, 2005), Nagarjuna et al. in 2006 (Nagarjuna, Mahesh, & Rajagopal, 2006), Goswami and Tiwari in 2006 (Goswami & Tiwari, 2006), Kumar et al. in 2006 (A. Kumar, Prakash, Tiwari, Shankar, & Baveja, 2006), Biswas and Mahapatra in 2007 (Biswas & Mahapatra, 2007) and 2008(Biswas & Mahapatra, 2008), Ponnambalam and Kiat in 2008 (Ponnambalam & Kiat, 2008), Yogeswaran et al. in 2009(Yogeswaran, Ponnambalam, & Tiwari, 2009), Yusof et al. in 2011 (Yusof, Budiarto, & Deris, 2011), Mgwatu in 2011 (Mgwatu, 2011), Yusof et al. in 2011 (Yusof, Budiarto, & Venkat, 2011), Kumar et al. 2012 (V. M. Kumar, Murthy, & Chandrashekara, 2012), Yaqoub and Abdulghafour in 2012 (Yaqoub & Abdulghafour, 2012), Yusof et al. in 2012 (Yusof, Budiarto, & Deris, 2012) and Mahmudy et al. in 2012 (Mahmudy, Marian, & Luong, 2012) utilized mathematical modelling for loading problems of FMS.

Mathematical programming for loading problems of FMS is discussed by Kiran and Tansel in 1985 (A. S. Kiran & Tansel, 1985), Kiran in 1986 (S. Kiran, 1986), Nayak and Acharya in 1998 (Nayak & Acharya, 1998), Turkcan et al. in 2007 (Turkcan, Akturk, & Storer, 2007), Ozpeynirci and Azizoglu in 2010 (Ozpeynirci & Azizoglu, 2010), Mandal et al. in 2010 (Mandal, Pandey, & Tiwari, 2010)and Kosucuoglu and Bilge in 2012 (Kosucuoglu & Bilge, 2012).

Abazari et al. in 2012 (Abazari, Solimanpur, & Sattari, 2012) discussed linear mathematical programming for the loading problems.

MIP is utilized by Greene and Sadowski in 1986 (Greene & Sadowski, 1986), Liang and Dutt in 1990 (Liang & Dutt, 1990), Henery et al. in 1990 (Henery C. Co, Biermann, & Chen, 1990), Guerrero in 1999 (Guerrero, 1999), Lee and Kim in 2000 (D.-H. Lee & Kim, 2000) Kumar and Shanker in 2000 (N. Kumar & Shanker, 2000), Kumar and Shanker in 2001 (N. Kumar & Shanker, 2001), Yang and Wu in 2002 (Yang & Wu, 2002), Tadeusz in 2004 (Tadeusz, 2004), Bilgin and Azizoglu in 2006 (Bilgin & Azizoglu, 2006), Murat and Erol in 2012 (Murat & Erol, 2012) and Yusof et al. in 2012 (Yusof et al., 2012) for loading problems of FMS.

0-1 Linear MIP is utilized by Chakravarty and Schtub in 1984 (Chakravarty & Schtub, 1984), Co in 1984 (H. C. Co, 1984), Ammons et al. in 1985 (Ammons et al., 1985), Shankar and Tzen 1985 (Shankar & Tzen, 1985), Greene and Sadowski in 1986 (Greene & Sadowski, 1986) and Sarin and Chen in 1987 (Sarin & Chen, 1987); nonlinear MIP by Berrada and Stecke in 1986 (Berrada & Stecke, 1986)and Stecke and Brian in 1995(Stecke & Brian, 1995); linear MIP by Ventura et al. in 1988 (Ventura, Frank, & Leonard, 1988); and 0–1 MIP by Gamila and Motavalli in 2003 (Gamila & Motavalli, 2003) and Chan et al. in 2004 (Chan, Swamkar, & Tiwari, 2004) for loading problems of FMS.

Nonlinear and integer constraint was utilized by Kouvelis & Lee in 1991 (Kouvelis & Lee, 1991), non linear goal programming model by Kumar et. al. in 1991 (P. Kumar, Singh, & Tewari, 1991) and goal programming model by Atmaca & Erol in 2000 (Atmaca & Erol, 2000) for modelling loading problem of FMS were observed in the literature.

The mathematical formulated problems have been solved with application of *branch and bound algorithm* by Berrada and Stecke in 1986 (Berrada & Stecke, 1986); with application of *linearization methods by Stecke in 1981* (Stecke, 1981) *and 1983* (Stecke, 1983b), *and* Jahromi and Tavakkoli *in 2012* (Jahromi & Tavakkoli-Moghaddam, 2012); with application of *lagrangian approach* by Kinemia and Gershwin in 1985 (Kinemia & Gershwin, 1985), Sarin and Chen in 1987 (Sarin & Chen, 1987), Bilgin and Azizoglu in 2006 (Bilgin & Azizoglu, 2006) and Ozpeynirci and Azizoglu in 2010 (Ozpeynirci & Azizoglu, 2010); with application of *min-max approach* by Kumar et al. in 1987 (Kumar P., Singh N., & Tewari N. K., 1987); with application of *heuristics* by Ventura et al. in 1988 (Ventura et al., 1988), Stecke and Brian in 1995 (Stecke & Brian, 1995), Nayak and Acharya in 1998 (Nayak & Acharya, 1998), Lee and Kim in 2000 (D.-H. Lee & Kim, 2000), Dobson and Nambimadom in 2001 (Dobson & Nambimadom, 2001), Nagarjuna et al. and, (Nagarjuna et al., 2006) Goswami and Tiwari (Goswami & Tiwari, 2006) in 2006, and Kim et al. in 2012 (H. Kim et al., 2012).

The loading problem has been solved with application of *genetic algorithm (GA)* by Ozdamarl and Barbarosoglu in 1999 (Ozdamarl & Barbarosoglu, 1999), Kumar and Shanker (N. Kumar & Shanker, 2000) and Sawik (Sawik, 2000) in 2000, Yang and Wu in 2002 (Yang & Wu, 2002), Kumar et al. in 2006 (A. Kumar et al., 2006), Mandal et al. in 2010 (Mandal et al., 2010), and Yusof et al. (Yusof et al., 2012), Kosucuoglu and Bilge (Kosucuoglu & Bilge, 2012), and Abazari et al. (Abazari et al., 2012) in 2012; with application of *simulated annealing (SA) by* Ozdamarl and Barbarosoglu *in 1999* (Ozdamarl & Barbarosoglu, 1999), Chan et al. (Chan et al., 2004) *and* Tadeusz (Tadeusz, 2004) *in 2004, and* Mandal et al*. in 2010* (Mandal et al., 2010); *with application of particle swarm optimization (PSO)* by Biswas and Mahapatra in 2007 (Biswas & Mahapatra, 2007) and 2008 (Biswas & Mahapatra, 2008) and, Ponnambalam and Kiat in 2008 (Ponnambalam & Kiat, 2008); with application of *Harmony Search algorithm (HS)* by Yusof in 2011 (Yusof, Budiarto, & Deris, 2011); with application of *box complex method* by Kumar et al. in 1991 (P. Kumar et al., 1991); with application of *approximation technique* by Wilson in 1992 (Wilson J. M., 1992); and with application of *iterative algorithms* by Lee et al. in 1997 (D.-H. Lee et al., 1997) and Lee and Kim in 1998 (D.-H. Lee & Kim, 1998).

The loading problem of FMS has also been solved by techniques like *TS–SA hybrid algorithm* by Swarnkar and Tiwari in 2004 (Swarnkar & Tiwari, 2004), *GA-SA Hybrid algorithm* by Yogeswaran et al. in 2009 (Yogeswaran et al., 2009), *GA-HS hybrid algorithm* by Yusof et al. in 2011 (Yusof, Budiarto, & Venkat, 2011), *GA-PSO hybrid heuristic algorithm* by Kumar et al. in 2012 (V. M. Kumar et al., 2012), *TS-SA hybrid algorithm* by Murat & Erol in 2012 (Murat & Erol, 2012), *constraint method* by Sujono and Lashkari in 2007 (Sujono & Lashkari, 2007), *Sequential and simultaneous approaches* by Turkcan et al. in 2007 (Turkcan et al., 2007) and *artificial immune system (AIS)* by Mandal et al. in 2010 (Mandal et al., 2010).

h) Multi-Criterion Programming

The loading problem of FMS has been formulated with *multi-criterion programming* model by Kumar et al. in 1987 (Kumar P. et al., 1987).

i) Network Modelling

Network modelling has a wide range of applications. The manufacturing processes have also been be modelled as queueing networks, both as open or close networks. QN models are built in an aggregate way thus the models work well at the higher and more aggregate levels of a hierarchy of planning (Buzacott & Shanthikumar, 1980). Because of dynamic operations at lower levels, QN models are quite impractical at lower level of hierarchy. Also the specific distributions may not accurately reflect the true operating characteristics of the particular FMS. The queueing network modelling can be closed (CQN) and open (OQN) type. The difference between CQN and OQN is that CQN contains fixed number of parts with no external arrivals or departures. For analysis of the queueing network model Buzen's algorithm and mean value analysis were widely used.

FMS has been modelled with CQN by Solberg in 1977 (Solberg, 1977), 1979 (Solberg, 1979) and 1980 (Solberg, 1980) and Vinod and Sabbagh in 1986 (Vinod & Sabbagh, 1986), with *OQN by* Shanthikumar & Stecke *in 1984* (Shanthikumar & Stecke, 1984), with *CANQ by* Stecke and Solberg (Stecke & Solberg, 1985) and Stecke and Morin (Stecke & Morin, 1985) *in 1985 and* Afentakis *in 1989* (Afentakis, 1989).

FMS has also been modelled with advanced CQN by Seidmann et al. in 1987 (Seidmann, Schweitzer, & Shalev-oren, 1987), *with discrete generalized network by* Ram *et al. in 1990* (Ram, Sarin, & Chen, 1990) and with *queueing networks* by Narahari et al. in 1990 (Narahari, Viswanadham, Meenakshisundaram, & Rao, 1990) and Vishwanadham et al. in 1992 (Vishwanadham et al., 1992). *Queueing model* has been developed for the performance prediction of FMS's by Jain et al. in 2008 (Jain, Maheshwari, & Baghel, 2008). Modelling of the loading problems of FMS with single server *CQN model* by Stecke and Morin in 1984 (Stecke & Morin, 1984), *CQN* model by Stecke and Kim in 1987 (Stecke & Kim, 1987) and *constrained network model by* Bretthauer and Venkataramanan in 1990 (Bretthauer & Venkataramanan, 1990) were developed.

Solution of the network modelled FMS problems has been achieved by *surrogate and Lagrangian relaxation* by Bretthauer and Venkataramanan in 1990 (Bretthauer & Venkataramanan, 1990). Mean value analysis (MVA) has a wide suitability for solving the network models. MVA is an iterative technique that avoids numerical instabilities, developed by Reiser and Lavenberg in 1978-80 as an efficient solution technique for queueing network models, to overcome the numerical problems raised with the convolution algorithms (Reiser & Lavenberg, 1978)(Reiser & Lavenberg, 1980). MVA is based on applications of Little's theorem (Little, 1961). The application of Mean-value analysis of queues (MVAQ) for FMS modelling has been discussed by Suri and Hildebrant in 1984 (Suri & Hildebrant, 1984).

j) Perturbation Approach

Perturbation for modelling the loading problems of FMS has been used by Mukhopadhyay et al. in 1998 (Mukhopadhyay, Singh, & Srivastava, 1998).

Perturbation modelled FMS loading problem has been solved with application of SA in by Mukhopadhyay et al. 1998 (Mukhopadhyay et al., 1998).

k) Petri Nets

A Petri net has its origin from the dissertation of Carl Adam Petri, submitted in 1962 (Petri, 1962), to the faculty of Mathematics and Physics at the Technical University of Darmastadt, West Germany. The English translation of the report is also available in 1966 (Petri, 1966).

Petri nets are graphical and mathematical modelling tool used to model physical systems. Because of its graphic nature Petri nets are used as visual communication tool similar to flow charts, networks and block diagrams. It is possible to set up state equations, algebraic equations and other governing equations because of its mathematical nature.

FMS has been modelled with *timed Petri nets by* Cohen et al. *in 1983* (Cohen et al., 1983), with *Petri nets* by Narahari and Viswanadham in 1985 (Narahari & Viswanadham, 1985), with generalized *stochastic Petri nets* (GSPN) by Narahari et al. in 1990 (Narahari et al., 1990), with *stochastic Petri nets by* Vishwanadham et al. *in 1992* (Vishwanadham et al., 1992), with *Petri net* combined with heuristic by Lee and DiCesare in 1994 (D. Y. Lee & DiCesare, 1994), with *fuzzy coloured Petri nets* (CPNs) by Yeung et al. in 1996 (Yeung, Liu, Shiu, & Fung, 1996), with *colored Petri net* (CPN) based hierarchical model by Al-Titinchi and Al-Aubidy in 2004 (Al-Titinchi & Al-Aubidy, 2004). *Petri net* modelling has been used for loading problems of FMS by Tiwari et al. in 1997 (Tiwari M. K., Hazarika B., Vidyarthi N.K., 1997). Solution of the loading problem modelled using Petri nets has been done using *heuristics by Tiwari et al. in 1997* (Tiwari M. K., Hazarika B., Vidyarthi N.K., 1997).

l) Sequential Approach

The loading problem of FMS has been modelled with two-stage *sequential approach* by Liang in 1994 (Liang, 1993) and Ming in 1994 (Ming, 1994), and *sequential approach by* Liang and Dutta *in 2009* (Liang & Dutta, 2009).

The sequential modelled FMS problems have been solved with application of *Lagrangian relaxation* approach by Liang and Dutta in 2009 (Liang & Dutta, 2009).

m) Simulation Models

Simulation is a descriptive modelling technique through computer based programmes for analysis of the problems and solutions. FMS problems are very complex in nature, so simulation models are widely used to solve FMS problems because of its descriptive nature. Cost and computational time increases with increase in complexity of the problems.

A virtual manufacturing system mode has been developed for flexible manufacturing cells using object-oriented paradigm, and implemented with QUEST/IGRIP software by Kim and Choi in 2000 (S. Kim & Choi, 2000). Computer simulation package Simfactory II.5 has been used for modelling loading problem of FMS by Gupta in 1999 (Gupta, 1999).

n) Unit Operation Approach

Unit operation has been used to model Block Angular Structures of loading problems by Kouvelis and Lee in 1991(Kouvelis & Lee, 1991).

Table 1: Distribution density of FMS modelling methods

	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
1																									√	√		√		√		√					√
2													√																								
3											√		√																								
4							√		√	√	√	√	√		√	√	√	√			√		√	√							√		√				
5						√	√	√			√		√																								
6																√													√								
7					√	√	√	√	√	√	√	√		√	√	√			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	
8											√																										
9	√		√	√				√	√	√	√		√	√		√																√					
10																						√															
11							√		√					√		√				√	√							√									
12																	√	√															√				
13																							√	√													
14															√																						

Notations used in table 1

1. Artificial Intelligence
2. Branch and Backtrack Approach
3. Branch and Bound Approach
4. Heuristic Approaches
5. Hierarchical Model
6. Markov Chains
7. Mathematical Modelling
8. Multi-Criterion Programming
9. Network Modelling
10. Perturbation Approach

11. Petri Nets
12. Sequential Approach
13. Simulation Models
14. Unit Operation Approach

Figure 1: Modelling methods for the loading problems of FMS (1981-2013)

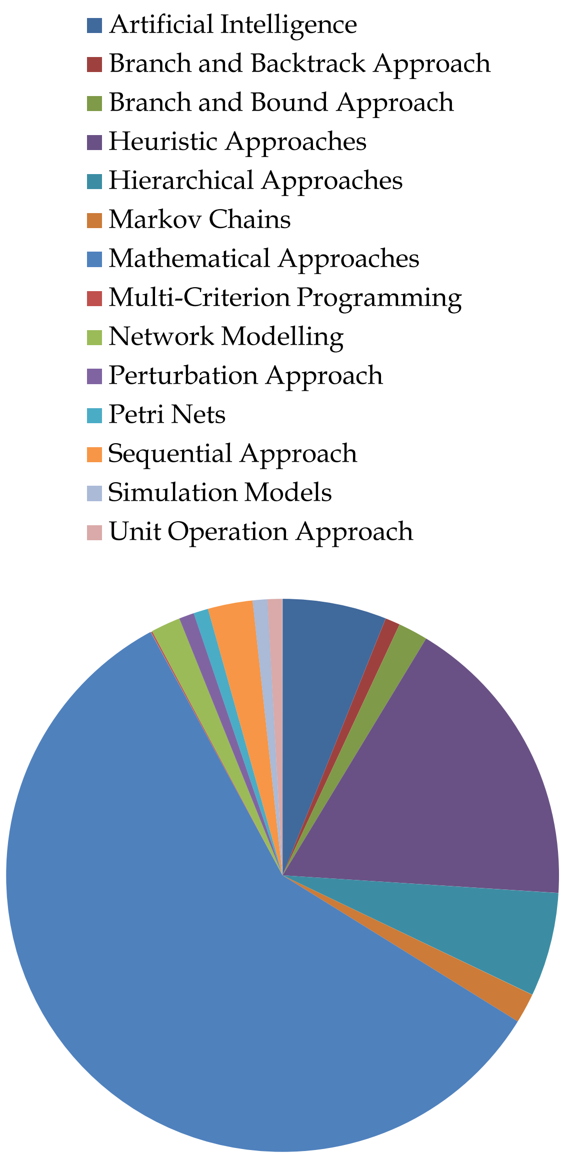
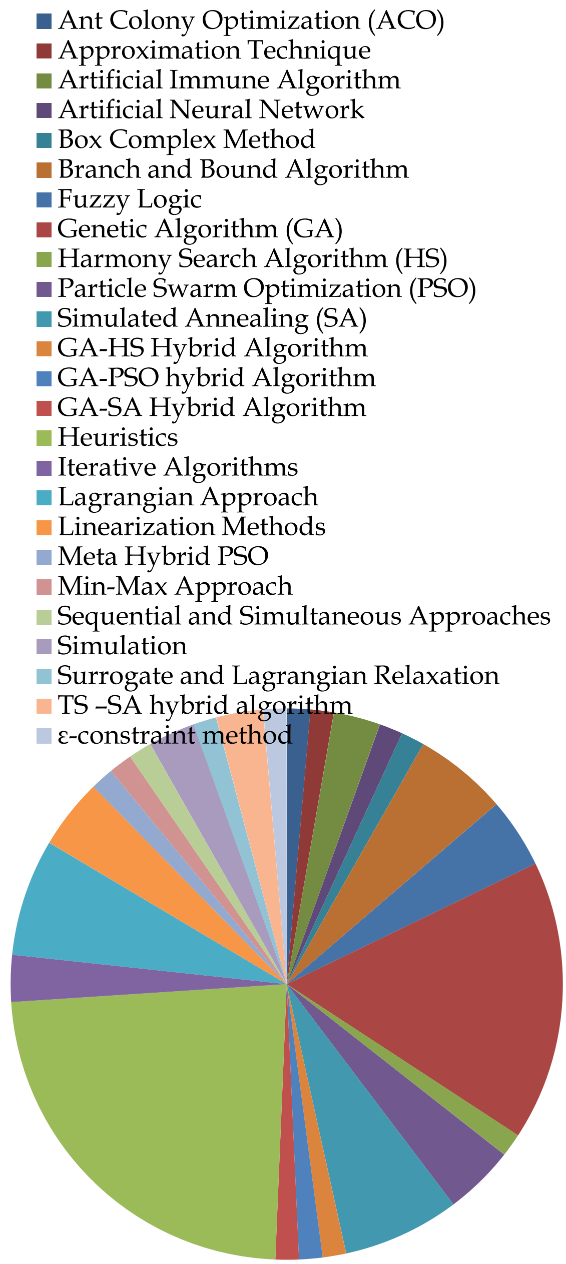
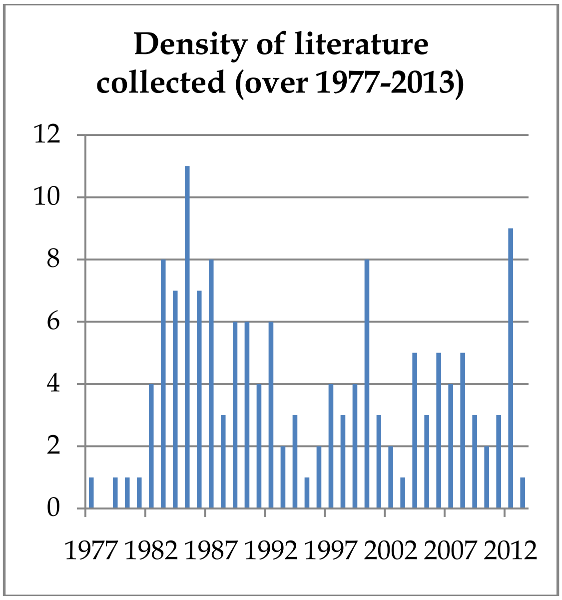


Figure 2 : Solution methodologies for loading problems of FMS





Accuracy, results acceptability and adaptability, computational time and cost are the major factors for selection of the type of modelling for a particular application, particularly loading problems of FMS.

III. Conclusion

Hierarchical modelling, mathematical modelling, heuristic approaches, network modelling, simulation techniques, artificial intelligence (fuzzy logic, artificial immune algorithms and artificial neural network), Petri nets, Markov chains, branch and bound approach, multi-criterion programming model, branch and backtrack approach, sequential approach, unit operation approach and perturbation approach have been discussed in the literature for modelling loading problems of FMS's. Mathematical, heuristics, hierarchical approaches and network modelling are the widely used and accepted ones. Moreover the global optimization techniques have been widely used for solving the formulated problems.

Solution of the mathematical models have been approached by branch and backtrack method, branch and bound algorithm, ant colony optimization (ACO), genetic algorithm (GA), harmony search algorithm (HS), simulated annealing (SA), particle swarm optimization (PSO), approximation technique, artificial immune algorithm, artificial neural network (ANN), box complex method, computer simulation package simfactory II.5, fuzzy-based solution methodology, GA-HS hybrid algorithm, GA-PSO hybrid heuristic technique, GA-SA hybrid algorithm, heuristic algorithms, meta hybrid PSO, min-max approach, sequential and simultaneous approaches, simulation, surrogate and lagrangian approaches, TS-SA hybrid algorithm and ε-constraint method.

Heuristics solutions do not assure optimal solution (Manoj Kumar Tiwari, Kumar, Kumar, Prakash, & Shankar, 2006), GA-based heuristics for the loading problem lead to constraint violations and large number of generations (A. Kumar et al., 2006) and PSO avoids premature convergence (Biswas & Mahapatra, 2007). Because of less computational requirements, easy and fast convergence, better ease of apply, less time requirements are some of the factors attracting the researchers to use global optimization techniques for solving the mathematical or other model of the loading problems and other problems and FMS's. The authors after spending a lot of time on analysing and studying the research papers, books, Ph.D. thesis and other relevant materials suggests integer programming for modelling the loading problems and PSO for solution of the model.

To analyse the system performance and to provide insight of how the system behaves, and how system component behaves, and to identify the key factors and parameters affecting the system, modelling and simulation of the physical system is the only best solution. Various types of results, graphs, plots etc can be generated for useful analysis of the system. The key to be remembered is that the validity and accuracy of the result will depend on the model developed, and the information induced in the model (value of parameters and key variables). It is the human who developed the model and it is him only to validate and validate the results. The software or model will give the results in the type the user wants. Validation, accuracy and acceptance of the results depend on the user. The modelling simulation and analysis can be expensive and time consuming to develop and run for desired accurate and acceptable results and outputs. An ideal model should be least expensive which should require least computational time. A research work is required to compare the various modelling techniques on basis of certain parameters, which will help the industry and academicians in selection of the type of modelling techniques under certain parameters and constraints. The authors are working on this research.

References Références Referencias

1. Abazari, A. M., Solimanpur, M., & Sattari, H. (2012). Optimum loading of machines in a flexible manufacturing system using a mixed-integer linear mathematical programming model and genetic algorithm. Computers & Industrial Engineering, 62(2), 469–478. doi:10.1016/j.cie.2011.10.013
2. Afentakis, P. (1989). A loop layout design problem for flexible manufacturing systems. International Journal of Flexible Manufacturing Systems, 1, 175–196.
3. Aldaihani, M. M., & Savsar, M. (2005). A stochastic model for the analysis of a two-machine flexible manufacturing cell. Computers & Industrial Engineering, 49, 600–610. doi:10.1016/j.cie. 2005.09.002

4. Al Titinchi, A. A., & Al Aubidy, K. M. (2004). Modeling and analysis of an on-line FMS scheduler using colored Petri mets. International Journal of Computing & Information Sciences, 2(2), 74–83.
5. Ammons, J. C., Lofgren, C. B., & McGinnis, L. F. (1985). A large scale machine loading problem in flexible assembly. Annals of Operations Research, 3, 319 – 332.
6. Atmaca, E., & Erol, S. (2000). Goal programming model for loading and routing problems in flexible manufacturing systems. ICMIT 2000 (IEEE), 843–847.
7. Bell, R., & Bilalis, N. (1982). Loading and control strategies for an FMS for rotational parts. In 1st International Conference on Flexible Manufacturing Systems. Brighton.
8. Berrada, M., & Stecke, K. E. (1986). A branch and bound approach for machine load balancing in Flexible Manufacturing Systems. Management Science, 32(10), 1316–1335.
9. Bilgin, S., & Azizoglu, M. (2006). Capacity and tool allocation problem in flexible manufacturing systems. Journal of the Operational Research Society, 57(6), 670–681. doi:: 10. 1057/palgrave.jors.260203
10. Biswas, S., & Mahapatra, S. S. (2007). Machine Loading in Flexible Manufacturing System : A Swarm Optimization Approach. In Eighth International Conference on Operations & Quant. Management (October 17-20, 2007) (pp. 621–628).
11. Biswas, S., & Mahapatra, S. S. (2008). Modified particle swarm optimization for solving machine-loading problems in flexible manufacturing systems. International Journal of Advanced Manufacturing Technology, 39, 931–942. doi:10.1007/s00170-007-1284-5
12. Biswas, S., & Mahapatra, S. S. (2009). Modified particle swarm optimization for solving machine-loading problems in flexible manufacturing systems. International Journal of Advanced Manufacturing Technology, 39(9-10), 931.
13. Bretthauer, K. M., & Venkataramanan, M. A. (1990). Machine loading and alternate routing in a flexible manufacturing system. Computers and Industrial Engineering, 18(3), 341–350.
14. Buzacott, J. A., & Shanthikumar, J. G. (1980). Models for understanding flexible manufacturing systems. Am. Institute of Industrial Engineering Trans., 3, 259–264.
15. CAM-I, I. (1984). Conceptual information model for an advanced factory management system (No. CAM-I Report R-84-FM-03.1 (August 1984)).
16. Chakravarty, A. K., & Schtub, A. (1984). Selecting parts and loading FMS. In 1. Proceedings of the First ORSA/TIMS Conference on FMS. Ann Arbor.
17. Chan, F. T. S., Swamkar, R., & Tiwari, M. K. (2004). A random search approach to the machine loading problem of an FMS. In Proceedings of the 2004 IEEE, International Symposium on Intelligent Control (pp. 96–101). Taipei, Taiwan, September 2-4,2004.
18. Chan, F. T. S., & Swarnkar, R. (2006). Ant colony optimization approach to a fuzzy goal programming model for a machine tool selection and operation allocation problem in an FMS. Robotics and Computer-Integrated Manufacturing, 22, 353–362. doi:10.1016/j.rcim.2005.08.001
19. Chatterjee, A., Cohen, M. A., Maxwell, W. L., & Miller, L. W. (1984). Manufacturing flexibility: models and measurements. In Proceedings of the First ORSA/TIMS, Special Interest Conference on Flexible Manufacturing Systems. Ann Arbor.
20. Chen, J., & Ho, S. (2005). A novel approach to production planning of flexible manufacturing systems using an efficient multi-objective genetic algorithm. International Journal of Machine Tools & Manufacture, 45, 949–957. doi:10.1016/j.ijmachtools.2004.10.010
21. Co, H. C. (1984). Design and implementation of FMS. Virginia Polytechnic Institute and State University.
22. Co, H. C., Biermann, J. S., & Chen, S. K. (1990). A methodical approach to the flexible manufacturing system batching, loading and tool configuration problems. International Journal of Production Research, 28(12), 2171–2186. doi:10.1080 /00207549008942860
23. Cohen, Guy, Dubois, Didier, Quadrat, J. P., & Viot, M. (1983). A linear system theoretic view of discrete event system. In Proceedings of the 22nd IEEE conference on Decision and Control. San Antonio TX (December 14-16).
24. Dobson, G., & Nambimadom, R. S. (2001). The batch loading and scheduling problem. Operations Research, 49(1), 52–65.
25. Eversheim, W., & Fromm, W. (1983). Production control in highly automated manufacturing systems. In Proceedings of AUTOFACT-Europe (pp. 3.1–3.13). Geneva.
26. Farkas, A., Koltai, T., & Stecke, K. E. (1999). Workload Balancing Using the Concept of Operation Types. doi:10.2139/ssrn.160288
27. Gamila, M. A., & Motavalli, S. (2003). A modeling technique for loading and scheduling problems in FMS. Robotics and Computer Integrated Manufacturing, 19, 45–54.
28. Goswami, M., & Tiwari, M. K. (2006). A reallocation-based heuristic to solve a machine loading problem with material handling constraint in a flexible manufacturing system. International Journal of Production Research, 44(3), 569–588. doi:10.1080/00207540500266263

29. Greene, T. J., & Sadowski, R. P. (1986). A mixed integer programming for loading and scheduling multiple manufacturing cells. European Journal of Operation Research, 24(3), 379–386. doi:10.1016/0377-2217(86)90031-7
30. Guerrero, F. (1999). Machine loading and part type selection in flexible manufacturing systems. International Journal of Production Research, 37(6), 1303–1317.
31. Gupta, J. N. D. (1999). Part dispatching and machine loading in flexible manufacturing systems using central queues. International Journal of Production Research, 37(6), 1427–1435.
32. Hsu, V. N., & De-Matta, R. (1997). An efficient heuristic approach to recognize the infeasibility of a loading problem. The International Journal of Flexible Manufacturing Systems, 9, 31–50.
33. Hwang, S. (1986). A constraint directed method to solve the part selection problem in flexible manufacturing systems planning stage. In Second ORSA/TIMS Conference on Flexible Manufacturing Systems: Operations Research Models and Applications. Ann Arbor.
34. Jahromi, M. H. M. A., & Tavakkoli-Moghaddam, R. (2012). A novel 0-1 linear integer programming model for dynamic machine-tool selection and operation allocation in a flexible manufacturing system. Journal of Manufacturing Systems, 31(2), 224–231. doi:10.1016/j.jmsy.2011.07.008
35. Jain, M., Maheshwari, S., & Baghel, K. P. S. (2008). Queueing network modelling of flexible manufacturing system using mean value analysis. Applied Mathematical Modelling, 32, 700–711. doi:10.1016/j.apm.2007.02.031
36. Kant, S., & Vaishya, R. O. (2013). An Artificial neural network (ANN) based solution approach to FMS loading problem. International Journal of Scientific and Research Publications, 3(2), 1–5.
37. Kato, K., Oba, F., & Hashimot, F. (1993). A GT-based heuristic approach for machine loading and batch formation in flexible manufacturing systems. Control Engineering Practice, 1(5), 845–850.
38. Kempf, K. G. (1985). Manufacturing and artificial intelligence. Robotics, 1, 13–25.
39. Kim, H., Yu, J., Kim, J., Doh, H.-H., Lee, D.-H., & Nam, S.-H. (2012). Loading algorithms for flexible manufacturing systems with partially grouped unrelated machines and additional tooling constraints. International Journal of Advanced Manufacturing Technology, 58, 683–691. doi:10.1007/s00170-011-3417-0
40. Kim, S., & Choi, K. (2000). Development of flexible manufacturing system using virtual manufacturing paradigm. International Journal of the Korean Society of Precision Engineering, 1(1), 84–90.
41. Kim, Y. D., & Yano, C. A. (1991). A heuristic approach for loading problems of flexible manufacturing systems. IIE Transactions.
42. Kim, Y.-D., & Yano, C. A. (1987). Heuristic approaches for loading problems in flexible manufacturing systems (No. Technical report 87-21).
43. Kim, Y.-D., & Yano, C. A. (1989). A new branch and bond algo for loading problems in flexible manufacting system.
44. Kim Yeong-Dae and Yano Candace A. (1987). A branch and bound approach for the loading problem in flexible manufacturing systems: an unbalancing case (No. Technical Report 87-18). Ann Arbor, Michigan.
45. Kimemia, J. G. (1982). Hierarchical control of production in FMS. MIT Laboratory for Information and Decision System, Report LIDS-TH-1215.
46. Kimemia, J. G., & Gershwin, S. B. (1983). An algorithm for the computer control production in FMS. IIE Transactions, 15(4), 353–363.
47. Kinemia, J. G., & Gershwin, S. B. (1985). Flow optimization in flexible manufacturing systems. International Journal of Production Research, 23, 81–96.
48. Kiran, A. S., & Tansel, B. C. (1985). A mathematical model for flexible manufacturing systems (No. Working Paper).
49. Kiran, S. (1986). Complexity of FMS loading and scheduling problems (No. Working Paper).
50. Kosucuoglu, D., & Bilge, U. (2012). Material handling considerations in the FMS loading problem with full routing flexibility. International Journal of Production Research, 50(22), 6530–6552.
51. Kouvelis, P., & Lee, H. L. (1991). Block angular structures and the loading problem in flexible manufacturing systems. Institute for Operations Research and the Management Sciences (INFORMS), 39(4), 666–676.
52. Kumar, A., Prakash, Tiwari, M. K., Shankar, R., & Baveja, A. (2006). Solving machine-loading problem of a flexible manufacturing system with constraint-based genetic algorithm. European Journal of Operational Research, 175, 1043–1069. doi:10.1016/j.ejor.2005.06.025
53. Kumar, N., & Shanker, K. (2000). A genetic algorithm for FMS part type selection and machine loading. International Journal of Production Research, 38(16), 3861–3887.
54. Kumar, N., & Shanker, K. (2001). Comparing the effectiveness of workload balancing objectives in FMS loading. International Journal of Production Research, 39(5), 843–871.
55. Kumar P., Singh N., & Tewari N. K. (1987). Multicriterion analysis of the loading problem in flexible manufacturing systems using min-max approach. The International Journal of Advanced Manufacturing Technology, 2(2), 13–20.

56. Kumar, P., Singh, N., & Tewari, N. K. (1991). A nonlinear goal programming model for multistage, multiobjective decission problems with application to grouping and loding problems in a flexible manufacturing system. European Journal of Operational Research, 53, 166–171.
57. Kumar, R. R., Singh, A. K., & Tiwari, M. K. (2004). A fuzzy based algorithm to solve the machine-loading problems of a FMS and its neuro fuzzy petri net model. International Journal of Advanced Manufacturing Technology, (23), 318–341. doi:10.1007/s00170-002-1499-4
58. Kumar, V. M., Murthy, A. N. N., & Chandrashekara, K. (2012). A hybrid algorithm optimization approach for machine loading problem in flexible manufacturing system. Journal of Industrial Engineering International, 8(3), 1–10.
59. Kusiak, A. (1983). Loading models in flexible manufacturing systems, recent developments in FMS and allied areas. In The Design and Operation of FMS. North Holland, New York.
60. Kusiak, A., & Finke, G. (1988). Selection of process plans in automated manufacturing systems. IEEE Journal of Robotics and Automation, 4, 397–402.
61. Land, A., & Doig, A. (1960). An automatic method of solving discrete programming problems. Econometrika, 28(3), 497–520.
62. Lee, D. Y., & DiCesare, F. (1994). Scheduling flexible manufacturing systems using Petri nets and heuristic search. IEEE Transactions on Robotics and Automation, 10(2), 123–132.
63. Lee, D.-H., & Kim, Y.-D. (1998). Iterative procedures for multi-period order selection and loading problems in flexible manufacturing systems. International Journal of Production Research, 36(10), 2653–2668.
64. Lee, D.-H., & Kim, Y.-D. (2000). Loading algorithms for flexible manufacturing systems with partially grouped machines. IIE Transactions, 32, 33–47.
65. Lee, D.-H., Lira, S.-K., Lee, G.-C., Jun, H.-B., & Kim, Y.-D. (1997). Multi-period part selection and loading problems in flexible manufacturing systems. Computers and Industrial Engineering, 33(3-4), 541–544.
66. Liang, M. (1993). Part selection, machine loading, and machine speed selection in flexible manufacturing systems. Computers and Industrial Engineering, 25(1-4), 259–262.
67. Liang, M., & Dutt, S. P. (1990). A mixed-integer programming approach to the machine loading and process planning problem in a process payout pnvironment. International Journal of Production Research, 28(8), 1471–1484. doi:10.1080/00207549008942806
68. Liang, M., & Dutta, S. P. (2009). Solving a combined part selection, machine loading, and tool configuration problem in flexible manufacturing systems. Production and Operations Management, 2(2), 97 – 113. doi:10.1111/j.1937-5956.1993.tb00093.x
69. Little, J. D. C. (1961). A proof of the queueing formula L=λW. Operational Research, 9(3), 383–387.
70. Lu, S. C.-Y. (1986). Knowledge-based expert systems: A new horizon of manufacturing automation", in: Knowledge Based Expert Systems for Manufacturing. In Winter Annual Meeting of the American Society of Mechanical Engineers (pp. 205–209). Anaheim, CA (December).
71. Mahmudy, W. F., Marian, R. M., & Luong, L. H. S. (2012). Solving part type selection and loading problem in flexible manufacturing system using real coded genetic algorithms – Part II : optimization. World Academy of Science, Engineering and Technology, 69, 778–782.
72. Mandal, S. K., Pandey, M. K., & Tiwari, M. K. (2010). Incorporating dynamism in traditional machine loading problem : an AI-based optimisation approach. International Journal of Production Research, 48(12), 3535–3559.
73. Maria, A. (1997). Introduction to modeling and simulation. In S. Andradottir, K. J. Healy, D. H. Withers, & B. L. Nelson (Eds.), Proceedings of the 1997 Winter Simulation Conference (pp. 7–13).
74. Mazzola, J. B. (1989). Heuristics for the FMS/MRP rough-cut capacity planning problem. In Proceedings of the Third ORSA/TIMS Conference on Flexible Manufacturing Systems: Operations Research Models and Applications.
75. Mgwatu, M. I. (2011). Interactive decisions of part selection , machine loading , machining optimisation and part scheduling sub-problems for flexible manufacturing systems. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies, 2(1), 93–109.
76. Ming, L. (1994). Integrating machining speed, part selection and machine loading decisions in flexible manufacturing systems. Computers & Industrial Engineering, 26(3), 599–608.
77. Mukhopadhyay, S. K., Midha, S., & Murlikrishna, V. (1992). A heuristic procedure for loading problem in flexible manufacturing systems. International Journal of Production Research, 30(9), 2213–2228. doi:10.1080/00207549208948146
78. Mukhopadhyay, S. K., Singh, M. K., & Srivastava, R. (1998). FMS machine loading: A simulated annealing approach. International Journal of Production Research, 36(6), 1529–1547.
79. Murat, A., & Erol, S. (2012). A hybrid simulated annealing-tabu search algorithm for the part selection and machine loading problems in flexible manufacturing systems. International Journal of Advanced Manufacturing Technology, 59, 669–679. doi:10.1007/s00170-011-3506-0

80. Nagarjuna, N., Mahesh, O., & Rajagopal, K. (2006). A heuristic based on multi-stage programming approach for machine-loading problem in a flexible manufacturing system. Robotics and Computer-Integrated Manufacturing, 22, 342–352. doi:10.1016/j.rcim.2005.07.006
81. Narahari, Y., & Viswanadham, N. (1985). A Petri net approach to the modelling and analysis of flexible manufacturing systems. Annals of Operations Research, 3, 449–472.
82. Narahari, Y., Viswanadham, N., Meenakshisundaram, C. R., & Rao, P. H. (1990). Integrated analytical models for flexible manufacturing systems. Sadhna, 15(4 & 5), 331–342.
83. Nayak, G. K., & Acharya, D. (1998). Part type selection, machine loading and part type volume determination problems in FMS planning. International Journal of Production Research, 36(7), 1801–1824.
84. O'Grady, P. J. (1987). Controlling Automated Manufacturing Systems. London: Chapman & Hall/ Kogam.
85. O'Grady, P. J., Bao, H., & Lee, K. H. (1987). Issues in intelligent cell control for flexible manufacturing systems. Computers in Industry, 9, 25–36.
86. Ozdamarl, L., & Barbarosoglu, G. (1999). Hybrid heuristics for the multi-stage capacitated lot sizing and loading problem. Journal of the Operational Research Society, 50(8), 810–825.
87. Ozpeynirci, S., & Azizoglu, M. (2010). A Lagrangean relaxation based approach for the in flexible allocation capacity problem manufacturing systems. Journal of the Operational Research Society (20, 61(5), 872–877. doi:10.1057/jors.2009.19
88. Petri, C. A. (1962). Kommunikation mit Automaten. Bonn: Institut fur Instrumrntelle Mathematik, Schriften des IIM Nr. 3.
89. Petri, C. A. (1966). Communication with Automata (No. Technical Report, RADC-TR-65-377, Volume-1, Suppl-1).
90. Petrovic, D., & Akoz, O. (2008). A fuzzy goal programming approach to integrated loading and scheduling of a batch processing machine. Journal of the Operational Research Society, 59(9), 1211–1219. doi:10.1057/palgrave.jors.2602467
91. Polya, G. (1945). Heuristics. In How To Solve It (pp. 112–113, 132).
92. Ponnambalam, S. G., & Kiat, L. S. (2008). Solving machine loading problem in flexible manufacturing systems using particle swarm optimization. World Academy of Science, Engineering and Technology, 2, 14–19.
93. Prakash, A., Khilwani, N., Tiwari, M. K., & Cohen, Y. (2008). Modified immune algorithm for job selection and operation allocation problem in flexible manufacturing systems. Advances in Engineering Software, 39, 219–232. doi:10.1016/j.advengsoft.2007.01.024
94. Rahimifard, S., & Newman, S. T. (2000). Machine loading algorithms for the elimination of tardy jobs in flexible batch machining applications. Journal of Materials Processing Technology, 107, 450–458.
95. Rai, R., Kameshwaran, S., & Tiwari, M. K. (2002). Machine-tool selection and operation allocation in FMS: Solving a fuzzy goal-programming model using a genetic algorithm. International Journal of Production Research, 40(3), 641–665. doi:10.1080/00207540110081515
96. Rajagopalan, S. (1986). Formulation and heuristic solutions for parts grouping and tool loading in flexible manufacturing systems. In Proceedings of the Second ORSA/TIMS Conference on Flexible Manufacturing Systems. Ann Arbor.
97. Rajamani, D., & Adil, G. K. (1996). Machine loading in flexible manufacturing systems considering routeing flexibility. International Journal of Advanced Manufacturing Technology, 11, 372–380.
98. Ram, B., Sarin, S., & Chen, C. S. (1990). A model and a solution approach for the machine loading and tool allocation problem in a flexible manufacturing system. International Journal of Production Research, 28, 637–645. doi:10.1080/00207549008942745
99. Reiser, M., & Lavenberg, S. S. (1978). Mean value analysis of closed multichaia queueing networks (No. Res. Report RC 7023). IBM Res. Rpt. RC 7023.
100. Reiser, M., & Lavenberg, S. S. (1980). Mean value analysis of closed multichain queueing networks. Journal of ACM, 27(2), 313–322.
101. Roh H.-K. and Kim Yeon-D. (1997). Due-date based loading and scheduling methods for a flexible manufacturing system with an automatic tool transporter. International Journal of Production Research, 35(11), 2989–3004.
102. Romanycia, M. H. J., & Pelletier, F. J. (1985). What is a heuristic ? Computer Intelligance, 1, 47–58.
103. Sarin, S. C., & Chen, C. S. (1987). The machine loading and tool allocation problem in a flexible manufacturing system. International Journal of Production Research, 25(7), 1981–1094. doi:10.1080/00207548708919897
104. Sawik, T. (2000). An LP-based approach for loading and routing in a flexible assembly line. International Journal Production Economics, 64, 49–58.
105. Seidmann, A., Schweitzer, P. J., & Shalev-oren, S. (1987). Computerized closed qeueing network models of flexible manufacturing systems: a comparative vealuation. Large Scale Systems, 12, 91–107.
106. Shankar, K., & Srinivasulu, A. (1989). Some selection methodologies for loading problems in a

flexible manufacturing system. International Journal of Production Research, 27(6), 1019–1034. doi:10.1080/00207548908942605

107. Shankar, K., & Tzen, Y. J. (1985). A loading and dispatching problem in a random flexible manufacturing system. International Journal of Production Research, 23(3), 579–595. doi:10.1080/00207548508904730
108. Shanthikumar, J. G., & Stecke, K. E. (1984). Reducing work in process inventory in certain class of FMS (No. working paper no. 407). Ann Arbor MI.
109. Simpson, J. A., Hocken, R. J., & Albus, J. S. (1982). The automated manufacturing research facility of the National Bureau of Standards. Journal of Manufacturing System, 1, 17–32.
110. Solberg, J. J. (1977). A mathematical model of computerised manufacturing systems. In Proceedings of the 4th International Conference on Production Research. Tokyo, Japan, (August).
111. Solberg, J. J. (1979). Analytical performance of FMS. In Proceedings of the 18th IEEE conference on Decision and control (pp. 640–644). San Diego CA (December).
112. Solberg, J. J. (1980). CAN-Q User's Guide, Report no. 9 (revised), NSF GRANT No. APR74 15256. West Lafayetee IN.
113. Stecke, K. E. (1981). Linearized nonlinear MIP formulation for loading a Flexible Manufacturing System. The University of Michigan, Working Paper No 278.
114. Stecke, K. E. (1982). Nonlinear MIP formulation of production planing problems in flexible manufacturing systems (No. Working Paper no. 293). Michigan.
115. Stecke, K. E. (1983a). A hierarchical approach to solving machine grouping and loading problems of FMS. The University of Michigan, Working Paper No. 331-C.
116. Stecke, K. E. (1983b). Formulation and solution of nonlinear integer production planning problems for flexible manufacturing systems. Management Science, 29(3), 273–288. doi:DOI:10.1287/mnsc.29.3.273
117. Stecke, K. E. (1986). A hierarchical approach to solving machine grouping and loading problems of flexible manufacturing systems. European Journal of Operational Research, 24, 369–378.
118. Stecke, K. E. (2005a). Addressing industrial problems using various mathematical models. INFORMS Transactions on Education, 5(3), 8–18. doi:10.1287/ited.5.3.8
119. Stecke, K. E. (2005b). Using mathematics to solve some problems in industry. INFORMS Transactions on Education, 5(2), 1–8.
120. Stecke, K. E., & Brian, T. F. (1995). Heuristics for loading flexible manufacturing systems. In Raouf A. and Ben-Daya M. (Ed.), Flexible manufacturing systems: recent developments (pp. 171–180). Elsevier Science B.V.
121. Stecke, K. E., & Kim, I. (1987). A study of unbalancing and balancing for systems of pooled machines of unequal sizes. In In proceeding of IEEE International Conference on: Robotics and Automation (Vol. 4). Ann Arbor, Michigan: The University of Michigan, Volume-4.
122. Stecke, K. E., & Morin, T. L. (1984). Optimality of balanced workloads in Flexible Manufacturing Systems. European Journal of Operational Research (working Paper No. 289-C).
123. Stecke, K. E., & Morin, T. L. (1985). Optimality of balancing workloads in certain types of flexible manufacturing systems. European Journal of Operational Research, 20, 68–82.
124. Stecke, K. E., & Solberg, J. J. (1985). The optimality of unbalancing both workloads and machine group sizes in closed queueing networks of multi-server queues. Operational Research, 33, 822–910.
125. Stecke, K. E., & Talbot, B. F. (1985). Heuristics for loading flexible manufacturing systems, in Flexible Manufacturing: Recent Developments in FMS. In A. Raouf & S. I. Ahmad (Eds.), Robotics, CAD-CAM, CIM (pp. 73–84). Amsterdam: Elsevier Science Publishers.
126. Stecke, K. E., & Talbot, F. B. (1983). Heuristic loading algorithms for Flexible Manufacturing System. The University of Michigan, Working Paper No 348.
127. Stecke Kathryn E. and Solberg James J. (1981). Loading and control policies for a flexible manufacturing system. International Journal of Production Research, 19(5), 481–490. doi:10.1080/00207548108956679
128. Sujono, S., & Lashkari, R. S. (2007). A multi-objective model of operation allocation and material handling system selection in FMS design. International Journal Production Economics, 105, 116–133. doi:10.1016/j.ijpe.2005.07.007
129. Suri, R., & Hildebrant, R. R. (1984). Modelling flexible manufacturing systems using mean value analysis. Journal of Manufacturing Systems, 3(1), 27–38.
130. Swarnkar, R., & Tiwari, M. K. (2004). Modeling machine loading problem of FMSs and its solution methodology using a hybrid tabu search and simulated annealing-based heuristic approach. Robotics and Computer-Integrated Manufacturing, 20, 199–209. doi:10.1016/j.rcim.2003.09.001
131. Taboun, S. M., & Ulger, T. (1992). Multi-objective modelling of operation-allocation problem in flexible manufacturing systems. Computers and Industrial Engineering, 23(1-4), 295–299.

132. Tadeusz, S. (2004). Loading and scheduling of a flexible assembly system by mixed integer programming. European Journal of Operational Research, 154, 1–19. doi:10.1016/S0377-2217(02)00795-6
133. Tang, S., & Denardo, E. (1988). Models arising from a flexible manufacturing machine - Part II: minimization of the number of switching instants. Operations Research, 36(5), 778–784.
134. Tiwari, M. K., Kumar, S., Kumar, S., Prakash, & Shankar, R. (2006). Solving part-type selection and operation allocation problems in an FMS : an approach using constraints-based fast simulated annealing Algorithm. IEEE Transactions on Systems, Man, and Cybernetics—Part A: Systems and Humans, 36(6), 1170–1184.
135. Tiwari, M. K., Saha, J., & Mukhopadhyay, S. K. . (2007). Heuristic solution approaches for combined-job sequencing and machine loading problem in flexible manufacturing systems. International Journal of Advanced Manufacturing Technology, 31, 716–730. doi:10.1007/s00170-005-0259-7
136. Tiwari, M. K., & Vidyarthi, N. K. (2000). Solving machine loading problems in a flexible manufacturing system using a genetic algorithm based heuristic approach. International Journal of Production Research, 38(14), 3357–3384. doi:10.1080/002075400418298
137. Tiwari M. K., Hazarika B., Vidyarthi N.K., J. P. and M. S. K. (1997). A heuristic solution approach to the machine loading problem of an FMS and its Petri net model. International Journal of Production Research, 35(8), 2269– 2284.
138. Turkcan, A., Akturk, M. S., & Storer, R. H. (2007). Due date and cost-based FMS loading , scheduling and tool management. International Journal of Production Research, 45(5), 1183–1213. doi:10.1080/00207540600559955
139. Ventura, J. A., Frank, C. F., & Leonard, M. S. (1988). Loading tools to machines in flexible manufacturing systems. Computers & Industrial Engineering, 15(1-4), 223–230.
140. Vidyarthi, N. K., & Tiwari, M. K. (2001). Machine loading problem of FMS: A fuzzy-based heuristic approach. International Journal of Production Research, 39(5), 953–979.
141. Vinod, B., & Sabbagh, M. (1986). Optimal performance analysis of manufacturing systems subject to tool availability. European Journal of Operational Research, 24, 398–409.
142. Vishwanadham, N., Narahari, Y., & Johnson, T. L. (1992). Stochastic modelling of flexible manufacturing systems. Mathematical Computational Modelling, 16(3), 15–34.
143. Werra, D. De. (1987). Design and operation of flexible manufacturing systems : the kingdom of heuristic methods. Operations Research, 21(4), 365–382.
144. Wilson J. M. (1992). Approaches to machine load balancing in flexible manufacturing systems. The Journal of the Operational Research Society, 43(5), 415–423. Retrieved from http://www.jstor.org/stable/2583561
145. Yang, H., & Wu, Z. (2002). GA-based integrated approach to FMS part type selection and machine-loading problem. International Journal of Production Research, 40(16), 4093–4110.
146. Yaqoub, D. Z. H., & Abdulghafour, D. A. B. (2012). Development of Job Scheduling and Machine Loading System in FMS. Engineering & Technology Journal, 30(7), 1173–1186.
147. Yeung, D. S., Liu, J. N. K., Shiu, S. C. K., & Fung, G. S. K. (1996). Fuzzy coloured Petri nets in modelling flexible manufacturing systems. In ISAI/ IFIS'96 (pp. 101–107). ITESM.
148. Yogeswaran, M., Ponnambalam, S. G., & Tiwari, M. K. (2009). An efficient hybrid evolutionary heuristic using genetic algorithm and simulated annealing algorithm to solve machine loading problem in FMS. International Journal of Production Research, 47(19), 5421–5448. doi:10.1080/00207540801910429
149. Yusof, U. K., Budiarto, R., & Deris, S. (2011). Harmony search algorithm for flexible manufacturing system (FMS) machine loading problem. In 3rd IEEE Conference on Data Mining and Optimization (DMO), 28-29 June 2011 (pp. 26–31). Selangor, Malaysia.
150. Yusof, U. K., Budiarto, R., & Deris, S. (2012). Constraint-chromosome genetic algorithm for flexible manufacturing system machine-loading problem. International Journal of Innovative Computing, Information and Control, 8(3), 1591–1609.
151. Yusof, U. K., Budiarto, R., & Venkat, I. (2011). Machine loading optimization in flexible manufacturing system using a hybrid of bio-inspired and musical-composition approach. In Sixth International Conference on Bio-Inspired Computing: Theories and Applications (IEEE) (pp. 89–96). doi:10.1109/BIC-TA.2011.10

Global Journals Inc. (US) Guidelines Handbook 2015

www.GlobalJournals.org

Fellows

FELLOW OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (FARSE)

Global Journals Incorporate (USA) is accredited by Open Association of Research Society (OARS), U.S.A and in turn, awards "FARSE" title to individuals. The 'FARSE' title is accorded to a selected professional after the approval of the Editor-in-Chief /Editorial Board Members/Dean.

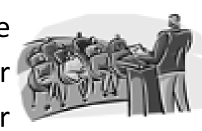
- The "FARSE" is a dignified title which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., FARSE or William Walldroff, M.S., FARSE.

FARSE accrediting is an honor. It authenticates your research activities. After recognition as FARSE, you can add 'FARSE' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, and Visiting Card etc.

The following benefits can be availed by you only for next three years from the date of certification:

FARSE designated members are entitled to avail a 40% discount while publishing their research papers (of a single author) with Global Journals Incorporation (USA), if the same is accepted by Editorial Board/Peer Reviewers. If you are a main author or co-author in case of multiple authors, you will be entitled to avail discount of 10%.

Once FARSE title is accorded, the Fellow is authorized to organize a symposium/seminar/conference on behalf of Global Journal Incorporation (USA).The Fellow can also participate in conference/seminar/symposium organized by another institution as representative of Global Journal. In both the cases, it is mandatory for him to discuss with us and obtain our consent.

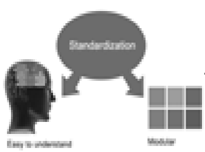


You may join as member of the Editorial Board of Global Journals Incorporation (USA) after successful completion of three years as Fellow and as Peer Reviewer. In addition, it is also desirable that you should organize seminar/symposium/conference at least once.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The FARSE can go through standards of OARS. You can also play vital role if you have any suggestions so that proper amendment can take place to improve the same for the benefit of entire research community.

As FARSE, you will be given a renowned, secure and free professional email address with 100 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.



The FARSE will be eligible for a free application of standardization of their researches. Standardization of research will be subject to acceptability within stipulated norms as the next step after publishing in a journal. We shall depute a team of specialized research professionals who will render their services for elevating your researches to next higher level, which is worldwide open standardization.

The FARSE member can apply for grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A. Once you are designated as FARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria. After certification of all your credentials by OARS, they will be published on your Fellow Profile link on website https://associationofresearch.org which will be helpful to upgrade the dignity.

The FARSE members can avail the benefits of free research podcasting in Global Research Radio with their research documents. After publishing the work, (including published elsewhere worldwide with proper authorization) you can upload your research paper with your recorded voice or you can utilize chargeable services of our professional RJs to record your paper in their voice on request.

The FARSE member also entitled to get the benefits of free research podcasting of their research documents through video clips. We can also streamline your conference videos and display your slides/ online slides and online research video clips at reasonable charges, on request.

The FARSE is eligible to earn from sales proceeds of his/her researches/reference/review Books or literature, while publishing with Global Journals. The FARSE can decide whether he/she would like to publish his/her research in a closed manner. In this case, whenever readers purchase that individual research paper for reading, maximum 60% of its profit earned as royalty by Global Journals, will be credited to his/her bank account. The entire entitled amount will be credited to his/her bank account exceeding limit of minimum fixed balance. There is no minimum time limit for collection. The FARSE member can decide its price and we can help in making the right decision.

The FARSE member is eligible to join as a paid peer reviewer at Global Journals Incorporation (USA) and can get remuneration of 15% of author fees, taken from the author of a respective paper. After reviewing 5 or more papers you can request to transfer the amount to your bank account.

MEMBER OF ASSOCIATION OF RESEARCH SOCIETY IN ENGINEERING (MARSE)

The ' MARSE ' title is accorded to a selected professional after the approval of the Editor-in-Chief / Editorial Board Members/Dean.

The "MARSE" is a dignified ornament which is accorded to a person's name viz. Dr. John E. Hall, Ph.D., MARSE or William Walldroff, M.S., MARSE.

MARSE accrediting is an honor. It authenticates your research activities. After becoming MARSE, you can add 'MARSE' title with your name as you use this recognition as additional suffix to your status. This will definitely enhance and add more value and repute to your name. You may use it on your professional Counseling Materials such as CV, Resume, Visiting Card and Name Plate etc.

The following benefitscan be availed by you only for next three years from the date of certification.

MARSE designated members are entitled to avail a 25% discount while publishing their research papers (of a single author) in Global Journals Inc., if the same is accepted by our Editorial Board and Peer Reviewers. If you are a main author or co-author of a group of authors, you will get discount of 10%.

As MARSE, you will be given a renowned, secure and free professional email address with 30 GB of space e.g. johnhall@globaljournals.org. This will include Webmail, Spam Assassin, Email Forwarders,Auto-Responders, Email Delivery Route tracing, etc.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time.This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.

The MARSE member can apply for approval, grading and certification of standards of their educational and Institutional Degrees to Open Association of Research, Society U.S.A.

Once you are designated as MARSE, you may send us a scanned copy of all of your credentials. OARS will verify, grade and certify them. This will be based on your academic records, quality of research papers published by you, and some more criteria.

It is mandatory to read all terms and conditions carefully.

Auxiliary Memberships

Institutional Fellow of Open Association of Research Society (USA)-OARS (USA)

Global Journals Incorporation (USA) is accredited by Open Association of Research Society, U.S.A (OARS) and in turn, affiliates research institutions as “Institutional Fellow of Open Association of Research Society” (IFOARS).

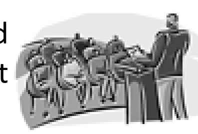
The “FARSC” is a dignified title which is accorded to a person’s name viz. Dr. John E. Hall, Ph.D., FARSC or William Walldroff, M.S., FARSC.

The IFOARS institution is entitled to form a Board comprised of one Chairperson and three to five board members preferably from different streams. The Board will be recognized as “Institutional Board of Open Association of Research Society”-(IBOARS).

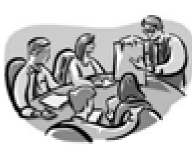
The Institute will be entitled to following benefits:

The IBOARS can initially review research papers of their institute and recommend them to publish with respective journal of Global Journals. It can also review the papers of other institutions after obtaining our consent. The second review will be done by peer reviewer of Global Journals Incorporation (USA) The Board is at liberty to appoint a peer reviewer with the approval of chairperson after consulting us.

The author fees of such paper may be waived off up to 40%.



The Global Journals Incorporation (USA) at its discretion can also refer double blind peer reviewed paper at their end to the board for the verification and to get recommendation for final stage of acceptance of publication.

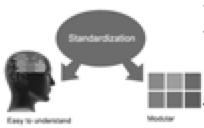


The IBOARS can organize symposium/seminar/conference in their country on behalf of Global Journals Incorporation (USA)-OARS (USA). The terms and conditions can be discussed separately.

The Board can also play vital role by exploring and giving valuable suggestions regarding the Standards of “Open Association of Research Society, U.S.A (OARS)” so that proper amendment can take place for the benefit of entire research community. We shall provide details of particular standard only on receipt of request from the Board.

The board members can also join us as Individual Fellow with 40% discount on total fees applicable to Individual Fellow. They will be entitled to avail all the benefits as declared. Please visit Individual Fellow-sub menu of GlobalJournals.org to have more relevant details.

We shall provide you intimation regarding launching of e-version of journal of your stream time to time. This may be utilized in your library for the enrichment of knowledge of your students as well as it can also be helpful for the concerned faculty members.



After nomination of your institution as “Institutional Fellow” and constantly functioning successfully for one year, we can consider giving recognition to your institute to function as Regional/Zonal office on our behalf.
The board can also take up the additional allied activities for betterment after our consultation.

The following entitlements are applicable to individual Fellows:

Open Association of Research Society, U.S.A (OARS) By-laws states that an individual Fellow may use the designations as applicable, or the corresponding initials. The Credentials of individual Fellow and Associate designations signify that the individual has gained knowledge of the fundamental concepts. One is magnanimous and proficient in an expertise course covering the professional code of conduct, and follows recognized standards of practice.

Global RESEARCH RADIO

Open Association of Research Society (US)/ Global Journals Incorporation (USA), as described in Corporate Statements, are educational, research publishing and professional membership organizations. Achieving our individual Fellow or Associate status is based mainly on meeting stated educational research requirements.

Disbursement of 40% Royalty earned through Global Journals : Researcher = 50%, Peer Reviewer = 37.50%, Institution = 12.50% E.g. Out of 40%, the 20% benefit should be passed on to researcher, 15 % benefit towards remuneration should be given to a reviewer and remaining 5% is to be retained by the institution.

We shall provide print version of 12 issues of any three journals [as per your requirement] out of our 38 journals worth $ 2376 USD.

Other:

The individual Fellow and Associate designations accredited by Open Association of Research Society (US) credentials signify guarantees following achievements:

- The professional accredited with Fellow honor, is entitled to various benefits viz. name, fame, honor, regular flow of income, secured bright future, social status etc.

- In addition to above, if one is single author, then entitled to 40% discount on publishing research paper and can get 10%discount if one is co-author or main author among group of authors.
- The Fellow can organize symposium/seminar/conference on behalf of Global Journals Incorporation (USA) and he/she can also attend the same organized by other institutes on behalf of Global Journals.
- The Fellow can become member of Editorial Board Member after completing 3yrs.
- The Fellow can earn 60% of sales proceeds from the sale of reference/review books/literature/publishing of research paper.
- Fellow can also join as paid peer reviewer and earn 15% remuneration of author charges and can also get an opportunity to join as member of the Editorial Board of Global Journals Incorporation (USA)
- • This individual has learned the basic methods of applying those concepts and techniques to common challenging situations. This individual has further demonstrated an in–depth understanding of the application of suitable techniques to a particular area of research practice.

Note :

"

- In future, if the board feels the necessity to change any board member, the same can be done with the consent of the chairperson along with anyone board member without our approval.
- In case, the chairperson needs to be replaced then consent of 2/3rd board members are required and they are also required to jointly pass the resolution copy of which should be sent to us. In such case, it will be compulsory to obtain our approval before replacement.
- In case of "Difference of Opinion [if any]" among the Board members, our decision will be final and binding to everyone.

"

Process of submission of Research Paper

The Area or field of specialization may or may not be of any category as mentioned in 'Scope of Journal' menu of the GlobalJournals.org website. There are 37 Research Journal categorized with Six parental Journals GJCST, GJMR, GJRE, GJMBR, GJSFR, GJHSS. For Authors should prefer the mentioned categories. There are three widely used systems UDC, DDC and LCC. The details are available as 'Knowledge Abstract' at Home page. The major advantage of this coding is that, the research work will be exposed to and shared with all over the world as we are being abstracted and indexed worldwide.

The paper should be in proper format. The format can be downloaded from first page of 'Author Guideline' Menu. The Author is expected to follow the general rules as mentioned in this menu. The paper should be written in MS-Word Format (*.DOC,*.DOCX).

The Author can submit the paper either online or offline. The authors should prefer online submission.Online Submission: There are three ways to submit your paper:

(A) (I) First, register yourself using top right corner of Home page then Login. If you are already registered, then login using your username and password.

(II) Choose corresponding Journal.

(III) Click 'Submit Manuscript'. Fill required information and Upload the paper.

(B) If you are using Internet Explorer, then Direct Submission through Homepage is also available.

(C) If these two are not conveninet , and then email the paper directly to dean@globaljournals.org.

Offline Submission: Author can send the typed form of paper by Post. However, online submission should be preferred.

Preferred Author Guidelines

MANUSCRIPT STYLE INSTRUCTION **(Must be strictly followed)**

Page Size: 8.27" X 11'"

- Left Margin: 0.65
- Right Margin: 0.65
- Top Margin: 0.75
- Bottom Margin: 0.75
- Font type of all text should be Swis 721 Lt BT.
- Paper Title should be of Font Size 24 with one Column section.
- Author Name in Font Size of 11 with one column as of Title.
- Abstract Font size of 9 Bold, "Abstract" word in Italic Bold.
- Main Text: Font size 10 with justified two columns section
- Two Column with Equal Column with of 3.38 and Gaping of .2
- First Character must be three lines Drop capped.
- Paragraph before Spacing of 1 pt and After of 0 pt.
- Line Spacing of 1 pt
- Large Images must be in One Column
- Numbering of First Main Headings (Heading 1) must be in Roman Letters, Capital Letter, and Font Size of 10.
- Numbering of Second Main Headings (Heading 2) must be in Alphabets, Italic, and Font Size of 10.

You can use your own standard format also.
Author Guidelines:

1. General,

2. Ethical Guidelines,

3. Submission of Manuscripts,

4. Manuscript's Category,

5. Structure and Format of Manuscript,

6. After Acceptance.

1. GENERAL

Before submitting your research paper, one is advised to go through the details as mentioned in following heads. It will be beneficial, while peer reviewer justify your paper for publication.

Scope

The Global Journals Inc. (US) welcome the submission of original paper, review paper, survey article relevant to the all the streams of Philosophy and knowledge. The Global Journals Inc. (US) is parental platform for Global Journal of Computer Science and Technology, Researches in Engineering, Medical Research, Science Frontier Research, Human Social Science, Management, and Business organization. The choice of specific field can be done otherwise as following in Abstracting and Indexing Page on this Website. As the all Global

Journals Inc. (US) are being abstracted and indexed (in process) by most of the reputed organizations. Topics of only narrow interest will not be accepted unless they have wider potential or consequences.

2. ETHICAL GUIDELINES

Authors should follow the ethical guidelines as mentioned below for publication of research paper and research activities.

Papers are accepted on strict understanding that the material in whole or in part has not been, nor is being, considered for publication elsewhere. If the paper once accepted by Global Journals Inc. (US) and Editorial Board, will become the copyright of the Global Journals Inc. (US).

Authorship: The authors and coauthors should have active contribution to conception design, analysis and interpretation of findings. They should critically review the contents and drafting of the paper. All should approve the final version of the paper before submission

The Global Journals Inc. (US) follows the definition of authorship set up by the Global Academy of Research and Development. According to the Global Academy of R&D authorship, criteria must be based on:

1) Substantial contributions to conception and acquisition of data, analysis and interpretation of the findings.

2) Drafting the paper and revising it critically regarding important academic content.

3) Final approval of the version of the paper to be published.

All authors should have been credited according to their appropriate contribution in research activity and preparing paper. Contributors who do not match the criteria as authors may be mentioned under Acknowledgement.

Acknowledgements: Contributors to the research other than authors credited should be mentioned under acknowledgement. The specifications of the source of funding for the research if appropriate can be included. Suppliers of resources may be mentioned along with address.

Appeal of Decision: The Editorial Board's decision on publication of the paper is final and cannot be appealed elsewhere.

Permissions: It is the author's responsibility to have prior permission if all or parts of earlier published illustrations are used in this paper.

Please mention proper reference and appropriate acknowledgements wherever expected.

If all or parts of previously published illustrations are used, permission must be taken from the copyright holder concerned. It is the author's responsibility to take these in writing.

Approval for reproduction/modification of any information (including figures and tables) published elsewhere must be obtained by the authors/copyright holders before submission of the manuscript. Contributors (Authors) are responsible for any copyright fee involved.

3. SUBMISSION OF MANUSCRIPTS

Manuscripts should be uploaded via this online submission page. The online submission is most efficient method for submission of papers, as it enables rapid distribution of manuscripts and consequently speeds up the review procedure. It also enables authors to know the status of their own manuscripts by emailing us. Complete instructions for submitting a paper is available below.

Manuscript submission is a systematic procedure and little preparation is required beyond having all parts of your manuscript in a given format and a computer with an Internet connection and a Web browser. Full help and instructions are provided on-screen. As an author, you will be prompted for login and manuscript details as Field of Paper and then to upload your manuscript file(s) according to the instructions.

To avoid postal delays, all transaction is preferred by e-mail. A finished manuscript submission is confirmed by e-mail immediately and your paper enters the editorial process with no postal delays. When a conclusion is made about the publication of your paper by our Editorial Board, revisions can be submitted online with the same procedure, with an occasion to view and respond to all comments.

Complete support for both authors and co-author is provided.

4. MANUSCRIPT'S CATEGORY

Based on potential and nature, the manuscript can be categorized under the following heads:

Original research paper: Such papers are reports of high-level significant original research work.

Review papers: These are concise, significant but helpful and decisive topics for young researchers.

Research articles: These are handled with small investigation and applications

Research letters: The letters are small and concise comments on previously published matters.

5.STRUCTURE AND FORMAT OF MANUSCRIPT

The recommended size of original research paper is less than seven thousand words, review papers fewer than seven thousands words also.Preparation of research paper or how to write research paper, are major hurdle, while writing manuscript. The research articles and research letters should be fewer than three thousand words, the structure original research paper; sometime review paper should be as follows:

Papers: These are reports of significant research (typically less than 7000 words equivalent, including tables, figures, references), and comprise:

(a)Title should be relevant and commensurate with the theme of the paper.

(b) A brief Summary, "Abstract" (less than 150 words) containing the major results and conclusions.

(c) Up to ten keywords, that precisely identifies the paper's subject, purpose, and focus.

(d) An Introduction, giving necessary background excluding subheadings; objectives must be clearly declared.

(e) Resources and techniques with sufficient complete experimental details (wherever possible by reference) to permit repetition; sources of information must be given and numerical methods must be specified by reference, unless non-standard.

(f) Results should be presented concisely, by well-designed tables and/or figures; the same data may not be used in both; suitable statistical data should be given. All data must be obtained with attention to numerical detail in the planning stage. As reproduced design has been recognized to be important to experiments for a considerable time, the Editor has decided that any paper that appears not to have adequate numerical treatments of the data will be returned un-refereed;

(g) Discussion should cover the implications and consequences, not just recapitulating the results; conclusions should be summarizing.

(h) Brief Acknowledgements.

(i) References in the proper form.

Authors should very cautiously consider the preparation of papers to ensure that they communicate efficiently. Papers are much more likely to be accepted, if they are cautiously designed and laid out, contain few or no errors, are summarizing, and be conventional to the approach and instructions. They will in addition, be published with much less delays than those that require much technical and editorial correction.

The Editorial Board reserves the right to make literary corrections and to make suggestions to improve briefness.

It is vital, that authors take care in submitting a manuscript that is written in simple language and adheres to published guidelines.

Format

Language: The language of publication is UK English. Authors, for whom English is a second language, must have their manuscript efficiently edited by an English-speaking person before submission to make sure that, the English is of high excellence. It is preferable, that manuscripts should be professionally edited.

Standard Usage, Abbreviations, and Units: Spelling and hyphenation should be conventional to The Concise Oxford English Dictionary. Statistics and measurements should at all times be given in figures, e.g. 16 min, except for when the number begins a sentence. When the number does not refer to a unit of measurement it should be spelt in full unless, it is 160 or greater.

Abbreviations supposed to be used carefully. The abbreviated name or expression is supposed to be cited in full at first usage, followed by the conventional abbreviation in parentheses.

Metric SI units are supposed to generally be used excluding where they conflict with current practice or are confusing. For illustration, 1.4 l rather than 1.4 × 10-3 m3, or 4 mm somewhat than 4 × 10-3 m. Chemical formula and solutions must identify the form used, e.g. anhydrous or hydrated, and the concentration must be in clearly defined units. Common species names should be followed by underlines at the first mention. For following use the generic name should be constricted to a single letter, if it is clear.

Structure

All manuscripts submitted to Global Journals Inc. (US), ought to include:

Title: The title page must carry an instructive title that reflects the content, a running title (less than 45 characters together with spaces), names of the authors and co-authors, and the place(s) wherever the work was carried out. The full postal address in addition with the e-mail address of related author must be given. Up to eleven keywords or very brief phrases have to be given to help data retrieval, mining and indexing.

Abstract, used in Original Papers and Reviews:

Optimizing Abstract for Search Engines

Many researchers searching for information online will use search engines such as Google, Yahoo or similar. By optimizing your paper for search engines, you will amplify the chance of someone finding it. This in turn will make it more likely to be viewed and/or cited in a further work. Global Journals Inc. (US) have compiled these guidelines to facilitate you to maximize the web-friendliness of the most public part of your paper.

Key Words

A major linchpin in research work for the writing research paper is the keyword search, which one will employ to find both library and Internet resources.

One must be persistent and creative in using keywords. An effective keyword search requires a strategy and planning a list of possible keywords and phrases to try.

Search engines for most searches, use Boolean searching, which is somewhat different from Internet searches. The Boolean search uses "operators," words (and, or, not, and near) that enable you to expand or narrow your affords. Tips for research paper while preparing research paper are very helpful guideline of research paper.

Choice of key words is first tool of tips to write research paper. Research paper writing is an art.A few tips for deciding as strategically as possible about keyword search:

- One should start brainstorming lists of possible keywords before even begin searching. Think about the most important concepts related to research work. Ask, "What words would a source have to include to be truly valuable in research paper?" Then consider synonyms for the important words.
- It may take the discovery of only one relevant paper to let steer in the right keyword direction because in most databases, the keywords under which a research paper is abstracted are listed with the paper.
- One should avoid outdated words.

Keywords are the key that opens a door to research work sources. Keyword searching is an art in which researcher's skills are bound to improve with experience and time.

Numerical Methods: Numerical methods used should be clear and, where appropriate, supported by references.

Acknowledgements: Please make these as concise as possible.

References

References follow the Harvard scheme of referencing. References in the text should cite the authors' names followed by the time of their publication, unless there are three or more authors when simply the first author's name is quoted followed by et al. unpublished work has to only be cited where necessary, and only in the text. Copies of references in press in other journals have to be supplied with submitted typescripts. It is necessary that all citations and references be carefully checked before submission, as mistakes or omissions will cause delays.

References to information on the World Wide Web can be given, but only if the information is available without charge to readers on an official site. Wikipedia and Similar websites are not allowed where anyone can change the information. Authors will be asked to make available electronic copies of the cited information for inclusion on the Global Journals Inc. (US) homepage at the judgment of the Editorial Board.

The Editorial Board and Global Journals Inc. (US) recommend that, citation of online-published papers and other material should be done via a DOI (digital object identifier). If an author cites anything, which does not have a DOI, they run the risk of the cited material not being noticeable.

The Editorial Board and Global Journals Inc. (US) recommend the use of a tool such as Reference Manager for reference management and formatting.

Tables, Figures and Figure Legends

Tables: Tables should be few in number, cautiously designed, uncrowned, and include only essential data. Each must have an Arabic number, e.g. Table 4, a self-explanatory caption and be on a separate sheet. Vertical lines should not be used.

Figures: Figures are supposed to be submitted as separate files. Always take in a citation in the text for each figure using Arabic numbers, e.g. Fig. 4. Artwork must be submitted online in electronic form by e-mailing them.

Preparation of Electronic Figures for Publication

Even though low quality images are sufficient for review purposes, print publication requires high quality images to prevent the final product being blurred or fuzzy. Submit (or e-mail) EPS (line art) or TIFF (halftone/photographs) files only. MS PowerPoint and Word Graphics are unsuitable for printed pictures. Do not use pixel-oriented software. Scans (TIFF only) should have a resolution of at least 350 dpi (halftone) or 700 to 1100 dpi (line drawings) in relation to the imitation size. Please give the data for figures in black and white or submit a Color Work Agreement Form. EPS files must be saved with fonts embedded (and with a TIFF preview, if possible).

For scanned images, the scanning resolution (at final image size) ought to be as follows to ensure good reproduction: line art: >650 dpi; halftones (including gel photographs) : >350 dpi; figures containing both halftone and line images: >650 dpi.

Figure Legends: Self-explanatory legends of all figures should be incorporated separately under the heading 'Legends to Figures'. In the full-text online edition of the journal, figure legends may possibly be truncated in abbreviated links to the full screen version. Therefore, the first 100 characters of any legend should notify the reader, about the key aspects of the figure.

6. AFTER ACCEPTANCE

Upon approval of a paper for publication, the manuscript will be forwarded to the dean, who is responsible for the publication of the Global Journals Inc. (US).

6.1 Proof Corrections

The corresponding author will receive an e-mail alert containing a link to a website or will be attached. A working e-mail address must therefore be provided for the related author.

Acrobat Reader will be required in order to read this file. This software can be downloaded

(Free of charge) from the following website:

www.adobe.com/products/acrobat/readstep2.html. This will facilitate the file to be opened, read on screen, and printed out in order for any corrections to be added. Further instructions will be sent with the proof.

Proofs must be returned to the dean at dean@globaljournals.org within three days of receipt.

As changes to proofs are costly, we inquire that you only correct typesetting errors. All illustrations are retained by the publisher. Please note that the authors are responsible for all statements made in their work, including changes made by the copy editor.

6.2 Early View of Global Journals Inc. (US) (Publication Prior to Print)

The Global Journals Inc. (US) are enclosed by our publishing's Early View service. Early View articles are complete full-text articles sent in advance of their publication. Early View articles are absolute and final. They have been completely reviewed, revised and edited for publication, and the authors' final corrections have been incorporated. Because they are in final form, no changes can be made after sending them. The nature of Early View articles means that they do not yet have volume, issue or page numbers, so Early View articles cannot be cited in the conventional way.

6.3 Author Services

Online production tracking is available for your article through Author Services. Author Services enables authors to track their article - once it has been accepted - through the production process to publication online and in print. Authors can check the status of their articles online and choose to receive automated e-mails at key stages of production. The authors will receive an e-mail with a unique link that enables them to register and have their article automatically added to the system. Please ensure that a complete e-mail address is provided when submitting the manuscript.

6.4 Author Material Archive Policy

Please note that if not specifically requested, publisher will dispose off hardcopy & electronic information submitted, after the two months of publication. If you require the return of any information submitted, please inform the Editorial Board or dean as soon as possible.

6.5 Offprint and Extra Copies

A PDF offprint of the online-published article will be provided free of charge to the related author, and may be distributed according to the Publisher's terms and conditions. Additional paper offprint may be ordered by emailing us at: editor@globaljournals.org .

You must strictly follow above Author Guidelines before submitting your paper or else we will not at all be responsible for any corrections in future in any of the way.

Before start writing a good quality Computer Science Research Paper, let us first understand what is Computer Science Research Paper? So, Computer Science Research Paper is the paper which is written by professionals or scientists who are associated to Computer Science and Information Technology, or doing research study in these areas. If you are novel to this field then you can consult about this field from your supervisor or guide.

TECHNIQUES FOR WRITING A GOOD QUALITY RESEARCH PAPER:

1. Choosing the topic: In most cases, the topic is searched by the interest of author but it can be also suggested by the guides. You can have several topics and then you can judge that in which topic or subject you are finding yourself most comfortable. This can be done by asking several questions to yourself, like Will I be able to carry our search in this area? Will I find all necessary recourses to accomplish the search? Will I be able to find all information in this field area? If the answer of these types of questions will be "Yes" then you can choose that topic. In most of the cases, you may have to conduct the surveys and have to visit several places because this field is related to Computer Science and Information Technology. Also, you may have to do a lot of work to find all rise and falls regarding the various data of that subject. Sometimes, detailed information plays a vital role, instead of short information.

2. Evaluators are human: First thing to remember that evaluators are also human being. They are not only meant for rejecting a paper. They are here to evaluate your paper. So, present your Best.

3. Think Like Evaluators: If you are in a confusion or getting demotivated that your paper will be accepted by evaluators or not, then think and try to evaluate your paper like an Evaluator. Try to understand that what an evaluator wants in your research paper and automatically you will have your answer.

4. Make blueprints of paper: The outline is the plan or framework that will help you to arrange your thoughts. It will make your paper logical. But remember that all points of your outline must be related to the topic you have chosen.

5. Ask your Guides: If you are having any difficulty in your research, then do not hesitate to share your difficulty to your guide (if you have any). They will surely help you out and resolve your doubts. If you can't clarify what exactly you require for your work then ask the supervisor to help you with the alternative. He might also provide you the list of essential readings.

6. Use of computer is recommended: As you are doing research in the field of Computer Science, then this point is quite obvious.

7. Use right software: Always use good quality software packages. If you are not capable to judge good software then you can lose quality of your paper unknowingly. There are various software programs available to help you, which you can get through Internet.

8. Use the Internet for help: An excellent start for your paper can be by using the Google. It is an excellent search engine, where you can have your doubts resolved. You may also read some answers for the frequent question how to write my research paper or find model research paper. From the internet library you can download books. If you have all required books make important reading selecting and analyzing the specified information. Then put together research paper sketch out.

9. Use and get big pictures: Always use encyclopedias, Wikipedia to get pictures so that you can go into the depth.

10. Bookmarks are useful: When you read any book or magazine, you generally use bookmarks, right! It is a good habit, which helps to not to lose your continuity. You should always use bookmarks while searching on Internet also, which will make your search easier.

11. Revise what you wrote: When you write anything, always read it, summarize it and then finalize it.

12. Make all efforts: Make all efforts to mention what you are going to write in your paper. That means always have a good start. Try to mention everything in introduction, that what is the need of a particular research paper. Polish your work by good skill of writing and always give an evaluator, what he wants.

13. Have backups: When you are going to do any important thing like making research paper, you should always have backup copies of it either in your computer or in paper. This will help you to not to lose any of your important.

14. Produce good diagrams of your own: Always try to include good charts or diagrams in your paper to improve quality. Using several and unnecessary diagrams will degrade the quality of your paper by creating "hotchpotch." So always, try to make and include those diagrams, which are made by your own to improve readability and understandability of your paper.

15. Use of direct quotes: When you do research relevant to literature, history or current affairs then use of quotes become essential but if study is relevant to science then use of quotes is not preferable.

16. Use proper verb tense: Use proper verb tenses in your paper. Use past tense, to present those events that happened. Use present tense to indicate events that are going on. Use future tense to indicate future happening events. Use of improper and wrong tenses will confuse the evaluator. Avoid the sentences that are incomplete.

17. Never use online paper: If you are getting any paper on Internet, then never use it as your research paper because it might be possible that evaluator has already seen it or maybe it is outdated version.

18. Pick a good study spot: To do your research studies always try to pick a spot, which is quiet. Every spot is not for studies. Spot that suits you choose it and proceed further.

19. Know what you know: Always try to know, what you know by making objectives. Else, you will be confused and cannot achieve your target.

20. Use good quality grammar: Always use a good quality grammar and use words that will throw positive impact on evaluator. Use of good quality grammar does not mean to use tough words, that for each word the evaluator has to go through dictionary. Do not start sentence with a conjunction. Do not fragment sentences. Eliminate one-word sentences. Ignore passive voice. Do not ever use a big word when a diminutive one would suffice. Verbs have to be in agreement with their subjects. Prepositions are not expressions to finish sentences with. It is incorrect to ever divide an infinitive. Avoid clichés like the disease. Also, always shun irritating alliteration. Use language that is simple and straight forward. put together a neat summary.

21. Arrangement of information: Each section of the main body should start with an opening sentence and there should be a changeover at the end of the section. Give only valid and powerful arguments to your topic. You may also maintain your arguments with records.

22. Never start in last minute: Always start at right time and give enough time to research work. Leaving everything to the last minute will degrade your paper and spoil your work.

23. Multitasking in research is not good: Doing several things at the same time proves bad habit in case of research activity. Research is an area, where everything has a particular time slot. Divide your research work in parts and do particular part in particular time slot.

24. Never copy others' work: Never copy others' work and give it your name because if evaluator has seen it anywhere you will be in trouble.

25. Take proper rest and food: No matter how many hours you spend for your research activity, if you are not taking care of your health then all your efforts will be in vain. For a quality research, study is must, and this can be done by taking proper rest and food.

26. Go for seminars: Attend seminars if the topic is relevant to your research area. Utilize all your resources.

27. Refresh your mind after intervals: Try to give rest to your mind by listening to soft music or by sleeping in intervals. This will also improve your memory.

28. Make colleagues: Always try to make colleagues. No matter how sharper or intelligent you are, if you make colleagues you can have several ideas, which will be helpful for your research.

29. Think technically: Always think technically. If anything happens, then search its reasons, its benefits, and demerits.

30. Think and then print: When you will go to print your paper, notice that tables are not be split, headings are not detached from their descriptions, and page sequence is maintained.

31. Adding unnecessary information: Do not add unnecessary information, like, I have used MS Excel to draw graph. Do not add irrelevant and inappropriate material. These all will create superfluous. Foreign terminology and phrases are not apropos. One should NEVER take a broad view. Analogy in script is like feathers on a snake. Not at all use a large word when a very small one would be sufficient. Use words properly, regardless of how others use them. Remove quotations. Puns are for kids, not grunt readers. Amplification is a billion times of inferior quality than sarcasm.

32. Never oversimplify everything: To add material in your research paper, never go for oversimplification. This will definitely irritate the evaluator. Be more or less specific. Also too, by no means, ever use rhythmic redundancies. Contractions aren't essential and shouldn't be there used. Comparisons are as terrible as clichés. Give up ampersands and abbreviations, and so on. Remove commas, that are, not necessary. Parenthetical words however should be together with this in commas. Understatement is all the time the complete best way to put onward earth-shaking thoughts. Give a detailed literary review.

33. Report concluded results: Use concluded results. From raw data, filter the results and then conclude your studies based on measurements and observations taken. Significant figures and appropriate number of decimal places should be used. Parenthetical remarks are prohibitive. Proofread carefully at final stage. In the end give outline to your arguments. Spot out perspectives of further study of this subject. Justify your conclusion by at the bottom of them with sufficient justifications and examples.

34. After conclusion: Once you have concluded your research, the next most important step is to present your findings. Presentation is extremely important as it is the definite medium though which your research is going to be in print to the rest of the crowd. Care should be taken to categorize your thoughts well and present them in a logical and neat manner. A good quality research paper format is essential because it serves to highlight your research paper and bring to light all necessary aspects in your research.

Informal Guidelines of Research Paper Writing

Key points to remember:

- Submit all work in its final form.
- Write your paper in the form, which is presented in the guidelines using the template.
- Please note the criterion for grading the final paper by peer-reviewers.

Final Points:

A purpose of organizing a research paper is to let people to interpret your effort selectively. The journal requires the following sections, submitted in the order listed, each section to start on a new page.

The introduction will be compiled from reference matter and will reflect the design processes or outline of basis that direct you to make study. As you will carry out the process of study, the method and process section will be constructed as like that. The result segment will show related statistics in nearly sequential order and will direct the reviewers next to the similar intellectual paths throughout the data that you took to carry out your study. The discussion section will provide understanding of the data and projections as to the implication of the results. The use of good quality references all through the paper will give the effort trustworthiness by representing an alertness of prior workings.

Writing a research paper is not an easy job no matter how trouble-free the actual research or concept. Practice, excellent preparation, and controlled record keeping are the only means to make straightforward the progression.

General style:

Specific editorial column necessities for compliance of a manuscript will always take over from directions in these general guidelines.

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

- Insertion a title at the foot of a page with the subsequent text on the next page
- Separating a table/chart or figure - impound each figure/table to a single page
- Submitting a manuscript with pages out of sequence

In every sections of your document

· Use standard writing style including articles ("a", "the," etc.)

· Keep on paying attention on the research topic of the paper

· Use paragraphs to split each significant point (excluding for the abstract)

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

· Shun familiar wording, don't address the reviewer directly, and don't use slang, slang language, or superlatives

· Shun use of extra pictures - include only those figures essential to presenting results

Title Page:

Choose a revealing title. It should be short. It should not have non-standard acronyms or abbreviations. It should not exceed two printed lines. It should include the name(s) and address (es) of all authors.

Abstract:

The summary should be two hundred words or less. It should briefly and clearly explain the key findings reported in the manuscript--must have precise statistics. It should not have abnormal acronyms or abbreviations. It should be logical in itself. Shun citing references at this point.

An abstract is a brief distinct paragraph summary of finished work or work in development. In a minute or less a reviewer can be taught the foundation behind the study, common approach to the problem, relevant results, and significant conclusions or new questions.

Write your summary when your paper is completed because how can you write the summary of anything which is not yet written? Wealth of terminology is very essential in abstract. Yet, use comprehensive sentences and do not let go readability for briefness. You can maintain it succinct by phrasing sentences so that they provide more than lone rationale. The author can at this moment go straight to shortening the outcome. Sum up the study, with the subsequent elements in any summary. Try to maintain the initial two items to no more than one ruling each.

- Reason of the study - theory, overall issue, purpose
- Fundamental goal
- To the point depiction of the research
- Consequences, including definite statistics - if the consequences are quantitative in nature, account quantitative data; results of any numerical analysis should be reported
- Significant conclusions or questions that track from the research(es)

Approach:

- Single section, and succinct
- As a outline of job done, it is always written in past tense
- A conceptual should situate on its own, and not submit to any other part of the paper such as a form or table
- Center on shortening results - bound background information to a verdict or two, if completely necessary
- What you account in an conceptual must be regular with what you reported in the manuscript
- Exact spelling, clearness of sentences and phrases, and appropriate reporting of quantities (proper units, important statistics) are just as significant in an abstract as they are anywhere else

Introduction:

The **Introduction** should "introduce" the manuscript. The reviewer should be presented with sufficient background information to be capable to comprehend and calculate the purpose of your study without having to submit to other works. The basis for the study should be offered. Give most important references but shun difficult to make a comprehensive appraisal of the topic. In the introduction, describe the problem visibly. If the problem is not acknowledged in a logical, reasonable way, the reviewer will have no attention in your result. Speak in common terms about techniques used to explain the problem, if needed, but do not present any particulars about the protocols here. Following approach can create a valuable beginning:

- Explain the value (significance) of the study
- Shield the model - why did you employ this particular system or method? What is its compensation? You strength remark on its appropriateness from a abstract point of vision as well as point out sensible reasons for using it.
- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
- Very for a short time explain the tentative propose and how it skilled the declared objectives.

Approach:

- Use past tense except for when referring to recognized facts. After all, the manuscript will be submitted after the entire job is done.
- Sort out your thoughts; manufacture one key point with every section. If you make the four points listed above, you will need a least of four paragraphs.

- Present surroundings information only as desirable in order hold up a situation. The reviewer does not desire to read the whole thing you know about a topic.
- Shape the theory/purpose specifically - do not take a broad view.
- As always, give awareness to spelling, simplicity and correctness of sentences and phrases.

Procedures (Methods and Materials):

This part is supposed to be the easiest to carve if you have good skills. A sound written Procedures segment allows a capable scientist to replacement your results. Present precise information about your supplies. The suppliers and clarity of reagents can be helpful bits of information. Present methods in sequential order but linked methodologies can be grouped as a segment. Be concise when relating the protocols. Attempt for the least amount of information that would permit another capable scientist to spare your outcome but be cautious that vital information is integrated. The use of subheadings is suggested and ought to be synchronized with the results section. When a technique is used that has been well described in another object, mention the specific item describing a way but draw the basic principle while stating the situation. The purpose is to text all particular resources and broad procedures, so that another person may use some or all of the methods in one more study or referee the scientific value of your work. It is not to be a step by step report of the whole thing you did, nor is a methods section a set of orders.

Materials:

- Explain materials individually only if the study is so complex that it saves liberty this way.
- Embrace particular materials, and any tools or provisions that are not frequently found in laboratories.
- Do not take in frequently found.
- If use of a definite type of tools.
- Materials may be reported in a part section or else they may be recognized along with your measures.

Methods:

- Report the method (not particulars of each process that engaged the same methodology)
- Describe the method entirely
- To be succinct, present methods under headings dedicated to specific dealings or groups of measures
- Simplify - details how procedures were completed not how they were exclusively performed on a particular day.
- If well known procedures were used, account the procedure by name, possibly with reference, and that's all.

Approach:

- It is embarrassed or not possible to use vigorous voice when documenting methods with no using first person, which would focus the reviewer's interest on the researcher rather than the job. As a result when script up the methods most authors use third person passive voice.
- Use standard style in this and in every other part of the paper - avoid familiar lists, and use full sentences.

What to keep away from

- Resources and methods are not a set of information.
- Skip all descriptive information and surroundings - save it for the argument.
- Leave out information that is immaterial to a third party.

Results:

The principle of a results segment is to present and demonstrate your conclusion. Create this part a entirely objective details of the outcome, and save all understanding for the discussion.

The page length of this segment is set by the sum and types of data to be reported. Carry on to be to the point, by means of statistics and tables, if suitable, to present consequences most efficiently.You must obviously differentiate material that would usually be incorporated in a study editorial from any unprocessed data or additional appendix matter that would not be available. In fact, such matter should not be submitted at all except requested by the instructor.

Content

- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
- In manuscript, explain each of your consequences, point the reader to remarks that are most appropriate.
- Present a background, such as by describing the question that was addressed by creation an exacting study.
- Explain results of control experiments and comprise remarks that are not accessible in a prescribed figure or table, if appropriate.
- Examine your data, then prepare the analyzed (transformed) data in the form of a figure (graph), table, or in manuscript form.

What to stay away from

- Do not discuss or infer your outcome, report surroundings information, or try to explain anything.
- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
- Manuscript should complement any figures or tables, not duplicate the identical information.
- Never confuse figures with tables - there is a difference.

Approach

- As forever, use past tense when you submit to your results, and put the whole thing in a reasonable order.
- Put figures and tables, appropriately numbered, in order at the end of the report
- If you desire, you may place your figures and tables properly within the text of your results part.

Figures and tables

- If you put figures and tables at the end of the details, make certain that they are visibly distinguished from any attach appendix materials, such as raw facts
- Despite of position, each figure must be numbered one after the other and complete with subtitle
- In spite of position, each table must be titled, numbered one after the other and complete with heading
- All figure and table must be adequately complete that it could situate on its own, divide from text

Discussion:

The Discussion is expected the trickiest segment to write and describe. A lot of papers submitted for journal are discarded based on problems with the Discussion. There is no head of state for how long a argument should be. Position your understanding of the outcome visibly to lead the reviewer through your conclusions, and then finish the paper with a summing up of the implication of the study. The purpose here is to offer an understanding of your results and hold up for all of your conclusions, using facts from your research and generally accepted information, if suitable. The implication of result should be visibly described. Infer your data in the conversation in suitable depth. This means that when you clarify an observable fact you must explain mechanisms that may account for the observation. If your results vary from your prospect, make clear why that may have happened. If your results agree, then explain the theory that the proof supported. It is never suitable to just state that the data approved with prospect, and let it drop at that.

- Make a decision if each premise is supported, discarded, or if you cannot make a conclusion with assurance. Do not just dismiss a study or part of a study as "uncertain."
- Research papers are not acknowledged if the work is imperfect. Draw what conclusions you can based upon the results that you have, and take care of the study as a finished work
- You may propose future guidelines, such as how the experiment might be personalized to accomplish a new idea.
- Give details all of your remarks as much as possible, focus on mechanisms.
- Make a decision if the tentative design sufficiently addressed the theory, and whether or not it was correctly restricted.
- Try to present substitute explanations if sensible alternatives be present.
- One research will not counter an overall question, so maintain the large picture in mind, where do you go next? The best studies unlock new avenues of study. What questions remain?
- Recommendations for detailed papers will offer supplementary suggestions.

Approach:

- When you refer to information, differentiate data generated by your own studies from available information
- Submit to work done by specific persons (including you) in past tense.
- Submit to generally acknowledged facts and main beliefs in present tense.

Please carefully note down following rules and regulation before submitting your Research Paper to Global Journals Inc. (US):

Segment Draft and Final Research Paper: You have to strictly follow the template of research paper. If it is not done your paper may get rejected.

- The **major constraint** is that you must independently make all content, tables, graphs, and facts that are offered in the paper. You must write each part of the paper wholly on your own. The Peer-reviewers need to identify your own perceptive of the concepts in your own terms. NEVER extract straight from any foundation, and never rephrase someone else's analysis.

- Do not give permission to anyone else to "PROOFREAD" your manuscript.

- Methods to avoid Plagiarism is applied by us on every paper, if found guilty, you will be blacklisted by all of our collaborated research groups, your institution will be informed for this and strict legal actions will be taken immediately.)
- To guard yourself and others from possible illegal use please do not permit anyone right to use to your paper and files.

Criterion for Grading a Research Paper (Compilation) by Global Journals Inc. (US)

Please note that following table is only a Grading of "Paper Compilation" and not on "Performed/Stated Research" whose grading solely depends on Individual Assigned Peer Reviewer and Editorial Board Member. These can be available only on request and after decision of Paper. This report will be the property of Global Journals Inc. (US).

Topics	Grades		
	A-B	**C-D**	**E-F**
Abstract	Clear and concise with appropriate content, Correct format. 200 words or below	Unclear summary and no specific data, Incorrect form Above 200 words	No specific data with ambiguous information Above 250 words
Introduction	Containing all background details with clear goal and appropriate details, flow specification, no grammar and spelling mistake, well organized sentence and paragraph, reference cited	Unclear and confusing data, appropriate format, grammar and spelling errors with unorganized matter	Out of place depth and content, hazy format
Methods and Procedures	Clear and to the point with well arranged paragraph, precision and accuracy of facts and figures, well organized subheads	Difficult to comprehend with embarrassed text, too much explanation but completed	Incorrect and unorganized structure with hazy meaning
Result	Well organized, Clear and specific, Correct units with precision, correct data, well structuring of paragraph, no grammar and spelling mistake	Complete and embarrassed text, difficult to comprehend	Irregular format with wrong facts and figures
Discussion	Well organized, meaningful specification, sound conclusion, logical and concise explanation, highly structured paragraph reference cited	Wordy, unclear conclusion, spurious	Conclusion is not cited, unorganized, difficult to comprehend
References	Complete and correct format, well organized	Beside the point, Incomplete	Wrong format and structuring

Index

save our planet

Global Journal of Researches in Engineering

Visit us on the Web at www.GlobalJournals.org | www.EngineeringResearch.org
or email us at helpdesk@globaljournals.org

ISSN 9755861