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Multi-Function Operating Machine

Nanofibres Reinforced Composites

Highlights

Thermal Analysis of Shell

Study of Graphite Content

Discovering Thoughts, Inventing Future

VOLUME 14 ISSUE 4 VERSION 1.0

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Mechanical Properties of Jute Nanofibres Reinforced Composites

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Abstract- Cellulose nanofibres were extracted from natural fibre Jute by a chemical and mechanical technique to examine their potential for use as reinforcement fibres in biocomposite applications. The Present work was to investigate the possibilities of breaking down the sub-micron fibrillar structure to fabricate submicron and nano particles by high energy ball milling. Nano fibres of jute were characterized by X Ray Diffraction and its structural morphology has studied by Scanning electron microscope. FT-IR spectroscopy analysis showed that the lignin and hemicelluloses was removed for NaoH treated jute fibres. The XRD analysis that the particle size distribution reduced from micro to 20-50 nm. SEM observations revealed that the nano particles of jute fibre were exhibited spherical and elliptical shape. Nanofibre composites were prepared with different weight percentages (1 wt. % to 5 wt. %) via hand lay-up technique. The mechanical properties of nanofibre reinforcement has improved when compared with the virgin composite. The maximum improvements were observed in 3 wt. % Jute nanofibre composites.

Keywords: jute fibre, cellulose, chemical treatment, nanofibre.

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MECHANICALPROPERTIESOFJUTENANOFIBRESREINFORCEDCOMPOSITES

Strictly as per the compliance and regulations of:

Mechanical Properties of Jute Nanofibres Reinforced Composites

K. T. B Padal [α], K. Ramji [σ] & VVS Prasad [ρ]

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Keywords: jute fibre, cellulose, chemical treatment, nanofibre.

I. Introduction

Nature continues to be generous with mankind by providing all kinds of resources in abundance for his living and existence. In this technological era the products produced essentially depend on the new varieties of materials with special characteristics. In this regard the metal composites, plastic and fibre reinforced polymer composites are playing key role in all the fields of engineering and technology. Jute fibres are sustainable and biodegradable with many advantages of low density, low cost and high specific properties. The interest in natural fibre reinforced polymer composite has grown rapidly due to high performance in mechanical properties, significant processing advantages. Jute fibres have been applied to reinforcement to eco-composites and bio- composites. Natural fibres reinforced polymer composites form an interesting class of materials, which seem to have good potential as a substitute for the fibre reinforced materials, i.e. automotive and structural and non structural applications.

Nanotechnology has rapidly become an interdisciplinary field and one exciting research area is the isolation of nano cellulose fibre from bio resources using Top-down technique [2]. Nano fibres take advantage of their dramatically increased surface area to volume ratio [3 and 4]. The polymer composites can be reinforced by nano finres resulting in novel materials which can be used as light weight replacements for metals. Such nano technologically improved materials enable a weight reduction accompanied by an increase in stability and an enhanced functionally [5 and 6]. The direction of using nano fibres from natural fibres as reinforcing materials in plastics may bring changes in manufacturing scenario. Since these jute fibres are biodegradable and eco-friendly.

This research was focused on the development of a new isolation technique to extract cellulose nanofibres from jute by mechanical process using high energy ball milling [10, 11, and 12]. The morphology and crystallinity of the nanofibres of jute fibres were characterized by Scanning electron microscope, (SEM) and X-ray diffraction analysis (XRD), Fourier transformation infrared analysis (FTIR) The nanofibre reinforcement for biocomposite applications which influence of nanofibre morphologies on the mechanical properties.

II. Experimental Work

a) Materials

Jute fibres were collected from Nellimarla jute Mills Limited, Vizianagram, Andhra Pradesh, India. The matrix used in the present study was an Diglycidyl ether of bisphenol-A, a di-functional epoxy resin (LY 556), Tri– ethylene tetra amine (TETA) araldite hardener (HY951) and Woven roving glass fibre mat (WRM) of 410 gsm was taken from M/s ECMAS Pvt. Ltd, Visakhapatnam.

b) Synthesis of Nanofibres

i. *Chemical treatment*

The weighed jute fibres were cut into 5cm in length and are soaked into 4% NaoH solution at 80°c maintaining a liquor ratio of 15:1. The jute fibres were kept immersed in the alkaline solution for 5 hours by using a Remix Water bath shaker. The fibres were then washed with water to remove any NaoH sticking to the fibre surface and finally washed again with distilled water. The fibres are then dried at room temperature for 24 hours followed by oven drying at 100°c for 5 hours.

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ii. *Mechanical Milling*

The milling process is taken in two steps, the primary process is rotary milling and second process is high energy planetary ball milling by Retsch model PM100. The Jute fibre snippets were passed through a rotary mill fitted with a 0.08mm sieve which operates at a speed of 3000 rpm. The collected jute powder was wet milled in a high energy ball milling to synthesize nanofibres.

c) Characterization of Nano fibres

i. *Fourier –Transform infrared (FT-IR) analysis*

Fourier –transform infrared (FT-IR) spectra of jute fibre samples was obtained from thermo Nicolet Avatar 380 FT-IR, in which samples of untreated jute fibres , 5% Noah treated jute fibres, and nano jute fibre samples were pattelized with KBr powder with 42 scans and the resolution of 8cm^{-1}.

ii. *X-Ray Diffraction*

X-Ray diffractometer (Phillips made X Pert Pro Diffractometer model) analyzed the nano particles of jute at a scanning rate 4^0/min with Cu, K $_\alpha$ radiation at 45 kv and 40 mA. The size of the jute fibres were determined by using Scherrer formulae.

iii. *Scanning electron microscope*

The Scanning Electronic microscope (SEM) images of jute fibres and microfibrils were taken with JEOL model Scanning Electronic microscope. It is observed that the obtained jute fibres are micro to nano scale at different milling hours. The nano jute fibre particles exhibited spherically as well as elliptical shape.

d) Preparation of Jute nanofibre reinforced composites

The Jute nanofibres with varying percentage weight (1wt.% to 5wt.%) reinforced in epoxy resins to prepare nanofibre composites by hand lay-up technique. The composites were prepared by using glass fibre woven mat and epoxy resin with 50 wt.% / 50 wt.% fraction. The epoxy resin is reinforced with different weight percentage of Jute nanofibre reinforcing (0, 1, 2, 3, 4 and 5 wt. %) were mixed by using a mechanical stirrer at 750 rpm for 30 minutes at room temperature. Then, for each 100 gm of epoxy resin, 12% of curing agent TETA was added to the mixture by weight and thoroughly mixed until it became uniform. Finally, the composite is allowed to fully cure at room temperature for 24 hours. The finished laminate was used to prepare samples for testing the mechanical properties as per ASTM standards.

i. *Studies on Mechanical Properties*

Sufficient tensile strength, impact strength, hardness and damping are required for engineering materials. Especially this is an important mechanical test for polymer based nanocomposites. The mechanical properties of plastic as well as composite materials, tensile properties are probably the most frequently considered. These properties are an important indicator of the material's behavior under loading in tension. Tensile strength were carried out using a Universal testing machine (Instron corp.,) to evaluate the tensile strength of nanocomposites as per ASTM D-638 Type-I.

The impact properties of the polymeric materials depend mainly on the toughness of the material. Toughness can be described as the ability of the polymer to absorb applied energy. The molecular flexibility has a great significance in determining the relative brittleness of the material. Impact energy is a measure of toughness and the impact resistance is the ability of a material to resist breaking under a shock–loading In the present investigation notched izod impact strength of the specimens of dimensions 63.5x12.7x3mm was evaluated using an Impactometer (Ceast, Italy) as per ASTM-D-256 with a notch depth of 2.54 mm and notch angle of 45°.

The resistance of a material to an indentation deformation is hardness. The higher the hardness, the better the material resistance to the indenting deformation will be. For thermosetting materials, the hardness with the shore A reference is used for low modulus materials. The test enables the determination of the penetration depth in the sample under a given load and using a fixed time lap the indentation device is not supposed to be deformable. In the present work the Jute nanofibre reinforced polymer composite specimens are tested as per ASTM D 2240 by Barcoll hardness tester.

Damping is also a significant factor for the fatigue life and impact resistance of structures. Damping varies with different environmental effects such as frequency, amplitude of stress, temperature and static load.

III. Results and Discussion

a) Surface Modification

The most important factor in obtaining good fibre reinforcement in the composite is the strength of adhesion between the matrix polymer and the fibre. The extent of adhesion depends upon the structure and polarity of the materials. Owing to the presence of hydroxyl and other polar groups in various constituents of jute, the moisture regain is high which leads to poor wettability with the matrix and weak interfacial bonding between the fibres and the more hydrophobic matrices. Therefore in order to develop composites with improved mechanical properties, It is necessary to impart hydrophobocity to the fibres by suitable chemical treatment.

i. *FT-IR Analysis*

FT-IR spectra is used to measure the change of surface composition of the fibre chemical of untreated, treated and Jute nanofibres were shown in Table No.1. The absorbance peaks of interest in the study have been identified in the fig 1, 2 and 3 of raw jute, 4% Noah treated at 80°c and nanojute particles. Alkaline treatment reduced hydrogen bonding due to removal of the hydroxyl groups by reacting with sodium hydroxide. The result in the increase of the– OH concentration evident from the increased intensity of the peak between1000 and 1500 cm^{-1} compared to the untreated fibre.

Table 1 : Chemical Composition of Jute Fibers

Bond-Type	Raw jute (untreated)	4%NAOH treated at 80°c	Nano jute fibre particles
-OH stretching	3383.14	3448.72	3556.14
C-H Vibration	2912.51	2900.94	2900.94
C=O stretching	1735.93	Nil	Nil
C=C stretching	1647.21	1635.	1635.64
C-H bending	1373.32	1319	1319
C-H bending	1249.87	1234.44	1234.44
-OH	601.79	516.92	524.64

The absorbance between this ranges are indicative of the hemicelluloses. The hydroxyl groups are also involved in hydrogen bonding with the carboxyl groups, perhaps of the fatty acids, available on the fibre surface of jute fibre. This is indicated by the reduction of the peaks between (3383-3556) cm^{-1}. The peaks 1735 cm^{-1}seen in untreated fibres disappears upon alkali treatment. This is due to removal of the carboxylic group by alkali treatment. The reduction in the peak intensity found in alkali treated jute fibres indicates the particular reaction of the C=O bonds of hemicelluloses, which shows that hemicelluloses of jute is removed by alkalization. The intensity of peak1647 cm^{-1} (C=C stretching) is reduced to (1635-1647) cm^{-1} in alkali treated jute fibres. This may be due to the removal of un saturation present in the traces of jutefibres. The absorbed peak at 1373cm^{-1} shows diminishing intensity as the subjected higher concentration of caustic soda. The disappearance of the peak at 1249cm^{-1} after alkalization indicates the complete removal of hemicelluloses which indicates that hemicelluloses are easily removed by alkalization. The C-OH bending peak is observed at 516-601 cm^{-1}. From this analysis it is observed that several reactions take place during alkalization.

b) X-Ray Diffraction

X-Ray diffractometer (Phillips made X Pert Pro Diffractometer model) analysed the Nano particles of jute at a scanning rate 4°/min with Cu, K_α radiation at 45 kv and 40mA.

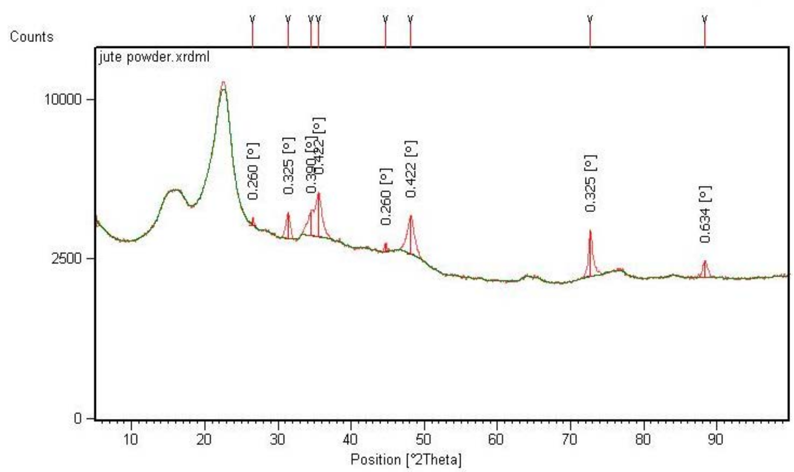

Figure 1 : XRD analysis of Nano jute particles

The sizes of the jute fibres were obtained 22nm to 52 nm with an average size of 33nm after 80 hours of milling. The crystalline size was calculated by using Scherrer formulae.

$$\text{Scherrer formulae: Crystalline size (d)} = \frac{k\lambda}{\beta cos\theta}$$

Where k = Shape factor (0.9 spherical particles)

λ = Wave length of copper K_α =1.540598

θ = Centre of the peak in degrees.

The crystallinity values obtained from the X-ray diffraction shows that the crystallinity values may be observed to decrease with increased milling time. The peak intensities of jute powder samples were observed to be reduced. It is concluded that the average crystalline size of the jute powder finer particles were at 20 nm to 50 nm. The sample Nano jute powder particles are scanned from 20 to 90 degrees of 2 Theta.

c) Scanning Electronic Microscope

The Scanning Electronic microscope (SEM) images of jute fibres and micro fibrils were taken with

JEOL model Scanning Electronic microscope. Before placing the samples into machines, the sample are coated with gold palladium using a sputtering machine to prevent charging. All images are taken at 1000 magnification. SEM analysis observed the effect of chemical treatment of jute fibres in the following figures at different milling hours of 20 hrs, 40 hrs, 60 hrs and 80 hrs of Ball milling.

Figure 2 : SEM images of Jute fibres after 20 hrs milling

Figure 3 : SEM images of Jute fibres after 40 hrs milling

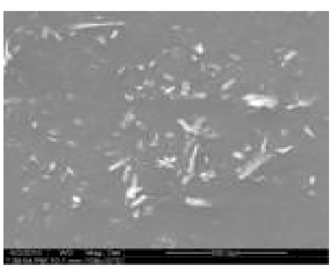

Figure 4 : SEM images of Jute fibres after 60 hrs milling

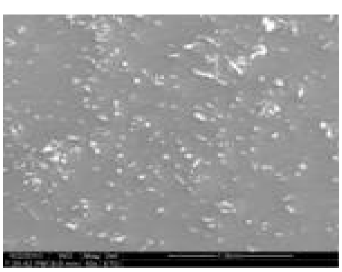

Figure 5 : SEM images of Jute nanofibres after 80hrs milling

d) *Mechanical Properties of nanofibre composites*

In order to study the reinforcement effects of different surface modified nanofibre with polymer resin matrix. The tensile strength, impact strength, hardeness and damping were determined.

i. *Tensile test*

Tensile test specimens were prepared as per ASTM D-638 and results are taken an average of the five tested samples. The mechanical properties are found to be increased with the reinforcement of jute nanofibres of (1wt. % to 5wt. %) composites and reached maximum of 96% improvement for 3wt. % nanocomposites. The nanoscale fibre reinforcement most strongly influences the matrix-dominated mechanical properties, while the in –plane ones are typically dominated by the fibre reinforcement.

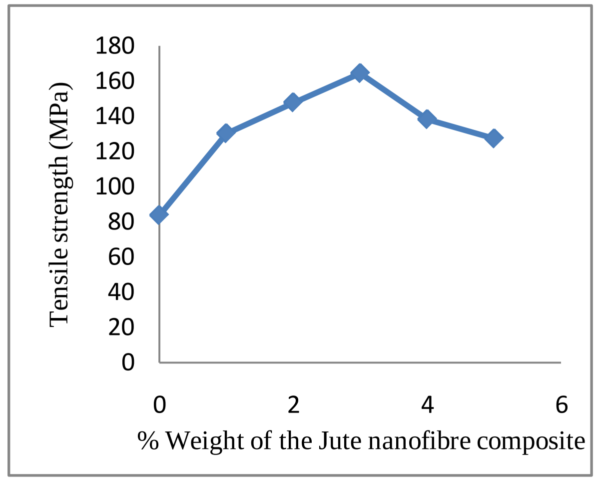

Figure 6 : Tensile properties of base composite and JNFC

ii. *Impact Test*

The impact test specimens are prepared as per ASTM D 256 and results are found to be increased for the reinforcement of nano jute particles. The maximum improvement is 38.5% for 3wt% nanojute composite. The result of the Izod test is reported as energy lost per unit cross-sectional area at the notch in J/mm^2. The variation of impact strength with (1wt% to 5wt %) JNF composites had been graphically represented in the results.

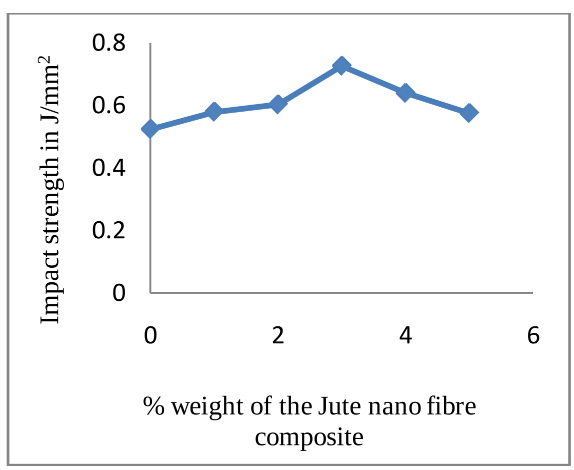

Figure 7 : Impact properties of base composite and JNFC

iii. *Hardness*

Hardness tests were prepared using Barcoll Hardness tested machine and testing specimens are prepared as per ASTM D-2583. The specimen was placed under the indenter of the Barcoll hardness tester and a uniform pressure was applied to the specimen until the dial indication reaches maximum. The depth of penetration was converted into absolute Barcoll numbers. Average of 5 specimens were reported for each nano composite. These tests were carried out at for different (1wt% to 5wt. %) JNF composites.

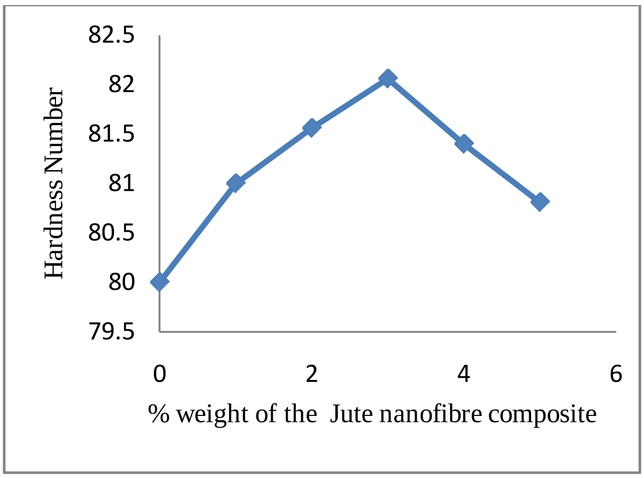

Figure 8 : Hardness properties of base composite and JNFC

The Barcoll hardness of the nano composites increases from to 80 to 82.5 when the nanofibre is reinforced in epoxy composites. The maximum improvement in hardness is obtained by 2.57% in 3 wt.% in Jute nanofibre composites. This is because of the strong interfacial bonding strength between the fibre and matrix which greatly increases the hardness of nanofibre reinforced composites. Due to an increase in the Jute nanofibres content the composite becomes stiffer and harder, and thus there is an increase in hardness with increasing fibre content.

iv. *Damping Ratio*

The damping behavior of nano jute fibre reinforced polymer composite is investigated experimentally with different weight percentage of composites at different modes. The effect of the natural frequency and the damping ratio are analyzed because polymer matrix composites have temperature dependent mechanical properties. It is observed that

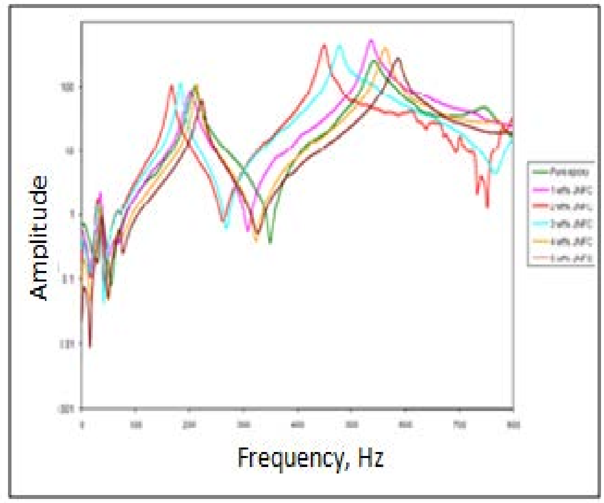

Figure 9 : Damping property of Base Composite and JNFC

Figure 7 shows the improvement in the natural frequency as noticed for both modes of nanofibre composites (1 wt.% to 5 wt.% JNF) when compared with basecomposite. The increased natural frequency is due to the good dispersion of Jute nanofibre reinforcement in the matrix which results in improved stiffness. It may be noted that the addition of Jute nanofibre has a considerable effect on the damping behaviour of nanocomposites. This may be due to the composites possessing high stiffness on account of the high modulus of nanofibres and its uniform distribution. The nanofibres are uniformly distributed, which results in a good bonding between the reinforcement and the matrix. This provides a large interfacial area between the matrix and nanofibres. This increases the modulus value as well as the energy dissipating interface.

IV. Conclusions

The development of nanocomposites based from nanofibre material is a rather new but rapidly evolving research area. Natural fibres are abundant in nature, biodegradable and relatively cheap, besides being promising nano-scale rinforcement materials for Polymers. In this work the nanocomposites were fabricated using jute nano fibre reinforcement in epoxy matrix. The mechanical properties of the jute nanofibre composites were studied through different experimental approaches.

The chemical structure of jute fibre after treatments showed an increase in cellulose content and a decrease in lignin and hemicellulose as compared with the original jute fibres.Jute fibres have been synthesized to produce nanofibres and used as reinforcement in the epoxy resin system to fabricate nanocomposites, which have imparted improved mechanical tensile, impact, hardness, and damping properties compared to the base composite.

The nano fibre composite with 1 wt.%, to 5 wt.% JNF were reinforced in epoxy resin to prepare nanocomposites. The tensile strength of nanocomposites were increased from 50% to 96% with an increasing jute nanofibre 1 wt.% to 5 wt.% content. The tensile strength,impact and hardness improvement was noticed for the 3 wt% JNF composites. The increase in strength can be attributed to strong interaction between the polymer and Jute nanofibres. The damping properties are improved by improving damping ratio for fibre reinforced composites by reinforcing nanofibres of jute upto 3 wt.%, thus leading to a higher performance in damping properties than those with jute nanofibre loading levels. The reinforment of jute nanofibre results in good damping.

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An Experimental Study and Development of Compressed Air Engine in 4 Stroke Single Cylinders

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Now this is not the only reason why we thought about this project. Another big reason is global warming, it's not an individual problem like in previous scenario but it's a global issue it's all about our entire human race's future. These thoughts leads us to a pollution free vehicle concept but as it is very difficult to run a car without degrading it's performance so we searched on internet about fuel which doesn't produce any harmful gases like carbon dioxide, which is mainly responsible for global warming.

Keywords: compressed air engine, 4 strokes single cylinder engine, zero pollution.

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AN EXPERIMENTALSTUDYANDDEVELOPMENTOFCOMPRESSEDAIRENGINEIN4STROKESINGLECYLINDERS

Strictly as per the compliance and regulations of:

An Experimental Study and Development of Compressed Air Engine in 4 Stroke Single Cylinders

Krishan Kant [α], Pawan Sharma [σ] & Nishant [ρ]

Abstract- Fuel prices are going higher and higher and will be difficult for the people to cope with these price hikes, it affects our day-today life because due to higher fuel prices transportation cost is higher and thus all the transported items like eatables items etc. will cost higher. Not only the transportation costs burden on people but manufacturing all puts loads, electricity generation through diesel generators used in industries costs more due to hiked fuel prices and it ultimately puts burden on customers.

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Keywords: compressed air engine, 4 strokes single cylinder engine, zero pollution.

I. Introduction

A Compressed-air engine is a pneumatic actuator that creates useful work by expanding compressed air. A compressed-air vehicle is powered by an air engine, using compressed air, which is stored in a tank. Instead of mixing fuel with air and burning it in the engine to drive pistons with hot expanding gases, compressed air vehicles (CAV) use the expansion of compressed air to drive their pistons. They have existed in many forms over the past two centuries, ranging in size from hand held turbines up to several hundred horsepower. The laws of physics dictate that uncontained gases will fill any given space. The easiest way to see this in action is to inflate a balloon. The elastic skin of the balloon holds the air tightly inside, but the moment you use a pin to create a hole in the balloon's surface, the air expands outward with so much energy that the balloon explodes. Compressing a gas into a small space is a way to store energy. When the gas expands again, that energy is released to do work. That's the basic principle behind what makes an air car go. Some types rely on pistons and cylinders, others use turbines. Many compressed air engines improve their performance by heating the incoming air, or the engine itself. Some took this a stage further and burned fuel in the cylinder or turbine, forming a type of internal combustion engine.

One manufacturer claims to have designed an engine that is 90 percent efficient. Compressed air propulsion may also be incorporated in hybrid systems, e.g., battery electric propulsion and fuel tanks to recharge the batteries. This kind of system is called hybrid-pneumatic electric propulsion. Additionally, regenerative braking can also be used in conjunction with this system.

II. Components of Compressed Air Engine

Various Mechanical parts used in engine are:

a) Crank shaft
b) Connecting rod
c) Piston cylinder
d) Poppet Valves
e) Roller bearing

a) Crank Shaft

The crankshaft, sometimes casually abbreviated to crank, is the part of an engine which translates reciprocating motion into rotary motion or vice versa. Crank shaft consists of the shaft parts which revolve in the main bearing, the crank pins to which the big ends of the connecting rod are connected, the crank webs or cheeks which connect the crank pins and the shaft parts.

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b) Connecting Rod

Connecting rod is a part of the engine which is used to transmit the push and pull from the piston pin to the crank pin. In many cases, its secondary function is to convey the lubricating oil from the bottom end to the top end i.e. from the crank pin to the piston pin and then for the splash of jet cooling of piston crown. The usual form of connecting rod used in engines has an eye at the small end for the piston pin bearing, a long shank, and a big end opening which is usually split to take the crankpin bearing shells.

The connecting rods of internal combustion engine are mostly manufactured by drop forging. The connecting rod should have adequate strength and stiffness with minimum weight. The materials for connecting rod range from mild or medium carbon steel to alloy steels.

c) Piston Cylinder

A cylinder is the central working part of a reciprocating engine or pump, the space in which a piston travels. Multiple cylinders are commonly arranged side by side in a bank, or engine block, which is typically cast from aluminum or cast iron before receiving precision machine work. Cylinders may be sleeved (lined with a harder metal) or sleeveless (with a wear resistant coating such as Nikasil).

A cylinder's displacement, or swept volume, can be calculated by multiplying its cross-sectional area (the square of half the bore by pi) and again by the distance the piston travels within the cylinder (the stroke). The engine displacement can be calculated by multiplying the swept volume of one cylinder by the number of cylinders.

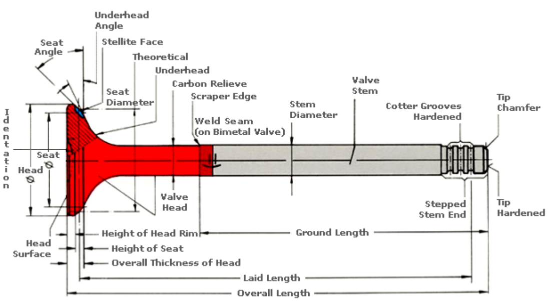
i. *Poppet Valves*

Poppet valves are used in most piston engines to open and close the intake and exhaust ports in the cylinder head. The valve is usually a flat disk of metal with a long rod known as the valve stem attached to one side.

The stem is used to push down on the valve and open it, with a spring generally used to return it to the closed position when the stem is not being depressed. At high revolutions per minute (RPM), the inertia of the spring makes it too slow to return the valve to its seat between cycles, leading to 'valve float'. In this situation desmodromic valves are used which, being closed by a positive mechanical action instead of by a spring, are able to cycle at the high speeds required in, for instance, motorcycle and auto racing engines .

d) Valve

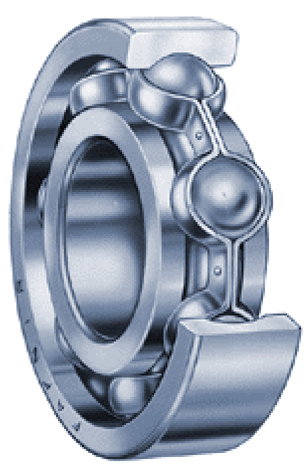
In very early engine designs the valves were 'upside down' in the block, parallel to the cylinders the so called L-head engine because of the shape of the cylinder and combustion chamber, also called 'flathead engine' as the top of the cylinder head is flat. Although this design makes for simplified and cheap construction, it has two major drawbacks; the tortuous path followed by the intake charge limits air flow and effectively prevents speeds greater than 2,000–2,500 RPM, and the travels of the exhaust through the block can cause overheating under sustained heavy load. This design evolved into 'Intake over Exhaust', IOE or F-head, where the intake valve was in the head and the exhaust valve was in the block; later both valves moved to the head.



e) Roller Bearing

The concept behind a bearing is very simple: Things roll better than they slide. The wheels on your car are like big bearings. If you had something like skis instead of wheels, your car would be a lot more difficult to push down the road. That is because when things slide, the friction between them causes a force that tends to slow them down. But if the two surfaces can roll over each other, the friction is greatly reduced.

Bearings reduce friction by providing smooth metal balls or rollers, and a smooth inner and outer metal surface for the balls to roll against. These balls or rollers "bear" the load, allowing the device to spin smoothly



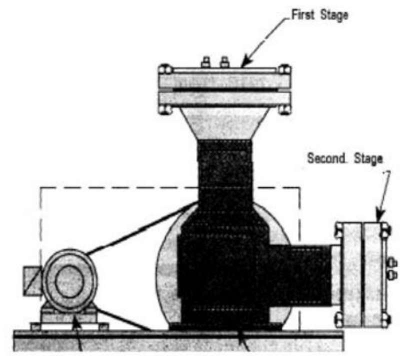
f) Compressor

A gas compressor is a mechanical device that increases the pressure of a gas by reducing its volume. Compressors are similar to pumps: both increase the pressure on a fluid and both can transport the fluid through a pipe. As gases are compressible, the compressor also reduces the volume of a gas. Liquids are relatively incompressible; while some can be compressed, the main action of a pump is to pressurize and transport liquids.

- *Classification*

Compressors are broadly classified as:

- Positive displacement compressor
- Dynamic compressor



III. Work Undertaken

As the fossil fuels are depleting day by day and burning them is causing a lot of pollution which is resulting into various environmental problems. Therefore, there is a need for a new fuel which is cheap, easy to find, in abundance and most importantly environment friendly. One such source that comes in mind is Air. With this project we will we able to run our vehicles on Air. In this project we are focusing to run 4-stroke engine using Compressed air and in turn cutting down the emission of greenhouse gases. Our main aim is to modify 4-stroke engine so that it can work on compressed air. Compressor is used for producing compressed air and after that compressed air is fed into the engine and pressure energy of compressed air exerts force on piston.

IV. Procedure

We have divided our project in various steps which made it easier for us to work. The various steps are as follows:

a) Collection of materials and components for our project

The project is a combination of different components namely compressor, engine, pressure gauges, pipes, nozzles etc.

Different components were collected by visiting different places during the project development phase. The compressor is available at the thermal lab in the college. Along with the compressor is a cylinder which can store the compressed air at maximum 14 bars. The compressor is a 2 stage reciprocating compressor. A 100cc Hero Honda Splendor engine was bought. A pressure gauge is also installed to control the pressure of the air flowing in the engine. Pipes are used to transfer air into the engine through the inlet valve of the engine via a pressure gauge. A tachometer is arranged from the college lab to read the rpm of the engine.

b) Modification of Camshaft

The camshaft is a very important part of an engine. A camshaft is a shaft to which a cam is fastened or of which a cam forms an integral part. It controls the opening and closing of the inlet and outlet valves so that fuel may enter the cylinder and the exhaust gases may leave the engine cylinder at the correct time. In our project, we have eliminated the use of spark plug.

The camshaft was constructed by joining a part of two different camshafts. Two camshafts were bisected axially with the help of an electric discharge machining (EDM). This task was completed at the NIT, KKR. Electric discharge machining (EDM), sometimes colloquially also referred to as spark machining, spark eroding, burning, die sinking or wire erosion, is a manufacturing process whereby a desired shape is obtained using electrical discharges (sparks).Material is removed from the workpiece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the 'tool' or 'electrode', while the other is called the work piece-electrode, or 'workpiece'. The bisected parts of two camshafts were joined together accordingly by gas welding the required parts to form a single camshaft. This camshaft has four lobes and they will work in such a way that the inlet and outlet valves will open and close alternatively in every stroke of the piston in the cylinder.

c) Installation of various components

After the modification of camshaft, this was the most important task in the project; we need to install other components which will work in tandem with each other. The various components to be installed are

- Compressed air cylinder
- Engine with modified camshaft
- Compressor
- Pressure gauge
- Nozzles
- Connecting pipes

i. *Perform Experiments*

After assembling all the components, we run the engine using only compressed air. Now, we have to perform various experiments on the engine. Different tests are performed to find out the efficiency of the engine.

- *Experiment 1*

RPM at different pressures of the compressed air

- *Experiment 2*

Time taken to empty 160 litre capacity tank at different pressure.

V. Fabrication/Development

a) Modification of Camshaft

The camshaft is the most important part of the whole project. Compressed air has to be injected into the cylinder through the inlet valve. As the compressed air is injected into the cylinder of the engine, it starts to expand. This moves the piston in downward direction and the kinetic energy is transferred to the crankshaft. Now, due to inertia of the flywheel, the piston moves in upward direction. This upward motion of the piston ejects the expanded air out of the engine through the exhaust valve. Thus in first stroke injection of compressed air takes place and in the second stroke expanded air is removed from the engine.

Two camshafts were bought. They need to be bisected axially i.e. cut into two pieces through their axes. This cutting is a work of precision as there is very less material to be wasted during cutting. So, to minimise material wastage during cutting, a very efficient method is adopted. The cutting action is performed by Wire Electric Discharge Machine (EDM). Electric discharge machining (EDM), sometimes colloquially also referred to as spark machining, spark eroding, burning, die sinking or wire erosion is a manufacturing process whereby a desired shape is obtained using electrical discharges sparks). Material is removed from the workpiece by a series of rapidly recurring current discharges between two electrodes, separated by a dielectric liquid and subject to an electric voltage. One of the electrodes is called the tool-electrode, or simply the 'tool' or 'electrode', while the other is called the workpiece-electrode, or 'workpiece'.

When the distance between the two electrodes is reduced, the intensity of the electric field in the volume between the electrodes becomes greater than the strength of the dielectric, which breaks, allowing current to flow between the two electrodes. This phenomenon is the same as the breakdown of a capacitor. As a result, material is removed from both the electrodes. Once the current flow stops (or it is stopped–depending on the type of generator), new liquid dielectric is usually conveyed into the inter-electrode volume enabling the solid particles (debris) to be carried away and the insulating proprieties of the dielectric to be restored. Adding new liquid dielectric in the inter-electrode volume is commonly referred to as flushing. Also, after a current flow, a difference of potential between the two electrodes is restored to what it was before the breakdown, so that a new liquid dielectric breakdown can occur.

The cutting on EDM gives four pieces from two camshafts. Two pieces are selected from these to form a single camshaft. These two pieces are joined together by gas welding. Welding gives very bad surface finish which if not fixed can cause a lot of vibrations and noise in the engine.

b) Assembling Components

Another important part of the project is the air compressor. For this project, a multi- stage air compressor is used which compresses the air and stores it in a 160 litre cylinder at maximum 10 bars. Multistage compressors are used in place of single stage compressors, because if the compression is done in one stage then the heat generated may be excessive and also material of construction would have to be of very high grade and possibly too expensive. Also power consumption of a single stage compressor would be higher.

The compressor cylinders of these compressors are lubricated with oil and hence the compressed air discharged from the compressor shall always contain traces of oil. Basic principal is that on the suction stroke of the first-stage piston, air at atmospheric pressure enters the cylinder through the inlet filter and valve located in the airhead. On the compression stroke of the first stage piston, the air is compressed to an intermediate pressure and discharged through the valve in to a common manifold. From the manifold, the air passes through the inter-cooler tubes, where the heat of first stage compression is removed by the action of the fan passing cool air over the inter-cooler tubes. On the suction stroke of the second stage piston this cooled air enters the second stage cylinder through the inlet valve. The compression stroke of the second stage piston compresses the air to the final discharge pressure and forces it out through the valve in to the receiver or system.

In a two stage air compressor, the air/gas is compressed to a certain pressure, which would be much lower than ultimately desired pressure in the first stage. This air is then passed through a heat exchanger called 'inter cooler', where the hot compressed air is cooled down, and then the air is further compressed to the final discharge pressure. In compressors where there are more than 2 stages of compression there shall be more than one inter-cooler. Two stage machine are equipped with highly efficient inter cooler tubes that provide maximum heat disperse between stages of compression. If cooling of the discharged air is required, a water-cooled or air-cooled after cooler should be installed between the compressor discharge and the receiver or system.

c) Engine Servicing

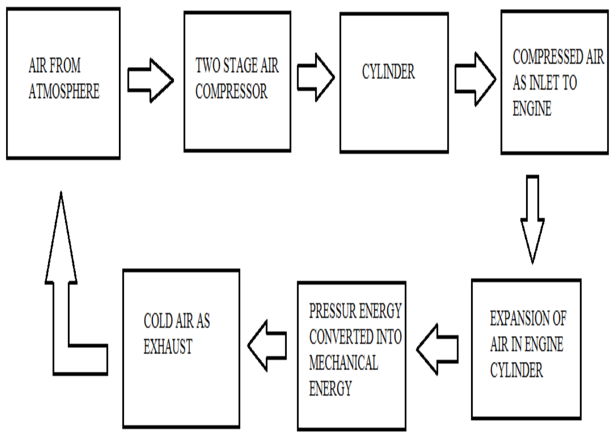
The engine from the previous project is taken and the camshaft is modified to work with compressed air. The engine was not in good shape to be used for this project. Because of this, proper servicing had to done. We overhauled the engine in the thermal lab and cleaned all the parts thoroughly with diesel. The old piston rings were also replaced by new ones as they were not in good shape. The new gaskets were placed to improve the sealing of the engine.

VI. Working of Project

All the components are connected with each other to form a working unit. Compressed Air is released from the cylinder by opening the outlet valve of the cylinder. The pressure can be controlled with the help of the valve. The compressed air moved through the pipe to the inlet of the pressure gauge. The pressure gauge shows the pressure of the air flowing into the engine. The amount of air entering the engine can be controlled by a valve.

When the air reached the inlet valve of the engine, a small amount of momentum need to be given to the flywheel of the engine, this is done by kicking up the engine.

The kick brings the engine to life and the engine keeps running on its own until the compressed air is forced into it. The RPM of the flywheel can be recorded with the help of a tachometer. It can be easily seen that as we increase the pressure of the compressed air supplied to the engine, the engine roars louder i.e. the rotatory speed of the flywheel of the engine is increased.



Working of Compressed Air Engine

VII. Results and Discussion

a) Analysis

This project is Compressed air engine and for experimental work, a 4-stroke engine is used. We have modified the camshaft in such a way that it allows the 4-stroke engine to work as 2-stroke engine. This means there will be one power stroke in one complete rotation of crankshaft. Air is freely available in the atmosphere.

- *According to ideal gas equation*

PV=nRT

Where,

P = Pressure

V = Volume

N = No. of moles

R = Universal Gas constant

T = Temperature

In the above equation, n, R & T are usually taken as constant. From the above equation, it can be seen that volume is inversely proportional to pressure. When the volume of any gas decreases its pressure increases. This means that when air is compressed into a smaller volume its pressure increases. Due to this, a large amount of energy is stored in air as pressure energy. When this compressed air expands, it releases its stored energy which can be used to work. As we have read and studied about Compressed Air, we came to know that it can easily replace other fuels. Moreover, it is more powerful than petrol.

Theoretically, the benefits of using Compressed Air in engine are known but to confirm them, various experiments are conducted. Therefore, experiments are conducted by introducing Compressed Air in the engine at different pressure and corresponding r.p.m of crank shaft is noted. Tests regarding the engine performance are done and also the effects of Compressed Air on the engine components are observed.

The experiments conducted on the engine are as follows:

At Constant Pressure

a) Experiment.1

Readings of Engine Running on compressed air at Constant pressure.

S.No.	Pressure (bar)	RPM		Mean RPM
		Min.	Max.	
1.	2	245	255	250
2.	3	455	465	460
3.	4	565	575	570
4.	5	710	720	715
5.	6	895	905	900

Running the engine on compressed air keeping the Pressure constant

b) Experiment #2

Running the engine on 160 litres capacity compressed air filled cylinder and note its time duration at different pressure.

S.No.	Pressure (bar)	Time (sec)
1.	2	670
2.	3	425
3.	4	332
4.	5	207
5.	6	162

As it has been mentioned earlier that compressed air can replace other fuels. We have modified 4-stroke engine to 2-stroke because air compressor sucks the air from atmosphere and compresses it. So, there is no need of suction and compression stroke separately in the engine. As the compressed air is injected in the engine, it expands and releases the energy stored in the compressed air and thus pushes the piston from TDC to BDC. Thus completes the power stroke. After that, when the piston moves from BDC to TDC, it ejects the cold air as exhaust to atmosphere.

In this way, 2 stroke cycles is more compatible with compressed air as fuel rather than 4 stroke cycle.

- *According to first experiment*

When we varied the pressure and noted the corresponding RPM, we observed that with the increase in pressure, there is an increase in RPM.

- *According to second experiment*

When we measured the time taken to empty the 160 litre capacity cylinder with respect to different pressure, we observed that with the increase in pressure, the time taken by cylinder to empty decreases.

From the above experiments, we can assume 3 bar as the ideal pressure for running the compressed air engine to obtain ideal RPM. At 10 bar pressure, we obtained 5000 RPM which can run the vehicle at a velocity of around 100 km/hr.

By making certain changes in the engine, we can increase its efficiency and it can be used to drive the vehicles. We can reduce the overall weight of the vehicle and engine by using carbon fibre and aluminium alloys instead of steel parts.

There are always having some benefits and drawbacks of a new technology. This will also have, let's see all of them in brief.

Compressed-air vehicles are comparable in many ways to electric vehicles, but use compressed air to store the energy instead of batteries. Their potential advantages over other vehicles include:

- Much like electrical vehicles, air powered vehicles would ultimately be powered through the electrical grid which makes it easier to focus on reducing pollution from one source, as opposed to the millions of vehicles on the road.
- Transportation of the fuel would not be required due to drawing power off the electrical grid. This presents significant cost benefits. Pollution created during fuel transportation would be eliminated.
- Compressed-air technology reduces the cost of vehicle production by about 20%, because there is no need to build a cooling system, fuel tank, Ignition Systems or silencers.
- Air, on its own, is non-flammable.
- The engine can be massively reduced in size.
- The engine runs on cold or warm air, so can be made of lower strength light weight material such as aluminium, plastic, low friction Teflon or a combination.
- Low manufacture and maintenance costs as well as easy maintenance.
- Compressed-air tanks can be disposed of or recycled with less pollution than batteries.
- Compressed-air vehicles are unconstrained by the degradation problems associated with current battery systems.
- The air tank may be refilled more often and in less time than batteries can be recharged, with re-filling rates comparable to liquid fuels.
- Lighter vehicles cause less damage to roads, resulting in lower maintenance cost.
- Refuelling the compressed-air container using a home or low-end conventional air compressor may take as long as 4 hours though the specialized equipment at service stations may fill the tanks in only 3 minutes.

VIII. Motivation

In recent years, the price of petrol and diesel fuels is going to increase day by day. And the conditions are that vehicles are more and fuel is less. To drive vehicles are not easy for common people. Fuel price hike means that it would grossly affect the calculations that a middle class person has in mind while buying a vehicle. It may be easy to drive vehicles for rich people but not for the poor people.

So, we are working on a project to drive vehicle by using Compressed air. Because air is in abundant amount on earth.

This project will give us benefits as given below:-

i. *No Greenhouse Gas Emissions*

Gasoline and diesel powered vehicles emit greenhouse gases (GHGs) mostly carbon dioxide (CO2), that contribute to global climate change. Compressed air engine is powered by air which emits no GHGs from their tailpipe only cold air.

ii. *Less Air Pollutants*

Highway vehicles emit a significant share of the air pollutants that contribute to smog and harmful particulates in the U.S. CAVs powered by air emit no harmful pollutants.

iii. *Cuts Oil Dependence*

CAV could cut dependence on foreign oil since air can be derived from anywhere; it is a renewable resource. That would make our economy less dependent on other countries and less vulnerable to oil price shocks from an increasingly volatile oil market.

iv. *Increase Engine Life*

No knocking and heat produced therefore it increases engine life.

The engine has injections similar to normal engines, but uses special crank shaft and piston, which remain at TDC for about 70% of the engine's cycle. This allows more power to be developed in the engine.

In normal engine, there is overlapping of inlet and exhaust valves. In 360 degree rotation of crankshaft, the inlet valve remains open for 250 degree and the exhaust valve remains open for 240 degree. Both the valves overlap each other for 120 degree because of which there is a lot of pressure loss. This can be overcome by using solenoid valve which is electronically controlled and is more accurate than mechanical system.

IX. Conclusion

Results obtained by conducting tests on the engine by running the engine on compressed air, we conclude that the compressed air stores energy and that can be utilized for future use. The internal combustion engine is still the predominant means of propulsion, and we have made great strides in reducing its impact on the environment. We have also come a long way in solving the practical problems of electric vehicles, and in developing applications that make full use of their potential. And of course, need leads the world in hybrid technology. Hybrid vehicles have been contributing to a cleaner environment since 1997. Finally, Compressed Air Technology (CAT), which is the zero emission vehicle, may become the ultimate power source of the 21st century. We can use it as an energy storage devices like batteries, fossil fuels etc. It can eliminate batteries in electric cars, fossil fuels from IC engine cars. This will not only lower down monthly fuel costs but also help to put some effort in controlling global warming and many other air pollution issues. After studying various research papers and by this experiment we can conclude that compressed air can be used as fuel in an engine. It does not require cooling system as it produces cool air after expansion in exhaust. Thus, we conclude that this will lower down the maintenance cost of the vehicles which is ultimately beneficial at individual level and also at global level as it will bring down pollution levels.

The compressed air from the storage tank is supplied to the engine. The compressed air which expands in the cylinder moves the piston down. When the piston moves up the exhaust valve opens and the expanded air is pushed out. The linear up and down motion of the piston is converted to the rotary motion of the crank and crank shaft. This is transferred to the wheels by transfer mechanisms.

The output is cooled air. So, no polluting gases are released but only pure air which will help in cutting down the carbon emissions into the atmosphere and in turn bring down the pollution level of air. There is no burning of fuel so no heat is produced, so it helps increase the life of engine. This will give longevity to the life of engine with good performance. The maintenance cost of the complete vehicle will come down with increase in life and no environment polluting emissions.

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Selection of Appropriate Control Valves for Vacuum Systems

By H. M. Akram
Quaid-I-Azam University, Pakistan

Abstract- It is believed that a vacuum system designed for precise vacuum control will be much better from ample technical point of views with the convenience of better performance. Vacuum control valves are used for this purpose. These valves are mechanical devices employed to start, stop, fine control, adjust and maintain the required vacuum levels as well as for desired accurate flow rates of the process fluid in the vacuum system. As systems of various vacuum ranges are the requirement of different processes and research works, therefore the selection of such valves for diverse vacuum ranges is the matter of prime importance. Moreover, selection of the proper vacuum valve also involves a thorough knowledge of the process and processing fluid for which it will be used, the material of which it is made, in what geometry the valve is to fit and the size it must has to perform its designated task accordingly. Further more, the possible adverse occurrences that can take place in the system should also be observed for appropriate valve operation. In this paper effort is made to briefly deliberate these facts along with some guide lines regarding the selection of suitable vacuum valves for different vacuum systems.

Keywords: vacuum valve, selection criteria, fine control, vacuum system.

GJRE-A Classification : FOR Code: 091399

SELECTIONOFAPPROPRIATECONTROLVALVESFORVACUUM SYSTEMS

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Keywords: vacuum valve, selection criteria, fine control, vacuum system.

I. Introduction

Vacuum valves are basically mechanical devices constructed by different materials. These are installed in the vacuum system for multiple purposes like isolation, air-admittance, throttling, adjust & maintain the required vacuum levels as well as for accurate flow rates of the process fluid in the vacuum system. As for as the construction of a conventional valve is concerned, it comprises the housing or body that encloses the valves' mechanism vacuum leak tight as well as contains inlet and outlet ports, the bonnet, through which the motion from the external atmospheric side is transmitted, and the stem which transfers this motion to the valve disc that opens or closes the flow passage depending on its position [1]. There is diversity of vacuum valves available. Some commonly used valves in the vacuum systems are shown in figure-1. Since the valves are important part of the vacuum system, consequently care should be taken to ensure that the precise valve is selected for a specific vacuum range to ease the required process. In case of

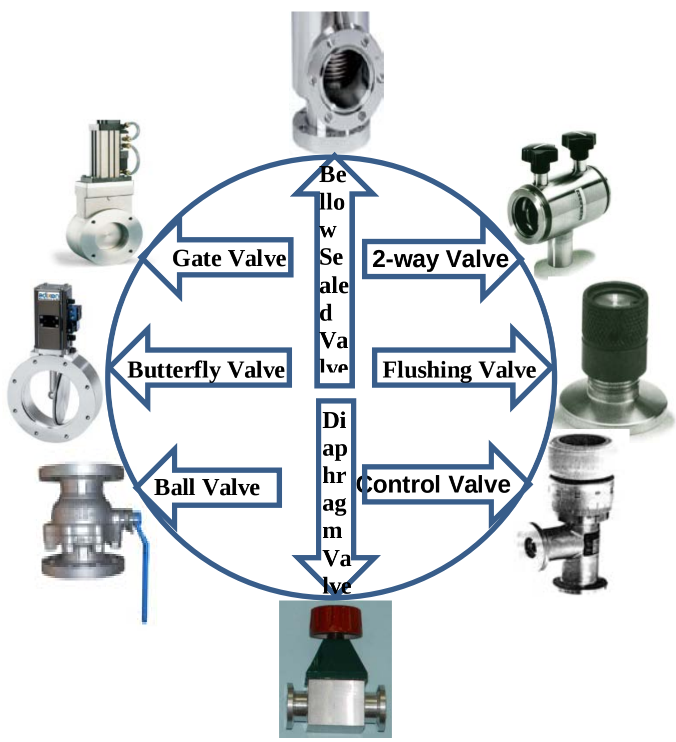

Figure 1 : Some valves commonly used in vacuum systems

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improper selection, valves can cause operational problems, including poor control, cavitation consequence, reduced conductance, and hydraulic transients that result the effects like poor performance, accelerated wear, repair, and replacement of the valve [2].The vacuum valves are classified on the basis of operating system. Classification of the systems forming a valve is shown in figure-2[3].

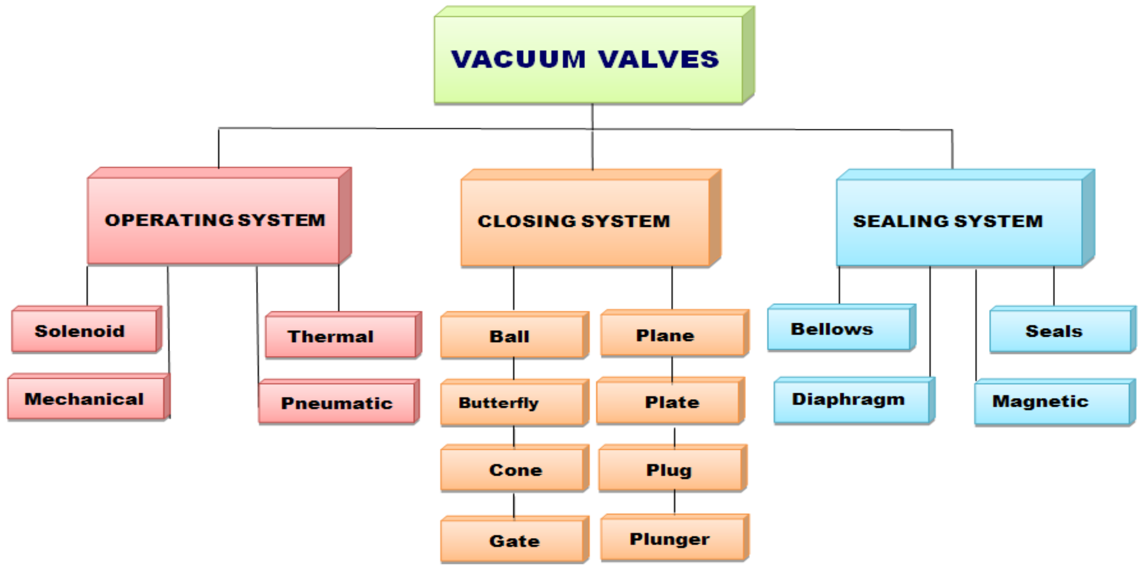

Figure 2 : Classification of the systems forming a valve

II. Valve Selection

There are diverse contemplations regarding the appropriate valve selection. Firstly, the valve should be selected according to the vacuum range in which the specific process has to take place. Secondly, which type of valve and its material is the most suitable for smooth process handling of the fluid in the vacuum setup, along with its long time suitability, compatibility and durability? Thirdly, the parameters like the size, geometry, flow capacity and conditions, shutoff response to leakage, virtual leak, temperature limits, cost, actuation, operational speed and time, port configuration, conductance, life cycles, maintenance ease, etc. Therefore, these considerations will briefly be discussed stepwise on the basis of various parameters in the following manner.

a) *Valve Selection on Vacuum Range Basis*

Vacuum has many ranges categorized on the basis of molecular density in the vacuum environment. These ranges along with molecular density are given in the table-1 [4]. Different vacuum valves are selected according to these vacuum ranges for their first-rate performance

Table 1 : Vacuum ranges along with molecular density

Range	Pressure (mbar)	Particle density (n/cm^3)
Atmospheric pressure	1×10^{3}	2.5×10^{19}
Low Vacuum	$1\times10^{3} - 1\times10^{0}$	$2.5\times10^{19} - 3.5\times10^{16}$
Medium Vacuum	$1\times10^{0} - 1\times10^{-3}$	$3.5\times10^{16} - 3.5\times10^{13}$
High Vacuum	$1\times10^{-3} - 1\times10^{-6}$	$3.5\times10^{13} - 3.5\times10^{10}$
Very high Vacuum	$1\times10^{-6} - 1\times10^{-9}$	$3.5\times10^{10} - 3.5\times10^{7}$
Ultra High Vacuum	$1\times10^{-9} - 1\times10^{-12}$	$3.5\times10^{7} - 3.5\times10^{4}$
Extreme High Vacuum	$1\times10^{-12} - 1\times10^{-15}$	$3.5\times10^{4} - 3.5\times10^{1}$

i. *Low and Medium Vacuum Valves*

Good quality commercial valves intended for pressure service are almost practically satisfactory for low vacuum range applications. Caste valves are acceptable for use in these ranges because out gassing and other sources of virtual leaks do not contribute significantly to the observed leakage rate. Moreover permeation is not a consideration in these vacuum ranges [5]. Therefore, the normal valves like ball valves, diaphragm valves, butterfly valves, gate valves, bellow sealed valves etc. can be used for these ranges.

Ball valves have many designs. One style of these valves has a spherical plug with a cylindrical hole drilled through to form the flow passage. For full-ported designs, the flow passage is the same diameter as the inside pipe diameter. These valves being low-cost and rugged are used in fore lines of the vacuum systems with low vacuum applications.

Diaphragm valves have good shut-off characteristics and there are no cavities that affect the flow of the fluid when open. These valves are constructed from either plastic or metal. Because the material of the membrane can chemically degrade, so the diaphragm valves are used for low vacuum range. It is suitable for the pharmaceutical and food industry.

Butterfly valves consist of a disc attached to a shaft with bearings used to facilitate rotation. The disk and seating is of varying designs. These valves are available in a range of sizes large enough to isolate diffusion pumps as well as small enough for many fore line applications. These are good for situations with straight flow. They are generally desirable due to their small size, which makes them a low cost control valve.

Gate valves are devices that are used for the flow of process fluid through a structure or aperture by opening, closing or obstructing a port or passage way. Gate valve applications include isolation between vacuum volume and pump, isolation between chamber and load lock during sample introduction, access between chamber and load lock during sample transfer, and isolation between synchrotron beam lines and experimental stations. Its actuation is available in manual as well as electropneumatic configurations. In open position these valves provide maximum clearance and conductance.

Bellow Sealed valves have metallic body and stainless steel bellow with seals made of different materials. These valves are of different sizes, geometry either straight through or right angled and can be operated manually or electropneumatically.

ii. *High and Very High Vacuum Valves*

Normally conventional valves are not acceptable for high and very high vacuum applications. Fine quality valves are used for these vacuum ranges, Interior surfaces of valves for such ranges must be properly machined and polished to minimize out gassing. Also the use of metal bellows to seal the shaft stem is standard, and the metal gaskets are used for the bonnet-to-body sealing. For high and very high vacuum ranges, fine quality high performance butterfly valves, gate valves, bellow sealed valves with some added features are used. They are installed in the vacuum system with metallic seals as elastomeric seals are avoided for such vacuum ranges due to their high out gassing rate.

iii. *Ultra High and Extreme High Valves*

For Ultra High Vacuum (UHV) and Extreme High Vacuum (XHV) ranges, specially made all metal valves are used. These valves are usually fabricated systematically from fine quality Stainless Steel or other suitable material having low out gassing rate. The internal surfaces of these valves are finished to the best quality and polished. Furthermore, these are with Conflate Flange (CF) and installed in the vacuum system with Oxygen Free High Conductivity (OFHC) Copper gasket using proper sealing torque, which is great enough to deform the Copper gasket on the valve CF knife-edge conical seat to make this joint leak tight [6]. The main reason that these valves are used in UHV and XHV with OFCS is to minimize the out gassing rate from these components which is the essential requirement for such uppermost quality vacuum ranges. Due to all metal assembly, these valves can be baked to high temperature for further reducing out gassing rate. These valves have different port geometry like straight through ports, right angled, 45 degree ports for simple system designing with maximum conductance. Excellent material gate valves are also used in this vacuum range as per requirement of the system.

iv. *Valve Selection on Control Basis*

Fine control valves are fitted in the vacuum systems of diverse vacuum ranges as given in table-1 to control precise flow rate for the desired vacuum level by fully or partially opening or closing as per requirement. They are mostly used to admit gas into a vacuum chamber or system at a controlled leak rate and less frequently to backfill a vacuum chamber to low pressure. These valves provide the essential control using a variable restriction created by a rotating plug or disk, a sliding sleeve or using a flexible membrane. Even when fully open, a control valve's low conductance means it should not be installed between a pump and vacuum volume. Other choice is needle valve used for precise flow control. In this valve a tapered stem fits into a conical sleeve. Moving the stem (needle) in/out changes the valve's conductance and consequently the gas flow rate through it. The needle's shaft is typically sealed by a dynamic O-ring or PTFE block. Another type of valve is air-vacuum or flushing valve generally used to admit air slowly at low pressure for the safety of the installed various equipment in the vacuum system.

b) Valve Selection on Material Basis

There is a variety of vacuum valves available. But it is generally not sufficient to simply select the type of valve suited to certain process parameters. Material with which the valve is made is also very important. Selection of valve fabricated with materials compatible with the process fluid helps ensure its lifespan and operation as well as the protection of the system. Valve construction materials include stainless steel, aluminum, brass and other suitable material. The choice of the valve material depends on the required bake out temperature, pressure range, and the construction material of the remaining vacuum system. Selecting the most appropriate materials of construction for valves is guided primarily by the service of the valve, then secondarily by cost; the least expensive material that is compatible with the service will be chosen to be used. Proper material selection promotes safety by avoiding the reaction of valve material with the process fluid. The standard materials need to be selected carefully as the parts made by these materials come into contact with the process fluid. These generally include the ball (for ball valves), the disk (for butterfly valves), the bellow (for bellow sealed valves) and the plug (for plug valves). This also includes the seats, which is the area where the valve disk "sits" when closed to provide the actual shut off. The material of seals and the valve body is also requires the same consideration during the material selection. [7]. All valves, small or large, should be constructed from materials whose out gassing load is low enough so that it does not contaminate the process at the operating vacuum.

c) Valve Selection on Design & Size Basis

After the selection of a specific valve type for a process, the next step is to figure out the size of the valve need to be installed in the vacuum system. Design and size of vacuum valves is determined by the size of the system for specific application. The valve may be small or large. Small valves are defined as valves with inside diameter less than 2 inches while the valves with inside diameter more than 2 inches are called large valves [8]. Valve should have maximum conductance for gas flow and long operating life [9]. The parameters to consider in valve sizing are the size and geometry of the system ports. The valve connecting ports should be of the same size and type as that of the vacuum system. The geometry of the valve should be well matching with that of the vacuum system. Vacuum valves are either straight through (ports at 180 degree) or corner (ports at 90 degree) or semi-corner (ports at 45 degree) valves. The selection of the right geometry valve ensures the appropriate conductance , rapid evacuation and proper flow rate The fluid flow characteristics are also important to make sure an appropriate size of the desired valve. Further typical criteria and requirements regarding the vacuum valve selection are listed in table-2 [1].

Table 2 : Typical criteria and requirements on vacuum valves

CRITERIA	REQUIREMENTS
Tightness of housings and valve seats	**Leak rate ≤ 10^{-9} mbar l s^{-1} (10^{-7} Pa l s^{-1})**
Differential pressure at valve disc	**At least 1 bar (10^5 Pa)**
Conductance	**Should be high. Resistance of flow should not impede gas flow noticeably**
Differential pressure when opened	**Should be as high as possible, e.g., 1 bar**
Description	**Appropriate materials and components** necessary
Bake-ability	**Maximum temperatures, e.g., 200 °C w when open, 150 °C when shut**
Service life	**As high as possible**
Safety criteria	**Self-shutting in the event of power failure**

From the above discussion it is quite obvious that there are various types of vacuum valves available for putting into practice in the vacuum systems.But an ideal valve should be selected. An ideal valve should meet specific requirements that have been briefly listed in table-2[3].

Table 3 : Requirements of an Ideal Vacuum Valve

AN IDEAL VALVE SHOULD MEET THE BRIEFLY LISTED SPECIFIC REQUIREMENTS:

- It should consist of minimum parts, with smallest surface area to reduce outgassing rate.
- It should have maximum conductance in open position without increasing system volume.
- It should have minimum possible leak rate through the closing system when it is closed.
- It should be mechanically strong, simple to construct, dismantle and reassemble.
- It should operate according to predetermined pressure or time or sequence.
- It should have leak tight seals between the body, the bonnet and the stem.
- It should have positive action not influenced by pressure difference.
- It should have body and bonnet made from non-porous materials.
- It should have very small virtual leaks due to its internal fittings.
- It should have the shape corresponding to its location on plant.
- It should have the minimum possible leak rate from outside.
- It should not contain materials with high vapor pressure.
- It should be able to operate at large ranges of pressures.
- It should have not double welds or other trapped areas.
- It should be easy to operate remotely or by interlock.
- It should be bankable to the required temperature.
- It should be chemically resistant to the process fluid.
- It should operate rapidly for the required action.
- It should be capable of a number of cycles.
- It should be easy to clean thoroughly.
- It should be easy to install.

Unfortunately no valve can meet all these requirements. Consequently, in selecting a valve for a specific application a compromise should be made, insisting on the most significant requirements for the desired particular purpose.

III. Conclusion

Vacuum control valves are the vital part of the vacuum systems. There is a variety of such valves available that can be put into practice in the vacuum system to carry out multiple functions. But the selection

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knowledge of the vacuum valve parameters like size, geometry, material, surface finish, vacuum range, flow capacity and conditions, shutoff response to leakage, temperature limits, cost, actuation, operational speed, port configuration, conductance, suitability, reliability, durability, life span, resistance to reaction, remote or interlock facility, installation, cleaning, dismantling and reassembling, leak rate, virtual leak, vapor pressure, out gassing, etc., are very essential. All these parameter have briefly been deliberated in this paper.

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New Nonlinear Damage Law by Fatigue based on the Curve of Bastenaire

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Summary- This article focuses on the improvement of the nonlinear damage law by fatigue of Chabobe. It is a solution to the dependency problem of parameters of the law vis-à-vis the SN curve of the material used for their production. The determination of the parameters, or wedging of the law, has the drawback of smoothing by linear regression the points of SN curve in a particular space specific to the law, called wedging space. So doing, the law is based on the regression line points, different from the actual SN curve of the material. The evolution of fatigue damage and hence the lifetime are then modified. The main idea is to develop a new damage law model, such as the SN curve generated by this formalism is identical to the one used to describe the fatigue behavior of the material under constant amplitude. In the present case, it's obviously the SN curve of Bastenaire model.

Keywords: uniaxial fatigue; damage law; lifetime; wedging; bastenaire.

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NEW NONLINEARDAMAGELAWBYFATIGUEBASEDONTHECURVEOFBASTENAIRE

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B. Tikri [α], N. Ngarmaïm [σ], M. Barka [ρ], N. Kimtangar [ω], F. Pennec [¥] & J.-L. Robert [§]

Summary- This article focuses on the improvement of the nonlinear damage law by fatigue of Chabobe. It is a solution to the dependency problem of parameters of the law vis-à-vis the SN curve of the material used for their production. The determination of the parameters, or wedging of the law, has the drawback of smoothing by linear regression the points of SN curve in a particular space specific to the law, called wedging space. So doing, the law is based on the regression line points, different from the actual SN curve of the material. The evolution of fatigue damage and hence the lifetime are then modified. The main idea is to develop a new damage law model, such as the SN curve generated by this formalism is identical to the one used to describe the fatigue behavior of the material under constant amplitude. In the present case, it's obviously the SN curve of Bastenaire model.

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I. Introduction

The existence in the literature of a large number of damage laws by fatigue for predicting lifetime of structures subjected to varying loads in service illustrates the difficulties of actually having a universal law to forecast lifetime [2]. Although the phenomenon of failure by fatigue of mechanical components subjected to cyclic mechanical strain was discovered more than a century by Wöhler, this type of damage remain still an outstanding event in terms of reliability. However, much progress has been made both in terms of its phenomenological characterization as of understanding of its mechanisms.

Among the proposed damage laws since several decades, the law of Chaboche has always seemed promising although its practical application raises some issues. The attractive aspects of this law are multiple: nonlinear evolution and accumulation of damage, influence of "small" cycles (cycles below the endurance limit) as soon as the damage is initiated, sequence effect (influence of the appearance order of cycles) and the effect of mean stress [3]. The implementation of Chaboche law faces an important challenge from the material parameters determination point of view. It requires the knowledge of the SN curve of the material which undergoes a linear regression in a reference particular and own to the law. Doing so, it significantly changes the SN curve and therefore deviates from the actual behavior of the material. This work is aimed toward the study and the resolution of this disadvantage. First are presented the issues of wedging of the Chaboche law and its impact on the estimated lifetime. An alternative is then proposed by modifying the formalism of the law in order to clear its sensitivity to the wedging field.

II. Presentation of the Chaboche Law

The implementation of the law of Chaboche is presented here; it helps to highlight the issue faced during its wedging.

a) Differential expression of the law

The increment δD of damage by fatigue generated by δN amplitude cycles σ_a and of σ_m average value is given by:

$$\delta D = \left[1-(1-D)^{\beta+1}\right]^{\alpha}\left[\frac{\sigma_a}{M_0(1-b\sigma_m)(1-D)}\right]^{\beta}\delta N \qquad (1)$$

With: - b, β and M_0 are coefficients specific to the material; b is the slope of Haigh traction diagram, modeled linearly as following: $\sigma_A(\sigma_m) = \sigma_{-1}(1-b\sigma_m)$

- $\sigma_A(\sigma_m)$ is the amplitude of the fatigue limit of the material under average stress σ_m , σ_{-1} is fatigue limit of the material in alternating symmetrical tensile (R= –1).
- The coefficient α is defined by:
  - For a cycle located above the endurance limit of the material (and called "large" cycle), $\sigma_a > \sigma_A(\sigma_m)$:

$$\alpha = 1 - a\left\langle\frac{\sigma_a - \sigma_A(\sigma_m)}{Rm-\sigma_m-\sigma_a}\right\rangle = 1 - a\frac{\sigma_a - \sigma_A(\sigma_m)}{Rm-\sigma_m-\sigma_a}$$

  - For a "small" cycle, $\sigma_a \le \sigma_A(\sigma_m)$: $a = 1$

b) Integration of differential law

The cumulative damage is done cycle by cycle for all cycles encountered during loading. The lifetime of the material is determined by integration of the differential damage law [1] knowing that the initial damage is zero (virgin material) and reaches unity when the crack initiation appears. Distinct values of the parameter α depending on the type of cycle met

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("small" or "large" cycle) generate two different integration formalisms of the damage.

i. *Integration of damage in case of small cycle*

The application of small cycle defined by (σ_a, σ_m), change the damage from Di value to Dj value. The integration of the damage in this case is given by:

$$\frac{1}{\beta+1}\ln\left(\frac{1-(1-D_j)^{\beta+1}}{1-(1-D_i)^{\beta+1}}\right)=\left[\frac{\sigma_a}{M_o(1-b\sigma_m)}\right]^{\beta} \quad (2)$$

By putting :

$$\begin{cases} X_i=\left[1-(1-D_i)^{\beta+1}\right]^{a} \\ X_j=\left[1-(1-D_j)^{\beta+1}\right]^{a} \end{cases} \quad (3)$$

The cumulative damage after applying the small cycle (σ_a, σ_m) is given by:

$$X_j=X_i\cdot e^{aM_o^{-\beta}(\beta+1)\left[\frac{\sigma_a}{(1-b\sigma_m)}\right]^{\beta}} \quad (4)$$

X appears as a functional damage whose characteristic is to cancel or be equal to unity at the same time as D. Note that if the level damage Di is zero initially, it remains after the application of small cycle. Small cycles do not contribute to material damage once the damage is initiated.

ii. *Integration of damage in case of large cycle*

The application of a large cycle defined by (σ_a, σ_m), moves the material damage from D_i value to Dj value. The integration of damage is then given by the following:

$$\left[1-(1-D_j)^{\beta+1}\right]^{1-\alpha}-\left[1-(1-D_i)^{\beta+1}\right]^{1-\alpha}=(1-\alpha_j)(1+\beta)\left[\frac{\sigma_a}{M_o(1-b\sigma_m)}\right]^{\beta} \quad (5)$$

Under constant amplitude, the integration leads to the SN curve expression within the meaning of the law of Chaboche; it is given by:

$$N_f=\frac{1}{aM_o^{-\beta}(1+\beta)K}\left[\frac{(1-b\sigma_m)}{\sigma_a}\right]^{\beta} \quad (6)$$

Where:

$$K=\frac{1-\alpha}{a}=\frac{\sigma_a-\sigma_A(\sigma_m)}{R_m-\sigma_m-\sigma_a}$$

N_f is the number of cycles at crack initiation within the material under constant amplitude loading defined by the (σ_a, σ_m).

By repeating,

$$X_i=\left[1-(1-D_i)^{\beta+1}\right]^{a} \quad \text{et} \quad X_j=\left[1-(1-D_j)^{\beta+1}\right]^{a},$$

the equation (5) of the integration of damage becomes:

$$X_j^{K_j}=X_i^{K_j}+\frac{1}{N_{fj}} \quad (7)$$

III. Wedging Principle of the Law

The damage cumulative observed in the case of a small cycle and a large cycle (equations (4), (6) and (7) respectively), requires the determination of the material parameters β and $aM_0^{-\beta}$. This step is the wedging of the law.

The application of an alternating symmetrical tensile-compression stress with constant amplitude $\sigma_m = 0$, $R = -1$) simplifies the expression [6] of the material lifetime N_f:

$$N_f=\frac{1}{aM_o^{-\beta}(\beta+1)K}\left(\frac{1}{\sigma_a}\right)^{\beta} \quad (8)$$

Giving:

$$\ln(N_f.K) = -\beta\ln\sigma_a - \ln(aM_o^{-\beta}(\beta+1)) \quad (9)$$

or again:

Y = AX + B

With: $\begin{cases} Y=\ln(K.N_f) \\ X=\ln\sigma_a \\ B=-\ln\left(aM_0^{-\beta}(\beta+1)\right) \\ A=-\beta \end{cases}$

The values of σ_a and N_f to be used for the determination of these parameters are those points of the SN curve of Bastenaire in symmetrical alternating traction. The selection of all known points of the SN curve or part of them only defines what is called the wedging windows of the law.

The SN curve subtended by the damage law of Chaboche is then based on equation [9] a straight line in reference (ln σ_a; ln(K.Nf)), reference that is later called the wedging space. To obtain both $aM_0^{-\beta}$ and β coefficients used in the damage integration, the points of the SN curve of the material (expressed using Bastenaire model) are placed in the wedging space (Figure 1). A linear regression of all those points or of part of them leads in practice to the determination of $aM_0^{-\beta}$ and β.

The main problem of wedging of the Chaboche law lays in the fact that the Bastenaire SN curve of the material is not linear in the wedging space, even if we consider as window all the curve or only part of it. No specific guidance is made by the author of the law [1]. This will practically generate under uniaxial fatigue with constant amplitude a lifetime prediction significantly different from those projected by the SN curve intrinsic of material. The use under uniaxial fatigue with variable amplitude, of a law that does not match the SN curve of material in fatigue under constant amplitude is a failure in its principle.

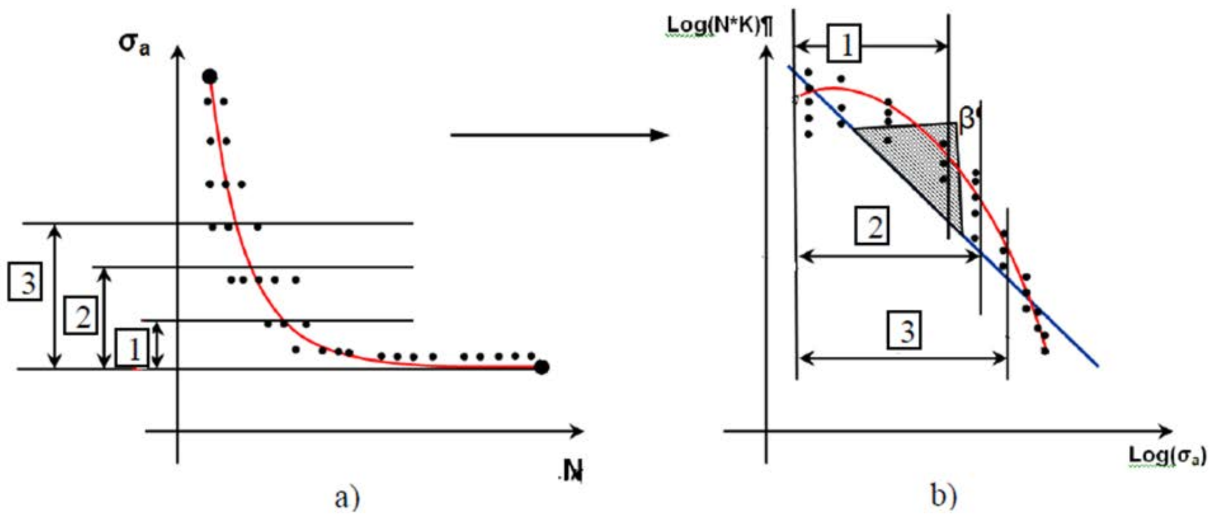

Figure 1 : Wedging principle of the law of Chaboche [5] : All points of the SN curve of Bastenaire are placed in the wedging space. Wedging by linear regression can be applied to all points or only points on a fraction of them (wedging window)

IV. Proposition of New Damage Law

Chaboche law was mainly applied, often successfully, to sequences containing two loading blocks commonly known as sequences High-Low or Low- High depending on the relative intensity of successive levels of stress [1].

The disadvantage of the law vis-à-vis its wedging makes the law not useful on its state. Depending on the wedging window chosen, the calculated lifetimes vary very importantly. The failure of the formalism of Chaboche law is in reality due to the fact that the SN curve of the material within the meaning of the law is a straight line in the wedging reference, which does not correspond to the usual SN curves of materials (Bastenaire model used here, but also those of Wöhler, Basquin or Stromeyer [4].

In other words, the problem of the sensitivity of the law vis-à-vis the wedging window used is the fact that the actual SN curve of the material does not match the one stipulated by the law, namely a straight line in the wedging space. Based on this observation, the main goal of the work done is to modify the formalism of the law to find the actual SN curve of the material when is realized the cumulative damage under constant amplitude loading.

The proposed model uses here also stress as mechanical state parameter, and it ties the increase δD of damage D to the number δN of cycles that generated it under the following differential form:

$$\delta D = \left[1-(1-D)^{\beta+1}\right]^{\alpha} x$$

$$\frac{1}{(1-D)^{\beta}}\left[\frac{R_m-\sigma_a-\sigma_m}{\sigma_a-\sigma_A(\sigma_m)}\cdot\frac{\sigma_{oo}(\sigma_m)-\sigma_D}{e^{-\left(\frac{\sigma_{oo}(\sigma_m)-\sigma_D}{B}\right)^{c}}}\right]\delta N \qquad (10)$$

The variables used in this law are similar to those used in Chaboche model. The only new variable, denoted σ_∞, represents the Y axis at origin of Goodman diagram passing through the point representative of the cycle analyzed. This variable is given by the expression: $\sigma_\infty = \sigma_a - b\sigma_{-1}\sigma_m$; the slope b of Goodman line is usually determined from the fatigue limits in symmetrical alternated traction and in repeated traction (σ_{-1} and σ_0 respectively). The integration results in the SN curve modeled by Bastenaire expression :

$$N_{fj} = \frac{1}{a(\beta+1)(\sigma_{oo}(\sigma_m)-\sigma\ \ )}\cdot e^{-\left(\frac{\sigma_{oo}(\sigma_m)-\sigma_D}{B}\right)^{c}} \qquad (11)$$

B and C are the Bastenaire model parameters calculated by smoothing experimental points used in the determination of the SN curve of the material.

V. Comparison of the New Proposed Law with the Chaboche Law Wedged on Several Different Windows and the Milner Law

Life Forecasts are made for steel 20MV6 subject to a sequence of variable amplitude loading CARLOS LATERAL used as reference in the automotive industry.

The wedging of the new law on the Bastenaire SN curve of the material lead to outstanding forecasts, especially for significant levels of stress, to those obtained by the law of Chaboche. Forecasts obtained from Miner linear law is also shown (Figure 2). The proposed new model provides intermediate life forecasts between those of Miner law and those of Chaboche law in the field of limited endurance.

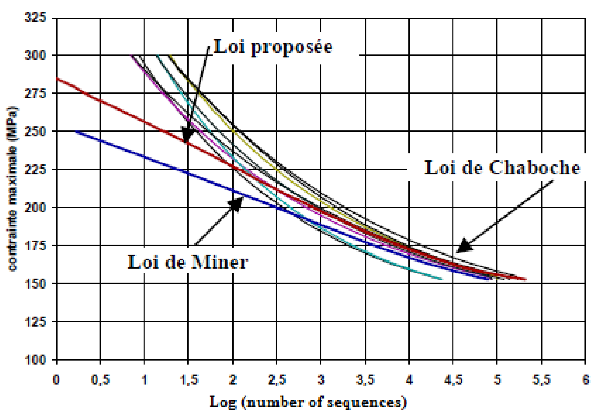

Figure 2 : Gassner curves obtained by using Chaboche law, Miner law and the new proposed damage law for the material 20MV6 subjected to CARLOS SIDE loading sequence [4]

VI. Conclusion

A new formalism of non-linear damage law by fatigue has been proposed. It is an alternative to the law of Chaboche because it eliminates the problem of wedging, that Chaboche law faces, on the material data that makes the S-N curve. The new law gives lifetime forecasts coincident with the SN curve of material in uniaxial fatigue under constant amplitude; it keeps the essential characteristics of the Chaboche law: sequence effect, the influence of the mean stress and non-linear accumulation of damage.

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Steady State Thermal Analysis of Shell and Tube Type Heat Exchanger to Demonstrate the Heat Transfer Capabilities of Various Thermal Materials using Ansys

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Keywords: counter flow shell and tube type heat exchanger, kern's method, ansys 14.0, steady state thermal simulation, thermal materials.

GJRE-A Classification : FOR Code: 660299, 091505

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Vindhya Vasiny Prasad Dubey [α], Raj Rajat Verma [σ], Piyush Shanker Verma [ρ] & A. K. Srivastava [ω]

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Keywords: counter flow shell and tube type heat exchanger, kern's method, ansys 14.0, steady state thermal simulation, thermal materials.

Nomenclature

m	mass flow rate of fluid (kg/second)
C_p	specific heat of fluid (J/kg-℃)
t	temperature of fluid (℃)
Q	amount of heat transfer taking place (watts)
LMTD (or ΔT)	Logarithmic Mean Temperature Difference (℃)
U_0	overall heat transfer coefficient (w/m^2°c)
A	area of heat exchanger (m^2)
ID	inner diameter
OD	outer diameter
l	length of heat exchanger (m)
N	number of tubes
D_b	tube bundle diameter (mm)
d	diameter of tubes (mm)
D	diameter of shell (mm)
B	baffle spacing (mm)
P_r	Prandtl number
R_e	Reynold's number
Nu	Nusselt number
h	heat transfer coefficient (w/m^2°c)

Subscripts

i	inner surface parameter
o	outer surface parameter
t	tube side parameter
s	shell side parameter
w	wall temperature parameter
h	hot fluid parameter
c	cold fluid parameter
1, 2	for inlet and outlet respectively
max	maximum amount of the quantity

Constants

K_1 ,n_1	constants depending on the pitch and type of pass

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Author ω: Professor & Head of Department, Mechanical Engineering Department, Shri Ramswaroop Memorial College of Engineering & Management, Lucknow.

I. Introduction

Heat exchanger is a mechanical device which is used for the purpose of exchange of heats between two fluids at different temperatures. There are various types of heat exchangers available in the industry, however the Shell and Tube Type heat exchanger is probably the most used and widespread type of the heat exchanger's classification. It is used most widely in various fields such as oil refineries, thermal power plants, chemical industries and many more. This high degree of acceptance is due to the comparatively large ratio of heat transfer area to volume and weight, easy cleaning methods, easily replaceable parts etc. Shell and tube type heat exchanger consists of a number of tubes through which one fluid flows. Another fluid flows through the shell which encloses the tubes and other supporting items like baffles, tube header sheets, gaskets etc. The heat exchange between the two fluids takes through the wall of the tubes. In the past decades the design and analysis of Shell and Tube Type Heat Exchanger has been done through various modes viz. theoretically, experimentally, by making software models etc. However a lesser attention has been given on the heat transfer capabilities of the materials. It was due to practical limitations as well as it was also not possible to change the material of tubes or shell again and again and test them under the severe loading conditions. But, now the intense development of CAD facility has given us the tool by which we may introduce number of materials and their combinations to the actual working conditions, and henceforth find their accuracy and compatibility with the desired functions. The works reviewed that have done the same work in the described field are summarized as follows:

Hari Haran et.al proposed a counter flow heat exchanger and after designing it, made a software model using PRO-E by using the derived dimensions and performed the steady state thermal simulation on ANSYS. For simplification of theoretical calculations they have also done a C code which is useful for calculating the thermal analysis of a counter flow of water-oil type shell and tube heat exchanger. They have compared the results obtained after thermal simulation and that obtained from the manual designing and found an error of *0.0274* in effectiveness.

Paresh Patel and Amitesh Paul had performed thermal analysis of shell and tube type heat exchanger using ANSYS, and CFD analysis has been carried out for different materials like steel, copper and aluminium and on the basis of results obtained they have described which material gives best heat transfer rates.

A. Gopi Chand et.al showed how to do the thermal analysis by using theoretical formulae and for this they had chosen a practical problem of counter flow shell and tube heat exchanger of water and oil type, by using the data that came from theoretical formulae, they designed a model of shell and tube heat exchanger using Pro-E and did the thermal analysis by using FLOEFD software and compared the result that obtained from FLOEFD software and theoretical formulae. For simplification of theoretical calculations they have also done a MATLAB code which is useful for calculating the thermal analysis of a counter flow of water-oil type shell and tube heat exchanger. The result after comparing both was that they were getting an error of 0.023 in effectiveness.

P. S. Gowthaman and S. Sathish proposed analysis of two different baffles in a shell and tube heat exchanger by using ANSYS FLUENT. It was found that the use of helical baffles in heat exchanger reduces Shell side pressure drop, pumping cost, weight, fouling etc as compared to segmental baffle for a new installation.

Ender Ozden and Ilker Tari had investigated the design of shell and tube heat exchanger by numerically modelling, in particular the baffle spacing, baffle cut and shell diameter dependencies of heat transfer coefficient and pressure drop. The flow and temperature fields are resolved by using a commercial CFD package and it is performed for a single shell and single tube pass heat exchanger with a variable number of baffles and turbulent flow. The best turbulent model among the one is selected to compare with the CFD results of heat transfer coefficient, outlet temperature and pressure drop with the Bell-Delaware method result. By varying flow rate the effect of the baffle spacing to shell diameter ratio on the heat exchanger performance for two baffle cut value is investigated.

II. Mathematical Modelling

Shell and tube heat exchangers are designed normally by using either Kern's method or Bell-Delaware method. Kern's method is mostly used for the preliminary design and provides conservative results whereas; the Bell-Delaware method is more accurate method and can provide detailed results. It can predict and estimate pressure drop and heat transfer coefficient with better accuracy. In this paper we have designed a simple counter flow shell and tube type heat exchanger to cool the water from 55℃ to 45℃ by using water at room temperature by using Kern's method. The steps of designing are described as follows:

a) First we consider the energy balance to find out the values of some unknown temperature values. Certainly some inputs like hot fluid inlet and outlet temperatures, cold fluid inlet temperature, mass flow rates of the two fluids are needed to serve the purpose. The energy balance equation may be given as:

$$Q = m_h c_{ph}(t_{h1}\text{-}t_{h2}) = m_c C_{pc}(t_{c2}\text{-}t_{c1})$$

b) Then we consider the LMTD expression to find its value:

$$LMTD = \frac{(\Delta T1-\Delta T2)}{ln(\frac{\Delta T1}{\Delta T2})}$$

Where, $\Delta T_1 = t_{h1}\text{-}t_{c2}$ and $\Delta T_2 = t_{h2}\text{-}t_{c1}$.

c) Our next step is to calculate the area required of the heat exchanger (on the basis of assumed U_0), number of tubes, tube bundle diameter, diameter of shell and its thickness with the help of following expressions:

$$A = \frac{Q}{U_0 \Delta T}$$

$$N_t = \frac{A}{\pi d_{t0} l}$$

$$D_b = d_{t0}\left(\frac{N_t}{K_1}\right)^{1/n_1}$$

$$D_i = D_b + \text{additional clearance}$$

$$D_o = D_i + 2 \times \text{thickness}$$

d) Then we calculate the proper baffle dimension viz. its diameter, thickness and baffle spacing.

e) Our next step is to find out heat transfer coefficients on the inner and outer surface of the tubes using following correlation:

$$\text{Nu} = 0.27(Re)^{0.63}(P_r)^{0.36}(P_r/P_{rw})^{0.25}$$

f) Then by the values obtained by the above equation we calculate the actual value of heat transfer coefficient and check whether the actual value is greater than the assumed one or not.

g) After rigorous mathematical calculations we have found out following values of interest:

$m_h = m_c = 0.222$ kg/sec

t_{h1}=55°C , t_{h2}=45°C , t_{c1}=25°C , t_{c2}= 35°C.

A =0.713815m^2

d_{t0} = 23 mm

d_{ti} = 20 mm

N_t = 9

D_i = 136 mm

D_o = 142 mm

Number of baffles = 5

Diameter of baffles = 136 mm

B = 300 mm

The first and the last baffles are complete, while the rest three are 25% cut in order to assure the shell side flow.

III. Problem Formulation

In this paper we are concerned with the study of heat transfer capabilities of various thermal materials that are generally used for shells, tubes or baffles of shell and tube type heat exchanger.

The fact which is noticeable is that the purpose of heat exchange can be done through any moderate conductor of heat, however the study of material prope-0 rties becomes necessary when we have to exchange a large amount of heat within a minimum stipulated time in order to meet out process and production standards as well as to secure the time economy. Also in the large installations it is always desired that the material could handle the overload situations as and when demanded, hence we may employ a good conductor instead of moderate one, but cannot use moderate one where good heat transfer capabilities is demanded. Under these circumstances it is inevitable to ensure the good heat transfer capabilities of the materials.

Here we are considering four materials viz. copper, aluminium, steel 1008 and steel 1010. We have to check their heat transfer capabilities under the above designed conditions and select the most suitable one. We are also concerned about choosing an economical combination of materials assigned to shell, tubes and baffles.

IV. Solution Method

In this paper we have proposed a software model of shell and tube type heat exchanger exactly of the above derived dimensions. After generating the model we have put those parts under the above stated thermal loading conditions and solved out the same under steady state thermal simulation. The results obtained were quite familiar with general considerations about the hierarchical nature of thermal conductivities of the concerned materials. ANSYS 14.0 has been used for the purpose of model generation and its further analysis. The solution phase generally involved three major steps which are described in detail under next sub headings:

a) Making of software model,

b) Mesh generation,

c) Steady state thermal simulation.

a) *Making of Software Model*

Using the above derived dimensions of shell, tubes and baffles we have made a software model using ANSYS 14.0. The parts individually as well as in assembly are as shown below-

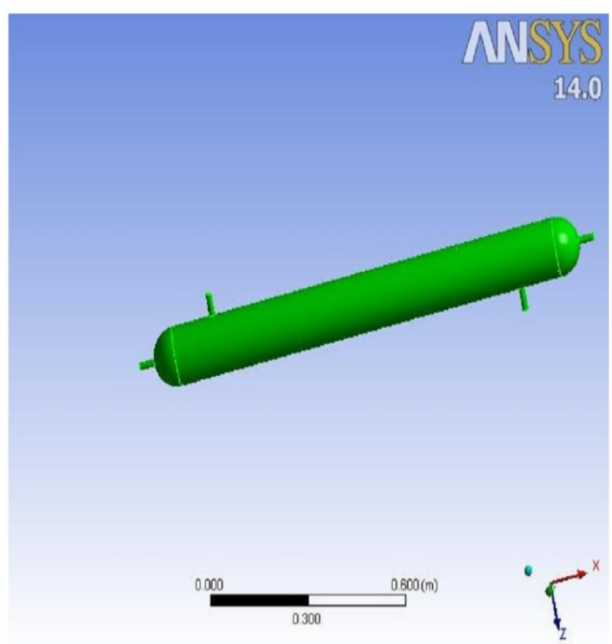

Figure 1 : Shell

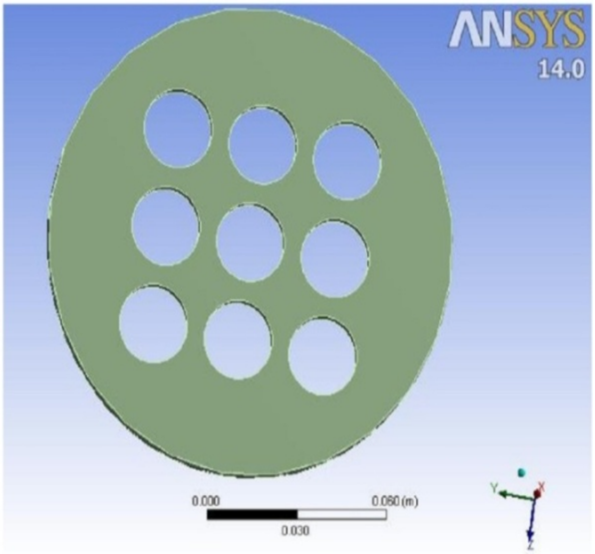

Figure 2 : Complete Baffle

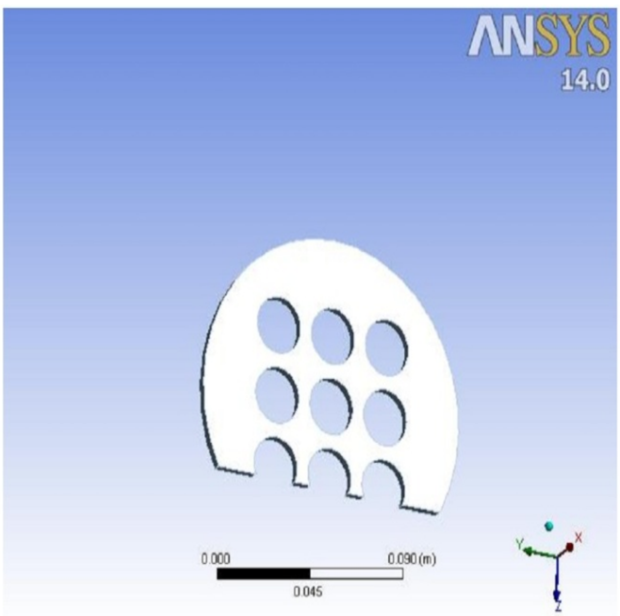

Figure 3 : 25% Cut Baffle

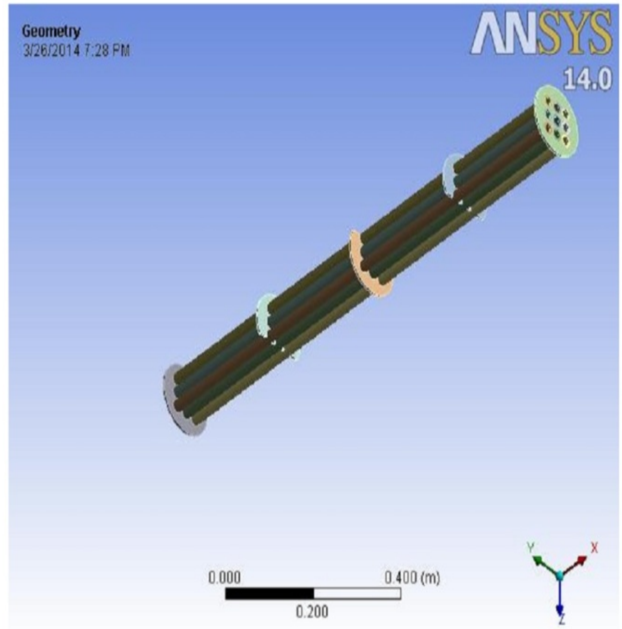

Figure 4 : Arrangement of Tubes and Baffles

b) *Mesh Generation*

The mesh has been generated to perform finite element analysis. In generating the mesh a compromise between computer speed and mesh quality has been adopted. The generated mesh along with its information has been shown in the following figure:

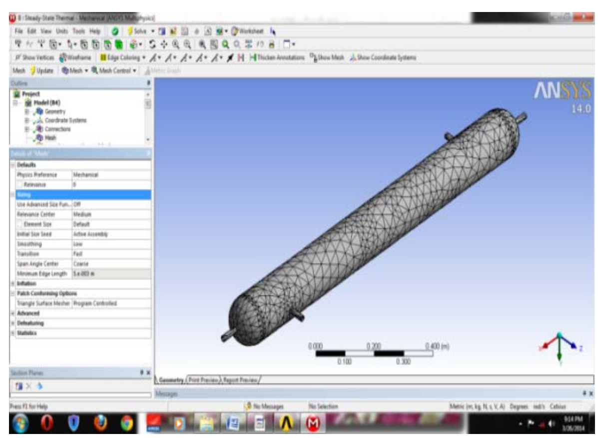

Figure 5 : Mesh Generation

c) *Steady State Thermal Simulation*

This is the final and the most important step of our analysis. Here we have applied the thermal loads on the various faces and edges and simulated to get the value of thermal flux of the overall assembly. The thermal loads applied are shown in the following figure-

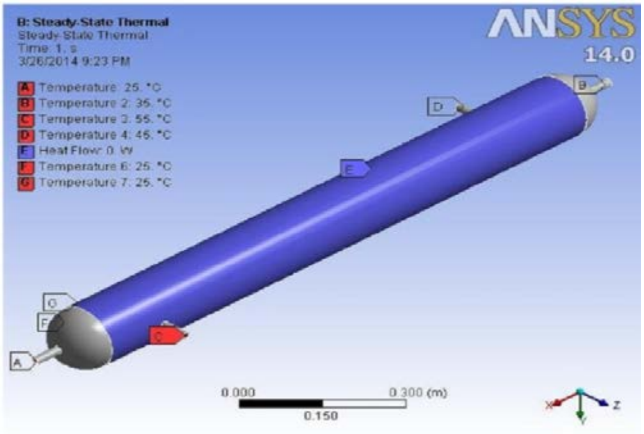

Figure 6 : Thermal Loads on Various Faces and Edges

V. Results & Discussion

Here we have employed five combinations of materials and put them under the above shown thermal loads. The description of material combinations and the heat flux obtained from them is as described below:

a) First we have assigned *Steel 1008 as the material of Shell* while the *tubes and baffles have been assigned Copper.* Under this condition the *maximum value* of heat flux obtained is *37667* w/m^2 while the *minimum value* is *0.064988* w/m^2.

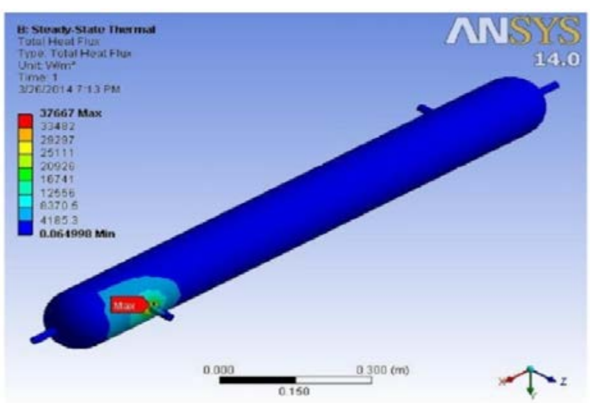

Figure 7 : Shell (Steel 1008), Tubes and Baffles (Copper)

b) Then we have assigned *Steel 1008 as the material of Shell* while the *tubes and baffles have been assigned Aluminium.* Under this condition the *maximum value* of heat flux obtained is *25718* w/m^2 while the *minimum value* is *0.0043108* w/m^2.

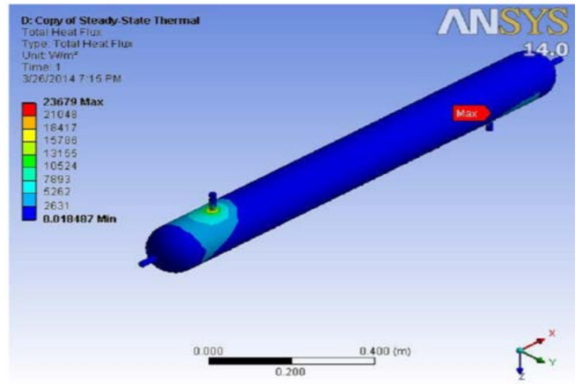

Figure 8 : Shell (Steel 1008), Tubes and Baffles (Alluminium)

c) Then we have assigned *Steel 1008 as the material of Shell* while the *tubes and baffles have been assigned Steel 1010.* Under this condition the *maximum value* of heat flux obtained is *23679* w/m^2 while the *minimum value* is *0.018487* w/m^2.

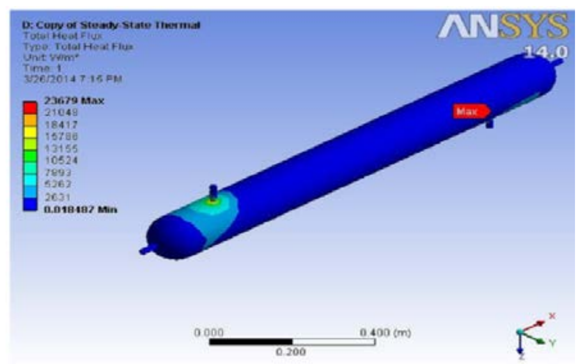

Figure 9 : Shell (Steel 1008), Tubes and Baffles (Steel 1010)

d) Then we have assigned *Aluminium to the whole assembly.* Under this condition the *maximum value* of heat flux obtained is *1.2497* $\times 10^5$ w/m^2 while the *minimum value is 0.097569* w/m^2.

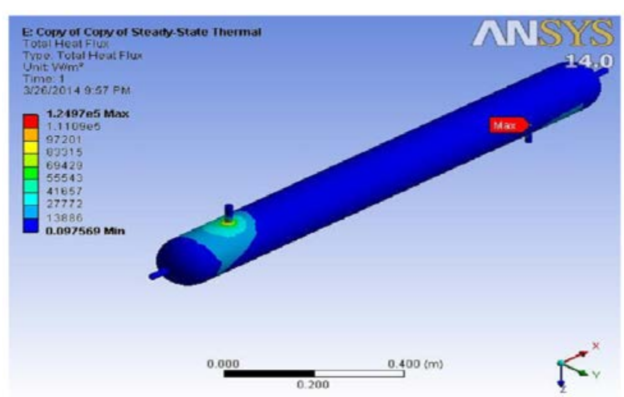

Figure 10 : Alluminium is Assigned to Shell, Tubes and Baffles

e) Then we have assigned *Copper to the whole assembly.* Under this condition the *maximum value* of heat flux obtained is *2.1048* $\times 10^5\ w/m^2$ while the *minimum value is 0.16433* w/m^2.

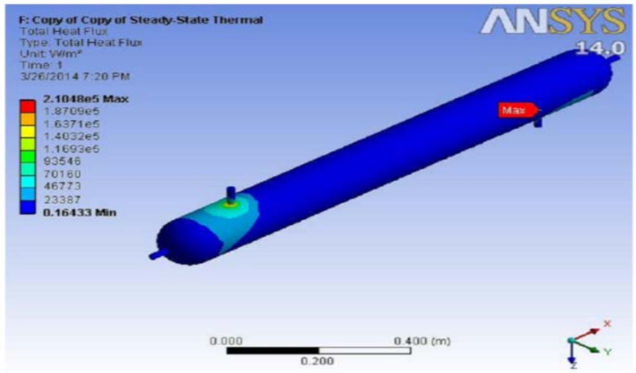

Figure 11 : Copper is Assignes to Shell, Tubes and Baffles

VI. Conclusion

The results of the above study may be summarized as follows:

SERIAL NO.	MATERIAL OF SHELL	MATERIAL OF TUBES & BAFFLES	MAXIMUM HEAT FLUX (w/m^2)	MINIMUM HEAT FLUX (w/m^2)
1.	STEEL 1008	COPPER	37667	0.064988
2.	STEEL 1008	ALUMINIUM	25718	0.0043108
3.	STEEL 1008	STEEL 1010	23679	0.018487
4.	ALUMINIUM	ALUMINIUM	1.2497$\times 10^5$	0.097569
5.	COPPER	COPPER	2.1048$\times 10^5$	0.16433

From this study it is clear that if we assign copper to the whole assembly then we shall get the best possible value of heat flux amongst the discussed materials; however that will also be a very costly affair. Secondly the outer surface of shell is generally insulated so that it may be assumed that no heat transfer is taking place in between shell and surroundings. Hence it will be a good deal to assign shell steel and tubes and baffles copper. In case we may also employ aluminium as the material of tubes and baffles, as it is second to none than copper as far as heat transfer is concerned, amongst the discussed materials. One additional property of aluminium is its light weight. However aluminium also possesses some problems during welding hence it may become difficult to join tubes and baffles. Steels are also moderate conductors of heat and can be employed, in case greater material economy is desired.

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Design Optimization and Comparative Stress Analysis of Connecting Rod using Finite Element Analysis

By Himanshu Arora, Ashwani Mishra, Swatantra Kulkarni, Prabhjot Singh & Ramanpreet Singh
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Abstract- A connecting rod is an important member of the engine assembly accompanied by mass production all over the world. Moreover it possesses great opportunity for research and development in terms of its material and its design parameters. In the present research work initially modelling of connecting rod was done in ANSYS 14.5 software and then analysed in again ANSYS 14.5 software itself. Analysis was mainly focussed on design parameters and its material .Then best design parameters and best material was chosen.

Keywords: connecting rod, finite element analysis, ortho- tropic material.

GJRE-A Classification : FOR Code: 091399

DESIGNOPTIMIZATIONANDCOMPARATIVESTRESSANALYSISOFCONNECTINGRODUSINGFINITEELEMENTANALYSIS

Strictly as per the compliance and regulations of:

Design Optimization and Comparative Stress Analysis of Connecting Rod using Finite Element Analysis

Himanshu Arora [α], Ashwani Mishra [σ], Swatantra Kulkarni [ρ], Prabhjot Singh [Ѡ] & Ramanpreet Singh [¥]

Abstract- A connecting rod is an important member of the engine assembly accompanied by mass production all over the world. Moreover it possesses great opportunity for research and development in terms of its material and its design parameters. In the present research work initially modelling of connecting rod was done in ANSYS 14.5 software and then analysed in again ANSYS 14.5 software itself. Analysis was mainly focussed on design parameters and its material .Then best design parameters and best material was chosen.

Keywords: connecting rod, finite element analysis, ortho- tropic material.

I. Introduction

A connecting rod acts as a bridge between piston assembly and crankshaft .By acting as a bridge it changes the motion of piston assembly which is nothing but a reciprocating motion to the rotating motion of the crankshaft. Therefore it is an important member of the engine assembly. Moreover it also witnesses high cycle of tensile and compressive loading during its operation and researchers have found out that piston end witnesses maximum stress and that can be decreased by either increasing the material near the piston end or by changing the design parameters of the connecting rod. Also being an important member of the engine assembly its proper functioning and safety from failure is important because its failure can lead to the replacement cost of the engine assembly. Additionally we are witnessing huge production of connecting rod as its demand is increasing day by day. Therefore there is a need for research and development in the field of its design parameters, material and a lot more to widen our horizon for the betterment of connecting rod and engine performance.

a) Literature Review

Anusha B et al. (2013) did a case study on a Hero Honda splendor connecting rod .In this study piston end was made to bear a pressure of 3.15 Mpa whereas big end was kept fixed. Modeling and analysis were performed in Pro/E and ANSYS respectively. The whole study was focused on the comparison of connecting rod made up of structural steel and cast iron which resulted in the fact that lesser stresses were induced in the structural steel connecting rod than cast iron connecting rod. Therefore connecting rod made up of structural steel was advised to use.

Vazhappilly C V et al. (2013) presented a literature survey of various research and developments that took place in the field of optimization technique, fatigue modelling, manufacturing cost analysis etc. Furthermore importance of CAD and Finite Element Analysis for optimization process was also presented.

Pathade V.C. et al. (2013) made three loads, 69kg, 85kg, and 99 kg, to be applied over the small end. Three approaches namely experimental, theoretical and numerical (Finite Element Analysis) were taken to do stress analysis of connecting rod. Comparison of the results of these methods was done and then it was noticed that small end was prone to more stresses than the other end.

Sarkate T. S. et al. (2013) performed static analysis and comparison of alloy aluminum 7068 and AISI 4340 alloy steel by using Pro/E Wildfire 4.0 and ANSYS V12. Aluminum 7068 alloy showed a reduction of 63.95% weight and 3.59% stresses.

Rao G N M et al. (2013) examined genetic steel, Aluminum, Titanium and Cast Iron to widen the horizon of the weight reduction possibilities for the connecting rod. Initially load to be applied was calculated, FEA was performed and then optimization was achieved. It was noticed that genetic steel connecting rod came out with better results than Aluminum, Titanium and Cast Iron in terms of deflection and stresses.

Prakash O. et al. (2013) investigated connecting rod of Universal Tractor (U650).They re-optimised, performed static and fatigue analysis and improved critical areas of connecting rod. Their work decreased the weight by 5gm and hence increased the performance of the engine.

b) Modeling

The connecting rod on which the present investigation is done is taken from the research paper of Pal S, Kumar S(2012), "Design Evaluation and optimization of connecting rod parameters using FEM" *IJEMR, Vol. 2, issue 6*[7].Modeling of the connecting rod is performed in ANSYS 14.5.

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c) Validation

The rod with the dimensions same as that of reference paper [7] was modeled and even the same compressive loads and fixed support were applied on the same portion of the connecting rod as in the reference paper [7].

Table 1 : The results of the maximum equivalent von-mises stresses in Mpa are

S. no.	Compressive Loads	Existing Model	Our Model	Variation (%)
1.	4319N	71.20	74.816	4.83

Hence our model is validated as we have got approximately same results as in the reference paper.

After validation Changes in design parameters of model taken from reference paper[7] was made and 3 more models of connecting rod were prepared and static FEA was performed on all of them including existing model from reference paper by applying 2 different orthotropic materials on all of them one by one and they were compared. The drawing of existing and best model is shown below.

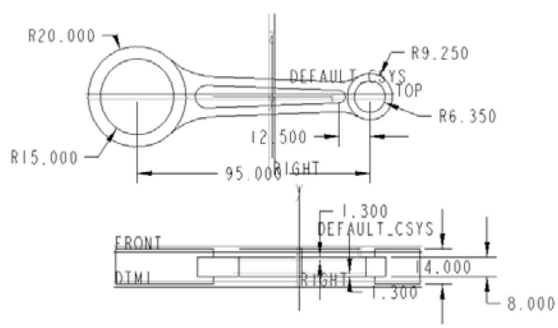


Figure 1 : Model from reference paper[7]

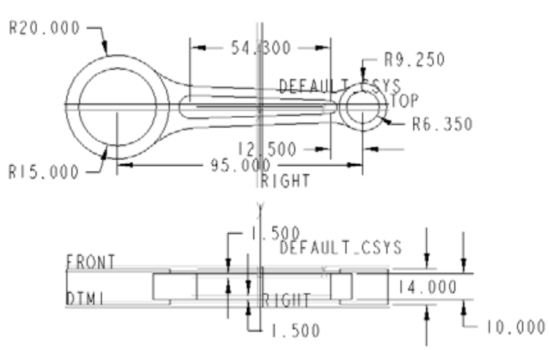


Figure 2 : Modified model I

II. Material Properties

Two orthotropic materials were used and compared.

Table 2 : Properties of E-glass/Epoxy [8]

Properties	E-Glass/ Epoxy
Longitudinal modulus $E1$ (GPa)	41Gpa
Transverse in-plane modulus $E2$	12Gpa
Transverse out of plane modulus $E3$	12Gpa
In-plane shear modulus $G12$	5.5Gpa
Out of plane shear modulus $G13$	5.5Gpa
Out of plane shear modulus $G23$	3.5Gpa
Major in plane Poisson's ratio $\upsilon 12$	0.28
Major out of plane Poisson's ratio $\upsilon 13$	0.28
Major out of plane Poisson's ratio $\upsilon 23$	0.5
Density(kg/m^3)	1850

Table 3 : Properties of Kevlar 49/Epoxy[8]

Properties	Kevlar 49/Epoxy
Longitudinal Modulus $E1$	80gpa
Transverse In-Plane Modulus $E2$	5.5 Gpa
Transverse Out of plane Modulus $E3$	5.5Gpa
In-Plane Shear Modulus $G12$	2.2Gpa
Out Of Plane Shear Modulus $G13$	2.2Gpa
Out Of Plane Shear Modulus $G23$	1.8Gpa
Major In-Plane Poisson's Ratio $Y12$	0.34
Major Out Of Plane Poisson's Ratio $Y13$	0.34
Major Out Of Plane Poisson's Ratio Y_{23}	0.4
Density(Kg/M^3)	1252

a) Loads

The crank end was kept fixed in every analysis and a compressive bearing load of 4319N [7] was applied.

III. Results

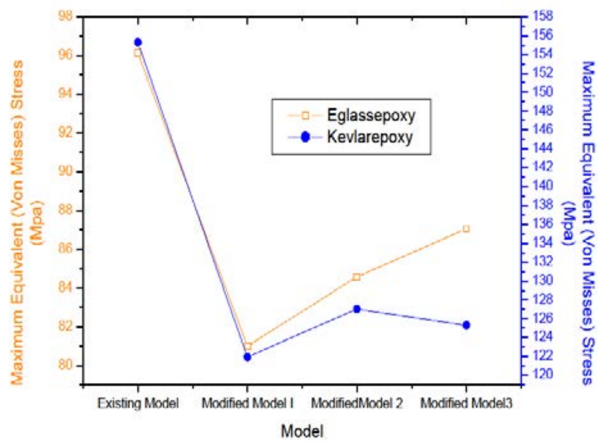
All the models and materials were compared on the basis of maximum equivalent von-mises stress which was noted after every analysis.

Table 4 : For Compressive bearing load 4319 N and Maximum equivalent von-mises stress

Parameters	Eglass/ Epoxy (Mpa)	Kevlar49/ Epoxy (Mpa)
Existing Model	96.135	155.31
Modified Model I	80.995	121.95
Variation*(%)	15.75	21.479
Modified Model 2	84.567	127.03
Variation*(%)	12.033	18.20
Modified Model3	87.05	125.31
Variation*(%)	9.45	19.31

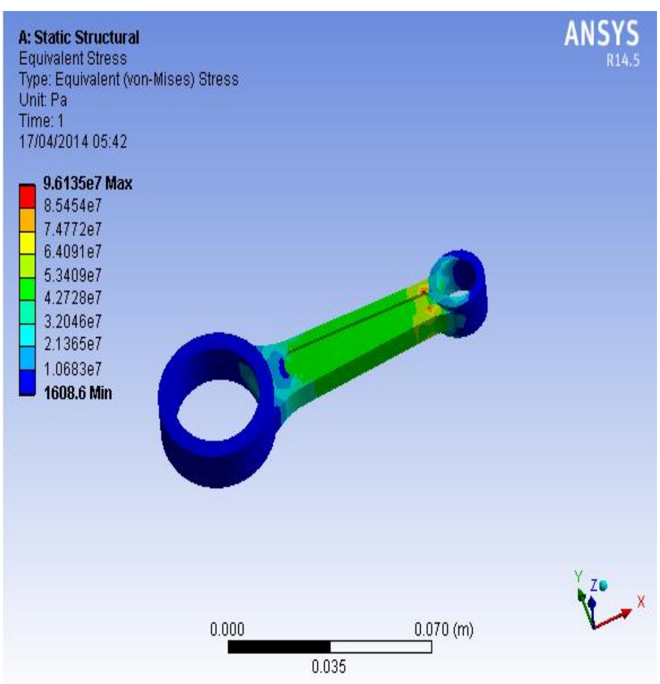
**Variation (%) with existing model.*

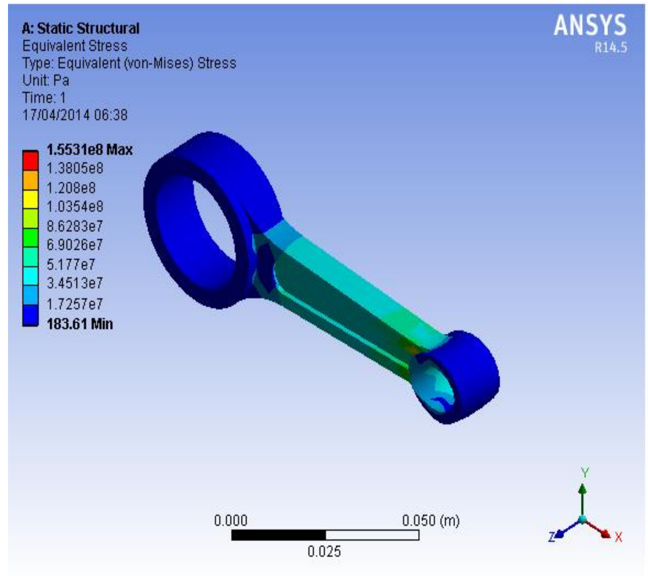
The comparison presented in above table have also been presented by graph.

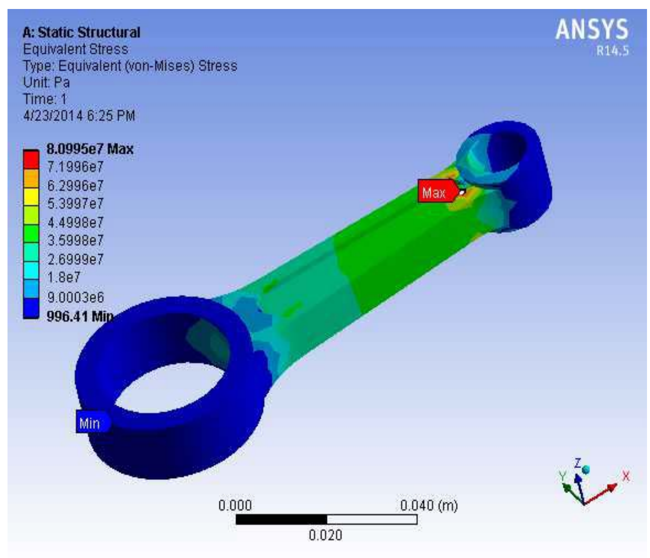


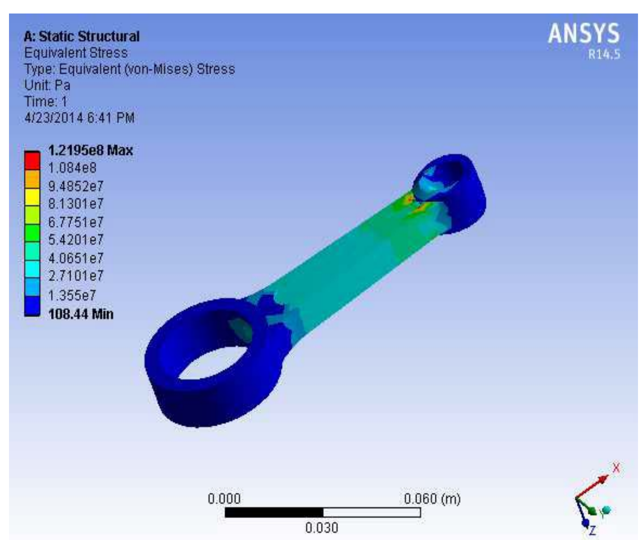
Graph for Table I

Following figures presents a comparison of static FEA between existing model from reference paper [7] and best modified design i.e. Modified Model I of connecting rod when compressive bearing load applied was 4319N and material used were E-glass/Epoxy and Kevlar49/Epoxy.









IV. Conclusion

Static FEA was performed on a connecting rod by applying a compressive bearing load on its piston end making the crank end fixed. The design of existing connecting rod taken from reference paper[7] was modified and all the designs were tested with 2 different orthotropic materials.

From analysis it was inferred that

a) Modifying the design parameters can yield better results. Since modified model I gave best results. Therefore this design proved to be the best among others tested.

b) Among 2 orthotropic materials investigated and compared the E-glass/epoxy proved to be best.

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Multi-Function Operating Machine: A Conceptual Model

By Sharad Srivastava & Shivam Srivastava
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Abstract- This paper presents the concept of Multi-Function Operating Machine mainly carried out for production based industries. Industries are basically meant for Production of useful goods and services at low production cost, machinery cost and low inventory cost. Today in this world every task have been made quicker and fast due to technology advancement but this advancement also demands huge investments and expenditure, every industry desires to make high productivity rate maintaining the quality and standard of the product at low average cost. We have developed a conceptual model of a machine which would be capable of performing different operation simultaneously, and it should be economically efficient .In this machine we are actually giving drive to the main shaft to which scotch yoke mechanism is directly attached, scotch yoke mechanism is used for sawing operation. On the main shaft we have use bevel gear system for power transmission at two location. Through bevel gear we will give drive to drilling centre and grinding centre. The model facilitate us to get the operation performed at different working centre simultaneously as it is getting drive from single power source. Objective of this model are conservation of electricity (power supply), reduction in cost associated with power usage, increase in productivity, reduced floor space.

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MULTI-FUNCTIONOPERATINGMACHINEACONCEPTUALMODEL

Strictly as per the compliance and regulations of:

Multi-Function Operating Machine: A Conceptual Model

Sharad Srivastava α & Shivam Srivastava σ

Abstract- This paper presents the concept of Multi-Function Operating Machine mainly carried out for production based industries. Industries are basically meant for Production of useful goods and services at low production cost, machinery cost and low inventory cost. Today in this world every task have been made quicker and fast due to technology advancement but this advancement also demands huge investments and expenditure, every industry desires to make high productivity rate maintaining the quality and standard of the product at low average cost. We have developed a conceptual model of a machine which would be capable of performing different operation simultaneously, and it should be economically efficient .In this machine we are actually giving drive to the main shaft to which scotch yoke mechanism is directly attached, scotch yoke mechanism is used for sawing operation. On the main shaft we have use bevel gear system for power transmission at two location. Through bevel gear we will give drive to drilling centre and grinding centre. The model facilitate us to get the operation performed at different working centre simultaneously as it is getting drive from single power source. Objective of this model are conservation of electricity (power supply), reduction in cost associated with power usage, increase in productivity, reduced floor space.

I. Introduction

Industries are basically meant for Production of useful goods and services at low production cost, machinery cost and low inventory cost. Today in this world every task have been made quicker and fast due to technology advancement but this advancement also demands huge investments and expenditure, every industry desires to make high productivity rate maintaining the quality and standard of the product at low average cost

In an industry a considerable portion of investment is being made for machinery installation. So in this paper we have a proposed a machine which can perform operations like drilling, sawing, shaping, some lathe operations at different working centers simultaneously which implies that industrialist have not to pay for machine performing above tasks individually for operating operation simultaneously.

Economics of manufacturing: According to some economists, manufacturing is a wealth-producing sector of an economy, whereas a service sector tends to be wealth-consuming. Emerging technologies have provided some new growth in advanced manufacturing employment opportunities in the Manufacturing Belt in the United States. Manufacturing provides important material support for national infrastructure and for national defense.

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II. Literature Review

Before starting our work we have undergone through many research papers which indicates that for a production based industries machine installation is a tricky task as many factor being associated with it such as power consumption (electricity bill per machine), maintenance cost, no of units produced per machine i.e. capacity of machine, time consumption and many more….

Some research papers which have led us to approach to the idea of a machine which may give solution to all these factors are as follows:

a) Heinrich Arnold1 November 2001

Rather long re-investment cycles of about 15 years have created the notion that innovation in the machine tool industry happens incrementally. But looking at its recent history, the integration of digital controls technology and computers into machine tools have hit the industry in three waves of technology shocks. Most companies underestimated the impact of this new technology. This article gives an overview of the history of the machine tool industry since numerical controls were invented and introduced and analyzes the disruptive character of this new technology on the market. About 100 interviews were conducted with decision-makers and industry experts who witnessed the development of the industry over the last forty years. The study establishes a connection between radical technological change, industry structure, and competitive environment. It reveals a number of important occurrences and interrelations that have so far gone unnoticed.

b) Dr. Toshimichi Moriwaki (2006)

Recent trends in the machine tool technologies are surveyed from the view points of high speed and high performance machine tools, combined multifunctional machine tools, ultra precision machine tools and advanced and intelligent control technologies.

c) Frankfurt-am Main, 10 January 2011

The crisis is over, but selling machinery remains a tough business. Machine tools nowadays have to be veritable "jack of all trades", able to handle all kinds of

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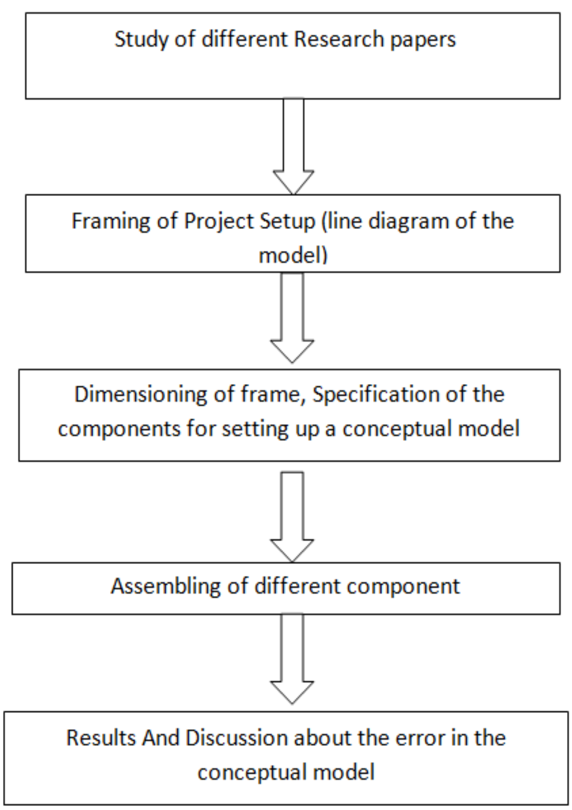
materials, to manage without any process materials as far as possible, and be capable of adapting to new job profiles with maximized flexibility. Two highly respected experts on machining and forming from Dortmund and Chemnitz report on what's in store for machine tool manufacturers and users.

Multi-purpose machines are the declarations of independence. The trend towards the kind of multi-purpose machining centers that are able to cost efficiently handle a broad portfolio of products with small batch sizes accelerated significantly during the crisis. "With a multi-purpose machine, you're less dependent on particular products and sectors", explains Biermann.

III. Proposed Methodology

In this project we will generally give the power supply to the shaft on which a bevel gear is mounted on it, and a second bevel gear at a right angle to it has been mounted on a drill shaft to which a drill bit is being attached. At one end of the shaft is connected to power supply, other end is being joined to a circular disc ,through this circular disc scotch yoke mechanism is being performed (rotator y motion is converted to reciprocating motion) . Also in between these two, a helical gear is mounted which transfer its motion to other helical gear which is mounted on a shaft consist of grinding wheel.



a) Experimental Set-Up

In this conceptual model we have involved the gear arrangement for power transmission at different working centers, basically gear or cogwheel is a rotating machine part having cut teeth, or cogs, which mesh with another toothed part in order to transmit torque, in most cases with teeth on the one gear being of identical shape, and often also with that shape on the other gear. Two or more gears working in tandem are called a transmission and can produce a mechanical advantage through a gear ratio and thus may be considered a simple machine. Geared devices can change the speed, torque, and direction of a power source. The most common situation is for a gear to mesh with another gear; however, a gear can also mesh with a non-rotating toothed part, called a rack, thereby producing translation instead of rotation.

b) Working Principle

There are only two major principle on which our proposed machine (conceptual model) generally works:

i. Scotch-Yoke mechanism

ii. Power transmission through gears.

a. Bevel gears

c) Scotch Yoke Mechanism

The Scotch yoke is a mechanism for converting the linear motion of a slider into rotational motion or vice-versa. The piston or other reciprocating part is directly coupled to a sliding yoke with a slot that engages a pin on the rotating part. The shape of the motion of the piston is a pure sine wave over time given a constant rotational speed.

d) Power Transmission Through Gears

Bevel gears are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped. Bevel gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The pitch surface of a gear is the imaginary toothless surface that you would have by averaging out the peaks and valleys of the individual teeth. The pitch surface of an ordinary gear is the shape of a cylinder. The pitch angle of a gear is the angle between the face of the pitch surface and the axis.

IV. Working of the Model

In the conceptual model of "Multi-Functional operating machine" we are giving supply to the main shaft (refer fig.13), as we move along the axis of shaft we have mounted a pair of bevel gears, through the pinion shaft we are giving drive to drill shaft through belt-pulley arrangement, we have installed the stepped pulley in the arrangement therefore we can made the speed variation. Now again as we move along the axis of main-shaft further we have again used the bevel gear arrangement to give the drive to grinding center.

As we can see that the scotch yoke mechanism is directly fabricated to the main shaft and have same angular velocity as that of main-shaft.

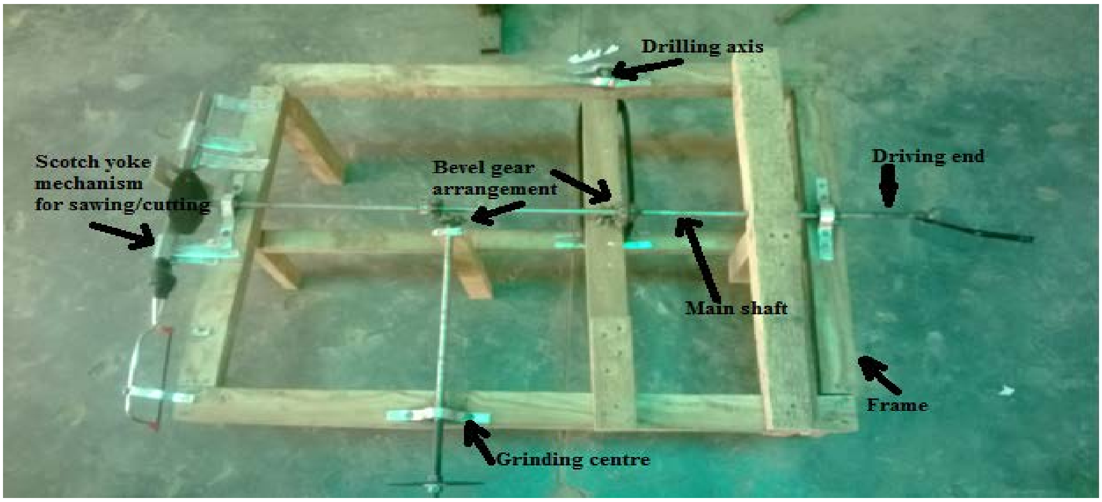


Figure 1 : Over View of The Model

Figure 2 : Grinding Centre getting power through bevel gear arrangement

Figure 3 : Sawing/ Cutting end using Scotch Yoke Mechanism

Figure 4 : Drilling centre getting drive through bevel gear and belt-pulley arrangement

a) Specification of the Components used in the conceptual model

i. Frame of the model: length=2.5 ft., width=2 ft., height=1 ft.
ii. Bevel gears: no. of teeth T1=12, T2=9.
iii. For gear: Base radius. =2cm, pitch cone angle=55 deg, pitch dia. = 4 cm.
iv. For Pinion Base radius. =1.4cm, Pitch Cone Angle=35 Deg, pitch dia. = 2.8 cm.
v. Shaft dia. =10 mm (approx.), shaft length=2.5ft.
vi. Roller bearings of inside dia.=9.5 mm
vii. Material of bevel gears is mild steel
viii. Shaft is also of mild steel.
ix. Length of Belt = 12 inch.
x. Thickness of belt= 14 mm.
xi. Diameter of pulley= 60 mm.
xii. Type of belt used = V-belt.
xiii. Frame is made of wood (neem).
xiv. Operation can be performed are: sawing/cutting, drilling, grinding (we have used a prototype wheel (dia. 12 cm) in-place of grinding wheel).

V. Result

Our main aim is to represent our innovative concept, we have taken some useful data from our conceptual model and tried to evaluate the percentage deviation from the standard calculated values which is as follows:-

Since pitch radius of pinion is r_p = 1.4 cm, pitch radius of gear r_g = 2 cm.

By the relation between pitch cone angle and velocity ratio we can find the velocity ratio as we have pitch cone angle for both gear and pinion as 55 deg. and 35 deg.

$\tan \Upsilon_p = \frac{\sin\theta}{\frac{\omega p}{\omega g} + \cos\theta}$ where θ is the angle between the shaft.

On putting θ= 90° and Υ_p = 35° we get $\frac{\omega p}{\omega g}$ = 1.428 i.e. our velocity ratio is 1.428

Now for the two complete revolution of main shaft the Drilling shaft and grinding shaft should have no of revolution = 2.856 (theoretically).

But from our model the no of revolution measured at drilling and grinding axis = 2.67 (i.e. two complete revolution plus 240° rotation.

Percentage Error in power transmission $= \frac{2.856 - 2.67}{2.856} * 100 = 6.51\%$

Now diameter of circular disc of Scotch yoke mechanism = 7.9 cm

Actual measured effective stroke length of yoke = 7.73 cm

Percentage error in the stroke length $= \frac{7.9 - 7.73}{7.9} * 100 = 2.15\%$

Similarly many values of rpm at drilling and grinding axis can be measured on changing the input; in this conceptual model feed to the work piece is given through the work table.

Since the model is subjected to friction therefore there is a error of 6.51% and 2.15% during power transmission and transverse motion of sawing blade respectively.

For Drilling and Grinding operation we have used the identical bevel gears therefore both operation will have same velocity ratio.

Table 1 : difference in between theoretical power transmission and actual power transmission

S no.	No. of revolution given to main shaft	Theoretical revolution at driven end	Actual revolution at driven end
1	1	1.428	1.335
2	2	2.856	2.67
3	3	4.284	4.22
4	4	5.712	5.65
5	5	7.14	7.075
6	6	8.568	8.503

Table 2 : difference in between theoretical effective stroke length of yoke and actual effective stroke length of yoke for different no. of revolution of main shaft

S no.	No. of revolution given to main shaft	Theoretical effective stroke length at driven end	Actual effective stroke length at driven end
1	1	7.9	7.73
2	2	7.9	7.73
3	3	7.9	7.73
4	4	7.9	7.73
5	5	7.9	7.73
6	6	7.9	7.73

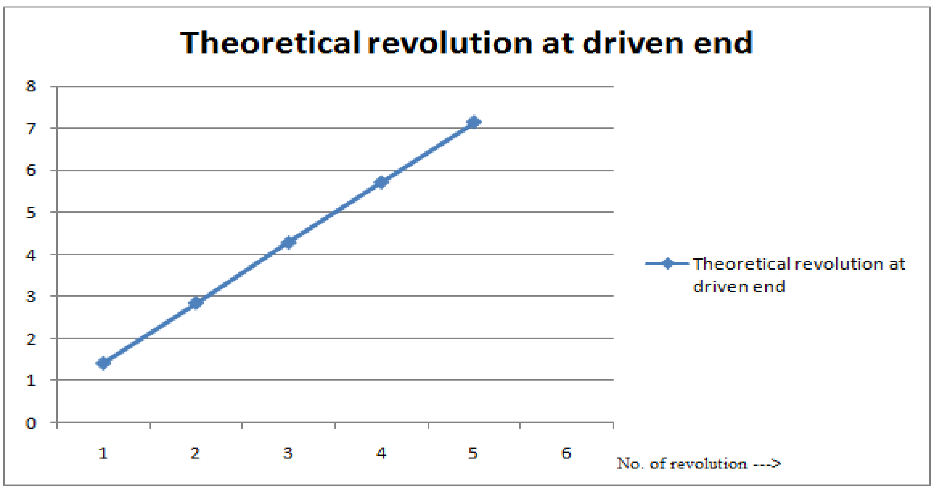


Figure 20 : Plot to show theoretical revolution at driven end

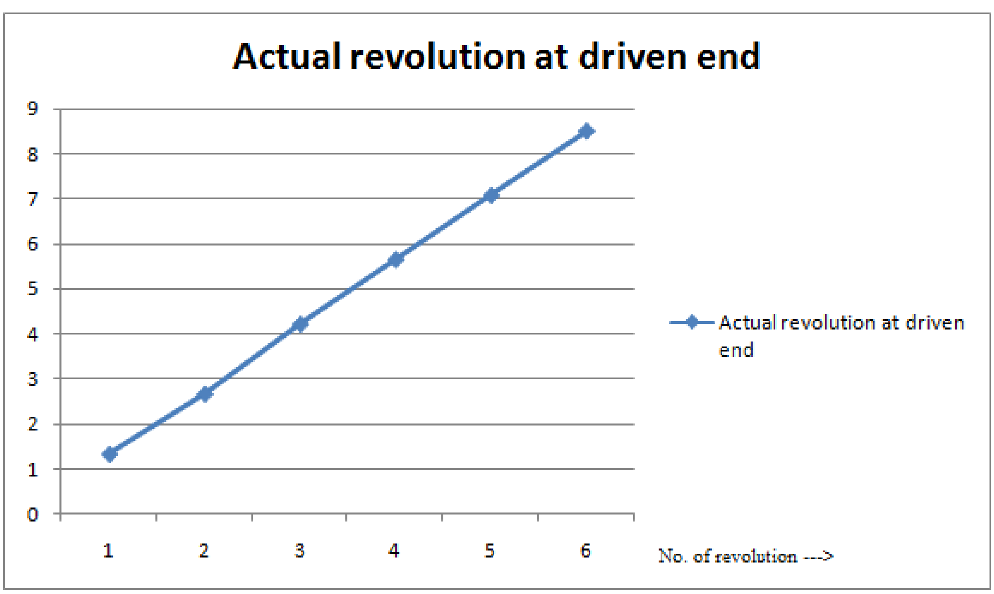


Figure 21 : Plot to show actual revolution at driven end

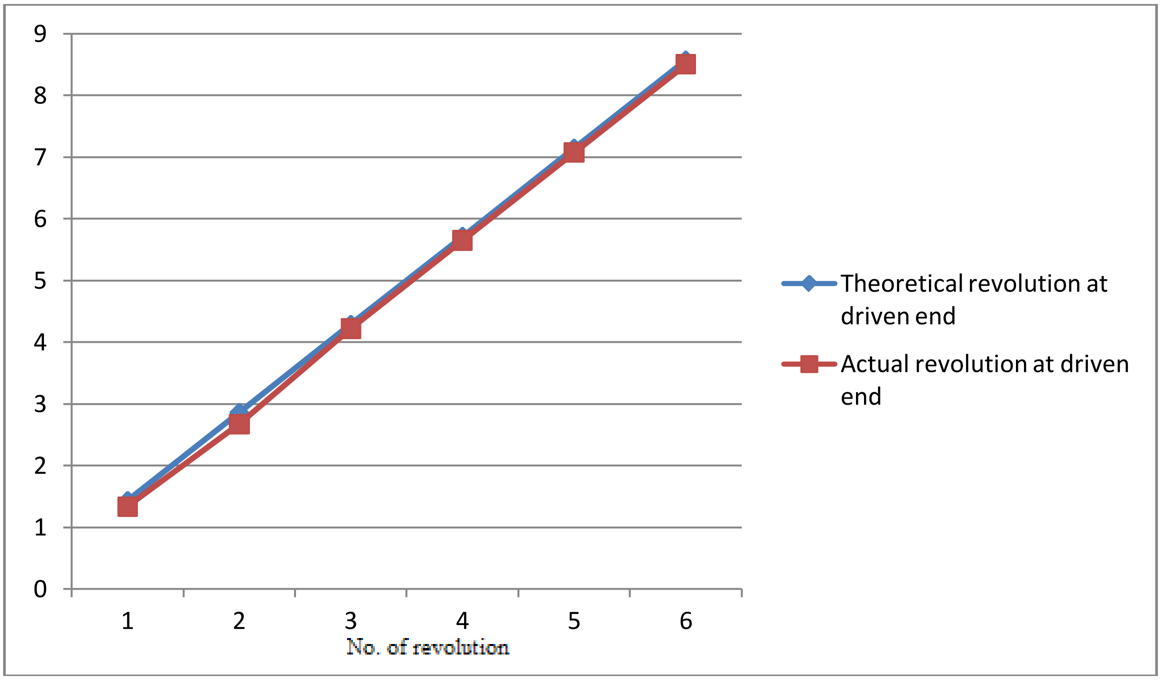


Figure 22 : Plot to show error in between Actual and theoretical power transmission at driven end

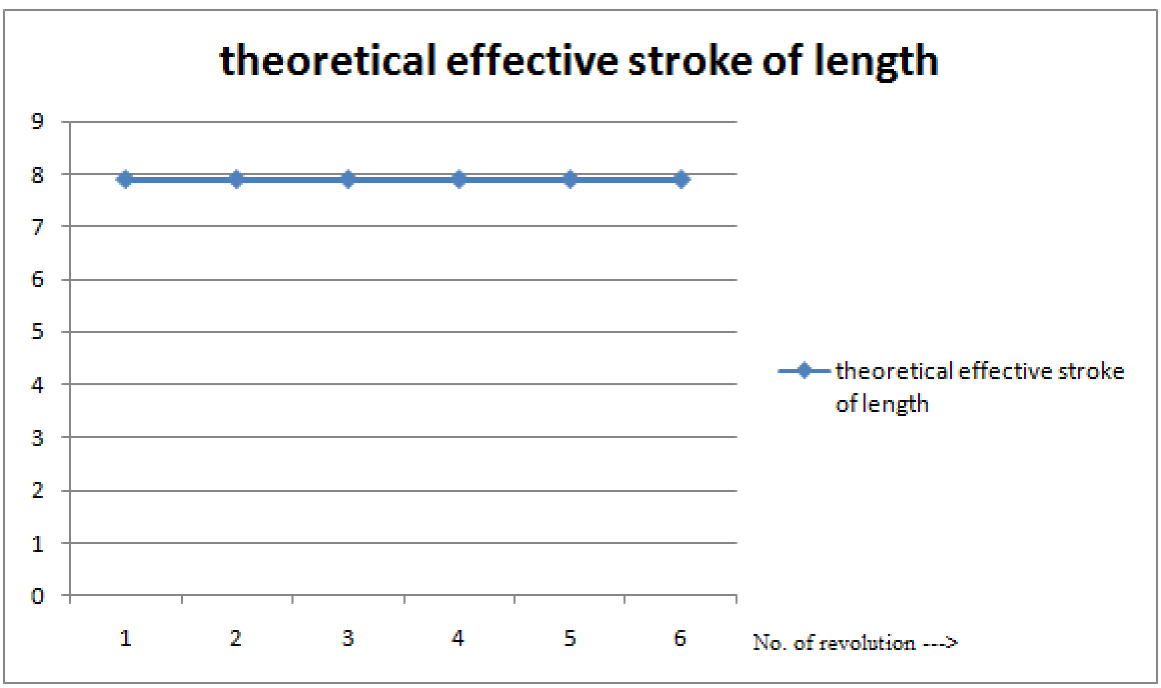


Figure 23 : Plot to show theoretical effective stroke of length at driven end

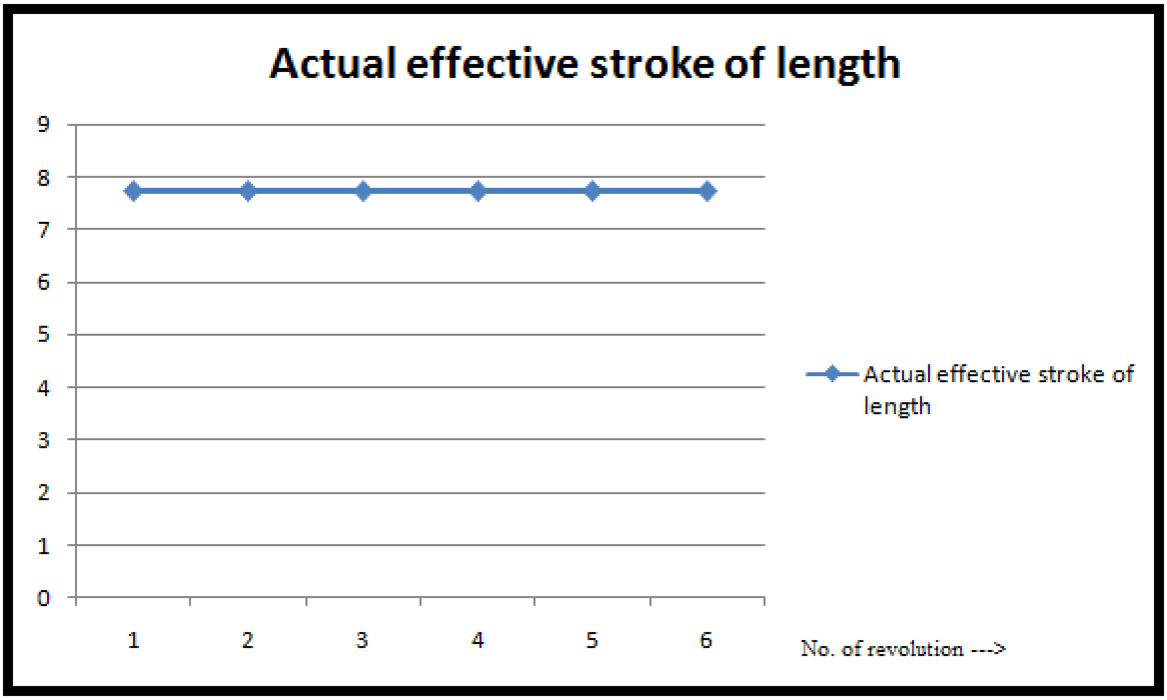


Figure 24 : plot to show actual effective stroke of length at driven end

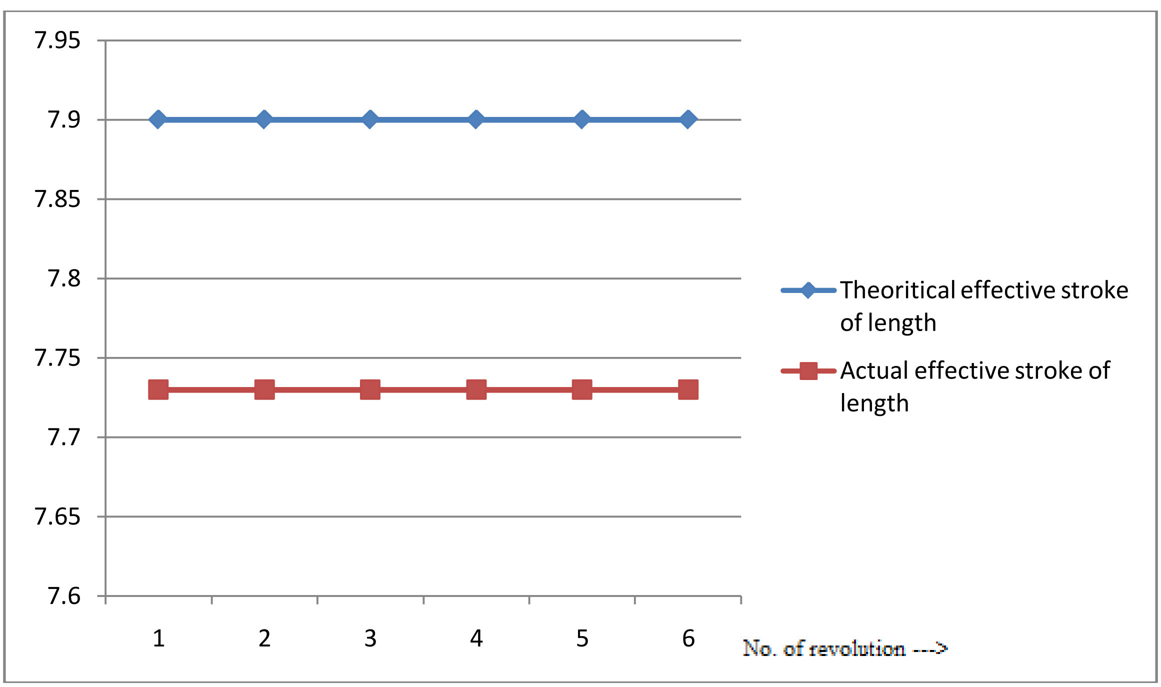


Figure 25 : Plot to show error in between Actual and theoretical effective stroke of length

VI. CONCLUSION

We can see that all the production based industries wanted low production cost and high work rate which is possible through the utilization of multi-function operating machine which will less power as well as less time, since this machine provides working at different center it really reduced the time consumption up to appreciable limit.

In an industry a considerable portion of investment is being made for machinery installation. So in this paper we have proposed a machine which can perform operations like drilling, sawing, grinding at different working centers simultaneously which implies that industrialist have not to pay for machine performing above tasks individually for operating operation simultaneously.

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Finite Element Modelling and Analysis of Trans-Tibial Prosthetic Socket

By Imran Ali, Ramesh Kumar & Yogendra Singh
ISM Dhanbad, India

Abstract- The intention of this paper was to analyze prosthetic socket of distinct materials and for different geometry for optimum design solution by finite element analysis. A modified three-dimensional finite element model of the patellar tendon-bearing (PTB) socket was developed in workbench of ANSYS 14.0 to find out the stress distribution and deformation pattern under functionally appropriate loading condition during normal gait cycle. All essential materials used in the analysis were assumed to be homogeneous, linearly elastic and isotropic. A variety of materials were used for the analysis of the socket like Polypropylene, Composite,90/10 PP/PE, HDPE and LDPE. Analysis was done on a various thickness of socket and of different length along with of different materials commonly applied in developing countries. For boundry condition, fixed support was applied to the distal end of the socket and vertical loads were applied under static condition at pattelar tendon-brim, medial tibia, lateral tibia and popliteal area during stance phase of gate cycle.

Keywords: patellar tendon-bearing (ptb), trans-tibial (tt) prosthesis, finite element (fe) model, socket/stump interface stress.

GJRE-A Classification : FOR Code: 290501

FINITEELEMENTMODELLINGANDANALYSISOFTRANS-TIBIALPROSTHETICSOCKET

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Keywords: patellar tendon-bearing (ptb), trans-tibial (tt) prosthesis, finite element (fe) model, socket/stump interface stress.

I. Introduction

The socket is a basic component for prosthetic performance. Below-knee amputees generally demonstrate some gait abnormalities such as lower walking speed [1], incresed energy cost [2], and asymmetries between legs of unilateral amputees in stance phase cycle, step length and maximum vertical force [3]. Successful fitment of prosthesis may be achieved by understanding the biomechanical structure of socket and its material, weight, thickness in particular to fulfill the desirable load distribution in soft tissues and bone of residual limb. Most commonly used socket design in developing countries is pattelar tendon bearing (PTB) socket developed following the World War II at the University of California, Berkeley in the late 1950 s [4,5]. The Finite Element Method (FEM) has been used widely in biomechanics to obtain stress, strain and deformation in complicated systems and have been identified as an important tool in analysing load transfer in prosthesis [6]. The finite element analysis (FEA) models have been used to study the effects of the inertial loads and contact conditions on the interface between prosthetic socket and stump of an amputee during gait cycle [7,8].The finite element methode has been used as a tool for parametric study and evaluation of prosthetic socket[9,10].

It is common for amputees to experience pain and discomfort in the residual limb while wearing the prosthetic socket [11]. For a lower limb amputee, the comfortableness of wearing prosthesis depends on the distribution of stress at the interface of residual limb and prosthetic socket is either at the pressure-tolerant (PT) or pressure-relief (PR) areas. By employing the technology of computer-aided engineering, the quality uncertainty and labour intensity of traditional process of fabricating a prosthetic socket can be improved. Lower limb prosthesis allows ambulation and improves the performance of daily routine activities. However, poor-fitted socket can lead to complications that have adverse effects on the activity level and gait cycle of people with lower limb amputation [12].

The interface between the stump of lower limb amputees and their prostheses is the prosthetic socket. The contact pressure at the residual limb and prosthetic socket interface is an essential index, and is considered as a promising measure towards good socket design. Therefore, the fundamental concern is to understand pressure distribution at the stump-socket interface. Although the use of pressure sensor is a direct experimental approach towards estimating interface pressure, the analytical approach is an alternating to the experimental one, and finite element modeling of the socket has been used to analyse the contact pressure. Although, the complex features of the soft limb tissues and of their interaction with the socket still remains difficult to model [13].

The variation of interface pressure between the stump and socket is an important factor in socket design and fit. Lower limb prosthetic socket users experience pressure between the stump and socket during daily routine activities. The underlying soft tissues and skin of the stump are not habitual to weight bearing; thus, there is the risk of degenerative tissue ulcer in the stump because of cyclic or constant peak pressure applied by the prosthetic socket [14]. The pressure also can lead to various skin deases such as follicular hyperkeratosis, allergic contact dermatitis, infection and veracious hyperplasia [15-17].

Despite significant scrutiny in the field of prosthetics in the previous decades, still many

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amputees experience pressure ulcers with the use of prostheses. Sometimes, skin problems lead to chronic infection, which may necessitate re-amputation. This will obviate the long-term use of prosthesis, which indicatively reduces the routine activities of prosthesis users and the quality of life [18]. Many studies have concentrated on interface pressure magnitude between the socket and stump during level walking [19-20].

a) Trans-Tibialprosthesis Description

The artificial limb consists of a foot-ankle unit which needs to be attached to the remainder of the amputee's natural leg or stump. The foot ankle unit is attached directly to the socket frame. The artificial shank can be attached to the foot ankle unit and then attached to the socket frame for a below-knee amputation. Today the sockets are roughly quadrilateral in shape. They attempt to have total contact between the stump and the socket.

II. Finite Element Model

A frequently used numerical analysis technique in biomechanics is the finite element technique, a computational approach for interface stress or structural deformation calculation evoluted in engineering mechanics. It has been introduces as a useful tool to understand the load transfer mechanics between a residual limb and its prosthetic socket. The finite element technique is a full-field analysis for calculating the state of stress and elestic strain in the specific field. This technique is well suited for parametric analysis in the process of design. The previous finite element analyses showed the significance of considering prestress in predicting interface stresses at loading stage[21-22].

One left unilateral male trans-tibial amputee participated in this study. The volunteer was 45 years of age, 166 cm tall, 70 kg in mass, and the cause of his amputation was an accident. He has been an active amputee for five years, using his prosthetic limb for all his daily chores. The simplified geometry of his residual limb was modeled in Pro-engineer and then it is being imported (in IGES formate) and modified in ANSYS 14.0 Workbench.

The finite element model was kept as simple as possible in terms of material properties and boundary conditions. Different materials for 2 mm, 3 mm, 4 mm, 5 mm, and 6 mm unit volume layer thickness was used for creating the 3-D FE model. Also the three dimension finite element model is developed for varrying the length of the socket of 16 cm, 17 cm, 18 cm, 19 cm, 20 cm, 21 cm. The model was meshed with brick element solid 185 with fused tibia and fibula bones. A total of 41,073 elements and 20,438 nodes were used.

On the meshed model fixed support is being applied at the distal end of the socket, distal end of the socket is further attached with the remaining parts of the prosthesis like shank, ankle foot. The different loading conditions as listed in table 2 were quasi-static approximations using experimentally obtained maximum vertical ground reaction for the prosthetic side of same subject while walking at a given speed using CGD gait cycle analyzer [24-27].

III. Material Properties

In this analysis the different material used are composite, polypropylene, 90/10 PP/PE (90% polypropylene and 10% ethylene), high density polyethylene (HDPE) and low density polyethylene (LDPE). The mechanical properties of the socket material were assumed to be linearly elastic, isotropic and homogeneous. Socket were analyzed for different materials and their valus of Young's modulus, Ultimate strength, Poisson's ratio and density is listed in table 1.

Table 1 : Properties of different socket material

Material	YM (MPa)	Density (Kg/m3)	US (MPa)	PR
Composite	1,600	1194	144	0.39
Polypropylene	1,100	910	80	0.37
PP/PE	1,500	830	39	0.3
HDPE	800	950	37	0.40
LDPE	280	920	25	0.41

Table 2 : Stance phase and Maximum vertical ground

Five phases of stance	Percentage	Variation of GRF(N)	Maximum GRF(N)
Initial Contact/Heel Strike (HS)	(0-13)%	0-620	620
Foot Flat/Loading Response (LR)	(13-38)%	620-1000	1000
Mid-Stance (MS)	(38-63)%	510-707	707
Terminal Stance/Heel Off (HO)	(63-88)%	630-1000	1000
Pre-Swing/Toe Off (TO)	(88-100)%	0-810	810

IV. Results

The results for total deformation, shear stress and equivalent von-Mises stress of developed and modified transtibial socket model were obtained by using (ANSYS Workbench v14.0) program. Figure (1) shows the meshed view of the finite element three dimension socket model, and figure (2) shows the maximum von-Mises stress developed for different loading conditions of stance phase like Initial

Contact/Heel Strike (HS), Foot Flat/Loading Response (LR), Mid-Stance (MS), Terminal Stance/Heel Off (HO) and Pre-Swing/Toe Off (TO).

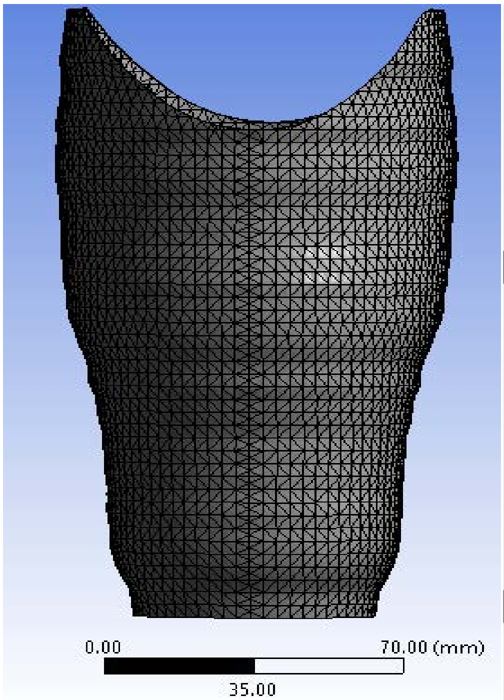

Figure 1 : Meshed view

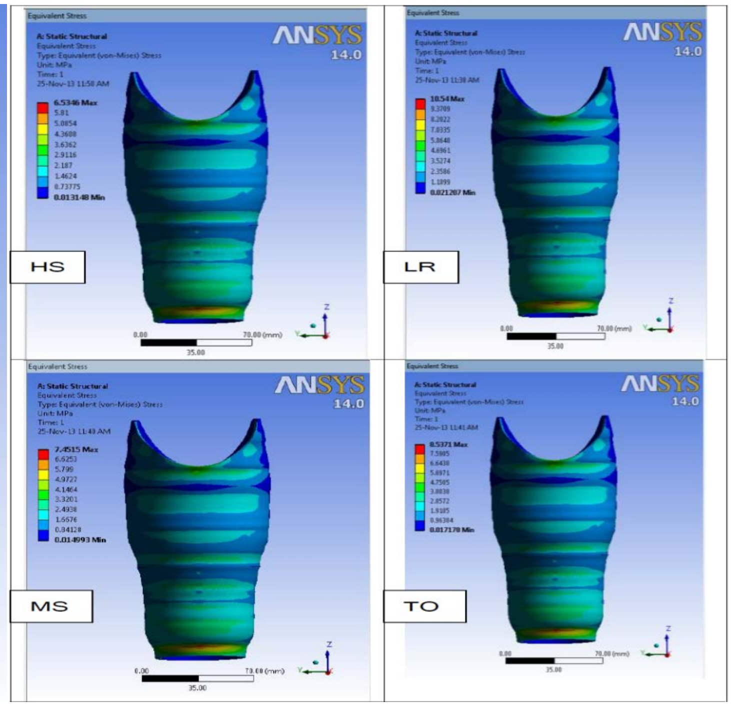

Figure 2 : Equivalent von-Mises stress at different stance

Figure 3 : shows the shear stress and figure (4) shows the total deformation developed for different loading conditions like Initial Contact/Heel Strike (HS), Foot Flat/Loading Response (LR), Mid-Stance (MS), Terminal Stance/Heel Off (HO) and Pre-Swing/Toe Off (TO) of stance phase

The maximum values of von-Mises stress, shear stress and total deformation occure in five phases of stance under the load of 1000 N are listed in the table 3 as shown below.

Table 3 : von-Mises stress, Shear stress and Total deformation at different phases of stance at 1000 N of load

Stance phase	von-Mises stress (MPa)	Shear stress (MPa)	Total deformation (mm)
Initial Contact/Heel Strike (HS)	6.55	1.02	0.55
Foot Flat/Loading Response (LR)	10.54	1.64	0.88
Mid-Stance (MS)	7.45	1.16	0.63
Terminal Stance/Heel Off (HO)	10.54	1.64	0.88
Pre-Swing/Toe Off (TO) of stance phase	8.54	1.33	0.72

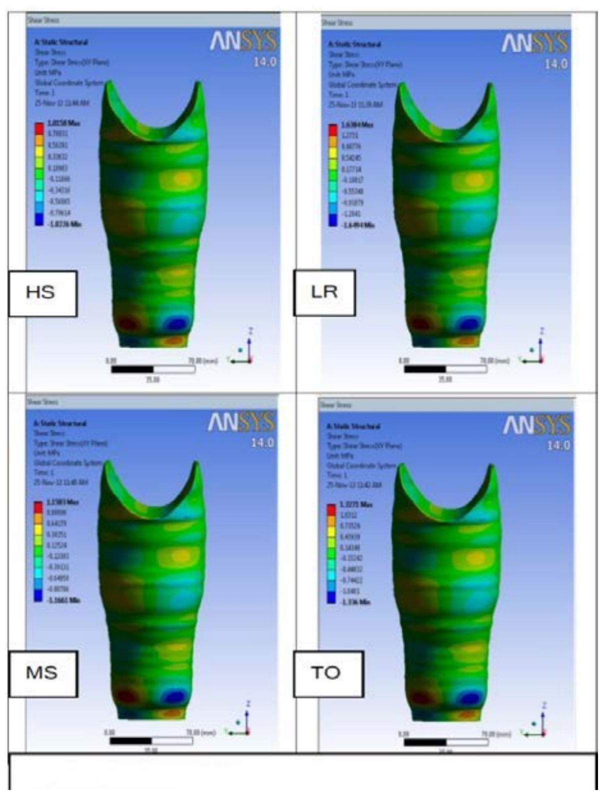

Figure 3 : Shear Stress

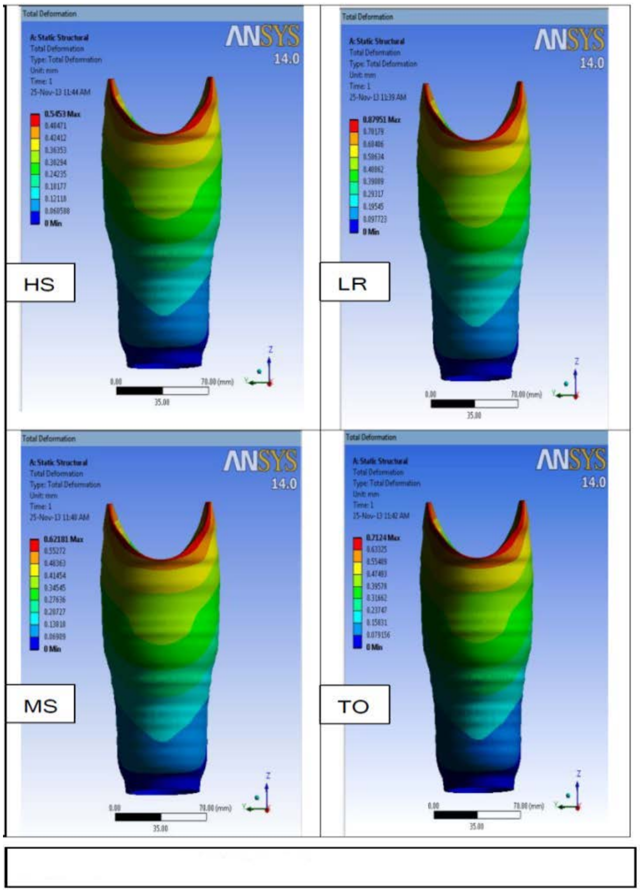

Figure 4 : Total deformation

Different approaches have been used to analyzed for socket material and thickness optimization:

a) Socket thickness vs Factor of safety

For different thickness of composite, polypropylene (PP), 90/10 PP/PE, HDPE and LDPE materials the weight of the socket were calculated and listed in table 4.

b) Tsai-Hill Criterion for socket failure

Socket failure is analyzed by Tsai-Hill Criterion based on maximum distortion criterion and used in this analysis to compare socket failure [23].

$$\text{Tsai-Hill Criterion, } C_{TH} = \frac{\sigma_1^2}{S_v^2} - \frac{\sigma_1 * \sigma_2}{S_v^2} + \frac{\sigma_2^2}{S_t^2} + \frac{\tau^2}{S_{sh}^2}$$

Where CTH is the Tsai-Hill failure coefficient, Sv, St and Ssh are the ultimate strengths of composite in the vertical, transverse and shear directions respectively listed in table 5 and σ1, σ2 and τ are the imposed stresses in the longitudinal, transverse, and shear planes. If the value of CTH is less than one than design is safe.

Table 4 : Weight of socket in grams [30]

Thickness (mm)	Composite	PP	PP/PE	HDPE	LDPE
2	140	106	102	111	107
3	209	160	155	168	174
4	280	212	208	214	222
5	350	266	261	278	269
6	420	320	315	334	323

Table 5 : Tensile and compressive strength of composite [31]

Strength (in MPa)	Sv	St	Ssh
Tension	584	43	44
Compression	803	187	64

c) Structural Behavior vs Length

The values of maximum von-Mises stress, shear stress and total deformation off all the material in different length were analyzed and shown in figures 11-13, and it is found that as the length of socket increses the values of stress and deformation decreases. The decrease in value of deformation as increase of length is higher in case of LDPE material.

d) Structural Behavior vs Thickness

The values of maximum von-Mises stress, shear stress and total deformation off all the material in different thickness were analyzed and shown in figures 8-10, and it is found that as the thickness of socket increses the values of stress and deformation decreases. The decrease in value of deformation as increase of thickness is higher in case of LDPE material.

V. Discussion

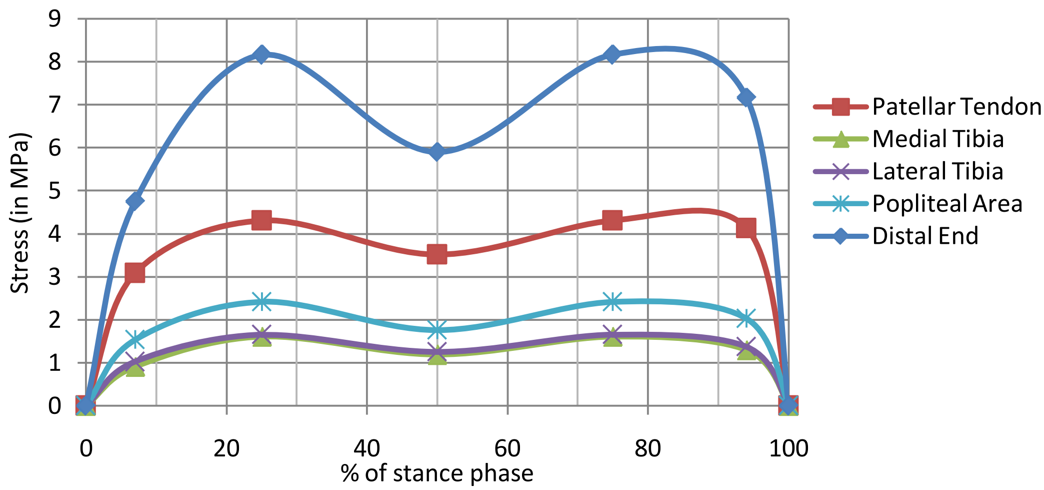

Figure 5 : Equivalent von-Mises stress at pressure tolerated areas in stance phase of gait cycle during normal walking on plane surface at a given speed

a) Case 1 : Weight of the socket

The variation of factor of safety as a function of Weight of the socket for a socket of different thickness is shown in figure 7, where factore of safety is being calculeted by dividing maximum von-Mises stress at a load of 620 N with the endurance limit (50% ultimate tensile strength value) [28]. During daily activities of an amputee the total load of knee joint in transtibial prosthesis passes on the prosthetic socket. During normal walking , the total joint reaction forces at knee joint is three to four times increases than the total body weight, during jumping and fast running load on knee joint increses more [29]. Therefore, six factore of safety is minimum desirable to withstand the loading of socket. The factor of safety is just below the level of five for LDPE and HDPE so, it can be suggested that LDPE and HDPE are note suitable for prosthetic socket design.

b) Case 2 : Analysis of failure

The finite element simulation result of rotation and displacement in different parts of socket validate the biomechanical requirement of structural integrity in patellar tendon bearing socket. Figure 7 shown below describes the variation of Tsai-Hill coefficient with tensile and compressive strength. The value of CTH coefficient in 2mm thick composite for tensile strength is 0.1864wich is only five times factore of safety but thickness between 3 mm (0.0724) to 4 mm (0.031) has a factore of safety more than twenty times. Therefore, the optimum solution of composite material of thickness 3 mm to 4 mm satisfied the Tsai-Hill criterion.

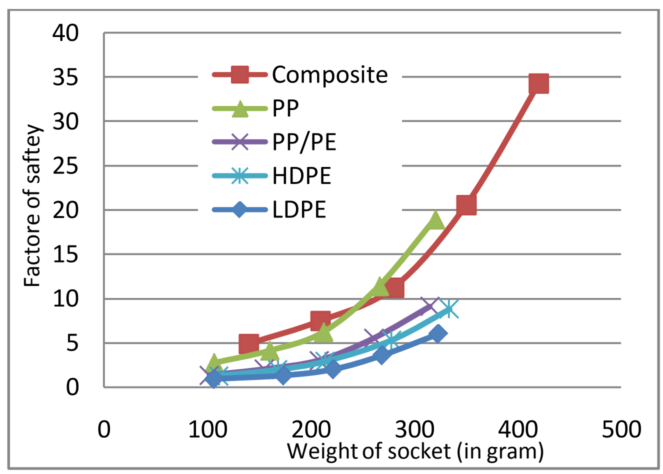

Figure 6 : Weight of socket in reference to Factor of safety

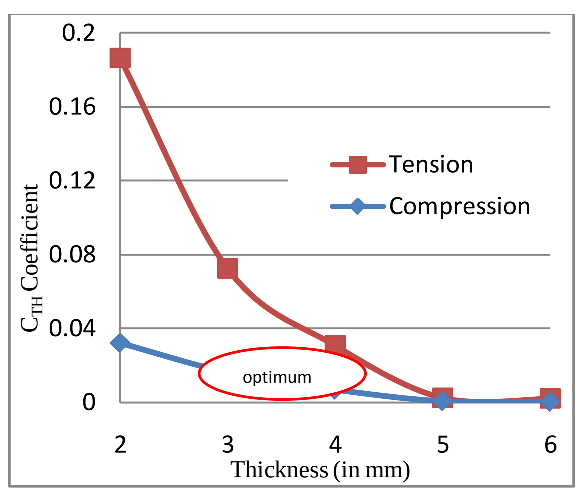

Figure 7 : Tsai-Hill coefficient with 620N load in tension and compression

c) Case 3 : Thickness of the socket

In all materials it is found that the von-Mises stress, shear stress and total deformation is inversely proportional to thickness except for LDPE of the socket figure 8-10. However the stress and stress variation were higher in case of 2mm and 3 mm socket and it is relatively low in case of 4mm and 6mm. Thus 3 mm to 4 mm could be a optimal solution in terms of thickness of the socket for all materials where this much thickness is used. The variation of von-Mises stress, shear stress and total deformation for different thickness of prosthetic socket were shown in figure 8, 9 and 10 respectively. The value of total deformation in case of LDPE of thickness less than 3 mm goes higher and it may loss biomechanical load bearing ability. Thus the result indicates that the LDPE socket length is not suitable fore fabrication of PTB socket of below 4 mm thickness.

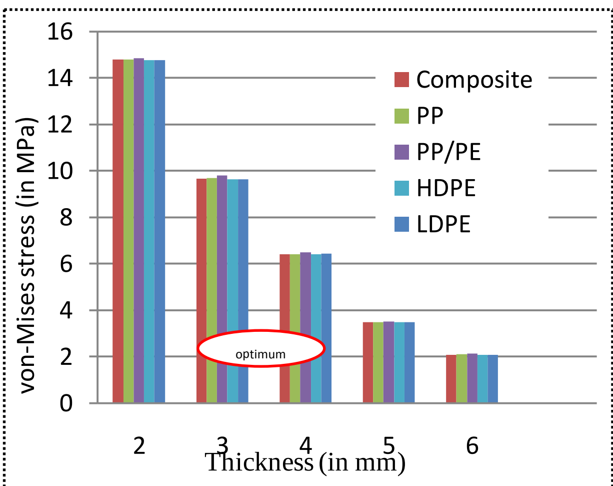

Figure 8 : Equivalent von-Mises stress in different thickness of composite, PP, PP/PE, HDPE and LDPE at 1000 N

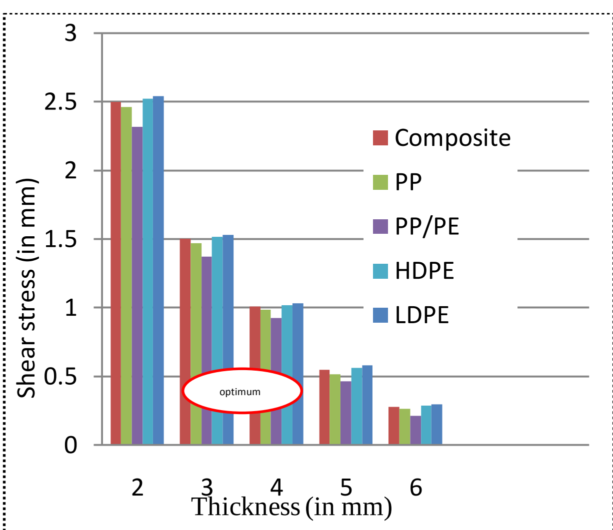

Figure 9 : Shear stress in different thickness of composite, PP, PP/PE, HDPE and LDPE at 1000 N

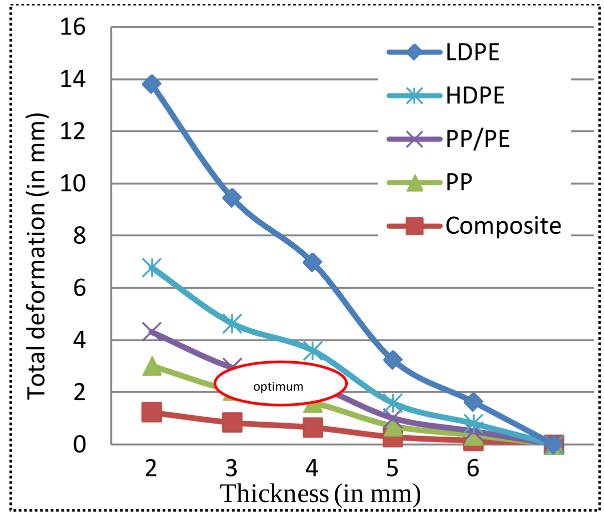

Figure 10 : Total deformation in different thickness of composite, PP, PP/PE, HDPE and LDPE at 1000 N

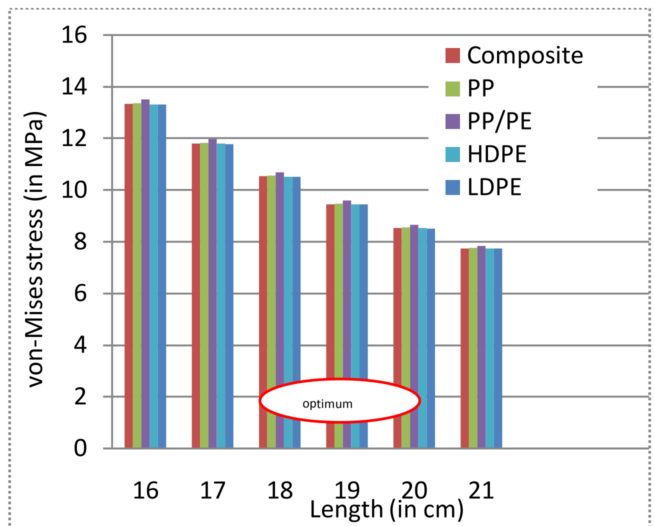

Figure 11 : Equivalent von-Mises stress in different length of composite, PP, PP/PE, HDPE and LDPE at 1000 N

e) Case 4 : Length of the socket

In all materials it is found that the von-Mises stress, shear stress and total deformation is inversely proportional to length of the socket figure 11-13. However the stress and stress variation were higher in case of 16 and 17 cm length socket and it is relatively low in case of 19cm and 20cm. Thus 19 cm to 20cm could be a viable solution in terms of length of the socket for all materials where this much length is possible. The variation of von-Mises stress, shear stress and total deformation for different length of prosthetic socket were shown in figure 11, 12 and 13 respectively. The value of total deformation in case of LDPE of length less than 16 cm goes higher and it may loss biomechanical load bearing ability. Thus the result indicates that the LDPE socket length is not suitable fore fabrication of PTB socket of below 16cm length.

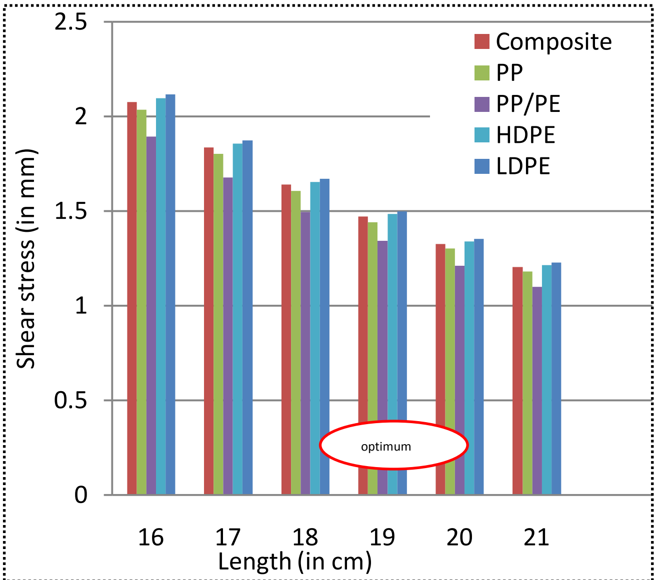

Figure 12 : Shear stress in different length of composite, PP, PP/PE, HDPE and LDPE at 1000 N

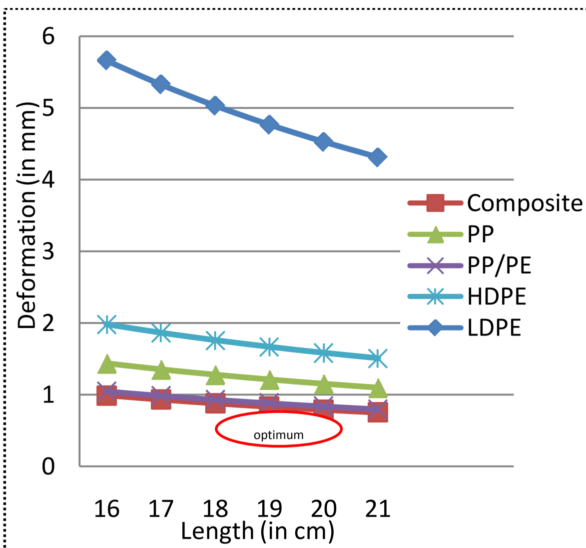

Figure 13 : Total deformation in different length of composite, PP, PP/PE, HDPE and LDPE at 1000 N

VI. Conclusions

The results summarized that assimilating local submissive properties within socket wall can be an effective methods to distribute maximum stress areas and also to relief contact pressure between the socket and stump. Based on the results and the discussion, the composite material is cheap, excellent strength, widely available butit has high weight that make it only useful to be used for adult with higher weights. The results obtained from analysis can be used as a reference to choose socket material, thickness and its optimal length for manufacturing of socket in developing countries. The socket buildup of composite material gives the optimal solution for patellar-tendon bearing socket design. The study reconnoitered further future scope for parametric analysis, investigating the effects of liner, socket stiffness, rectification scheme, soft tissues, and materials for the socket/stump interface stress distribution.

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Study of Graphite Content and Sintering Temperature on Wear and Microstructure of Fe+C Powder Metallurgy Preform

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Gyan Ganga Institute of Technology & Sciences, India

Abstract- The present paper investigates the effect of sintering temperature and graphite content on the microstructure and effect on wear and frictional properties of Fe+C powder metallurgy preforms. For the present work the specimens were prepared with graphite content 0.5%, 1%, 1.5% and 2% by weight and were sintered at three sintering temperature 800°C, 900°C and 1050°C. Microstructural properties were evaluated using scanning electron microscopy. The wear and friction property of the powder preforms were tested on Pin-On-Disc apparatus. The powder specimen was used as pins and the disc was of AISI 51200 steel. The experiments was carried out under load of 40 N, speed 1000 rpm, time 1500 seconds and relative humidity 60% - 65%. The result was 2% graphite content specimen with sintering temperature 1050°C showed good wear resistance. The wear rate decreased with the increase in sintering temperature and increase in graphite content of the specimen.

Keywords: wear and friction, iron powder, graphite contents, microstructure and powder metallurgy.

GJRE-A Classification : *FOR Code: 091399p*

STUDYOFGRAPHITECONTENTANDSINTERINGTEMPERATUREONWEARANDMICROSTRUCTUREOFFE+CPOWDERMETALLURGYPREFORM

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Study of Graphite Content and Sintering Temperature on Wear and Microstructure of Fe+C Powder Metallurgy Preform

Atish Sanyal [α], T.K Mishra [σ], Dr. Manish Choubey [ρ] & Dr. A.C Saxena [Ѡ]

Abstract- The present paper investigates the effect of sintering temperature and graphite content on the microstructure and effect on wear and frictional properties of Fe+C powder metallurgy preforms. For the present work the specimens were prepared with graphite content 0.5%, 1%, 1.5% and 2% by weight and were sintered at three sintering temperature 800°C, 900°C and 1050°C. Microstructural properties were evaluated using scanning electron microscopy. The wear and friction property of the powder preforms were tested on Pin-On-Disc apparatus. The powder specimen was used as pins and the disc was of AISI 51200 steel. The experiments was carried out under load of 40 N, speed 1000 rpm, time 1500 seconds and relative humidity 60% - 65%. The result was 2% graphite content specimen with sintering temperature 1050°C showed good wear resistance. The wear rate decreased with the increase in sintering temperature and increase in graphite content of the specimen.

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I. Introduction

The technology of pressing metal powders into required shape is not new and known as powder metallurgy technology. It is a popular route for producing light automotive and engineering parts. By the use of this technology the finished products can be produced with least wastage. But the parts obtained by this method are not fully dense as obtained by convectional process the effects of graphite content and temperature on microstructure and mechanical properties of iron-based powder metallurgy parts by Xiaxun Zhang, Fang Ma, Kai Ma and Xia Li (2011) the density of the specimen with higher sintering temperature are higher and with increase of graphite content porosity decreases. The minimization of wear and friction of any materiel is very important due to the energy crises faced by the world now days, therefore the materials should be wear resistant as well as lighter in weight. The study of wear resistant application of powder metallurgy iron based ternary alloy was studied by S.B. Halesh and P. Dinesh (2013) was carried out using pin-on-disc apparatus under different normal loads under lubricated dry conditions. The effect of load, sliding speed and times on wear rate of steel, aluminum and brass using pin-on-disc was studied and mathematical model has been made for all cases by Hani Aziz Ameen, Khairia Salman Hassan and Ethar Mohamed Mhdi Mubarak (2011). The effect of sliding speed and normal load on friction and wear property of aluminum using pin-on-disc apparatus was done by M.A. Chowdhury, M.K. Khalil, D.M. Nuruzzaman and M.L. Rahaman (2011) and found wear rate increases with the increase of sliding speed and normal load. Lubricated sliding wear behavior of a CI effect of Graphite and/ or talc fraction in oil with the effect of suspended solid lubricant was studied by B.K. Prasad (2010). The effect of temperature and sliding speed on adhesive wear of high speed steel and tungsten carbide coating under load 30 N and 150 N was studied by A. Babilius, P. Ambroza (2003). The effect of carbon on tensile properties and wear behavior of P/M Fe-Al alloy the ductility was due to grain refinement in carbon added alloy wear was studied by ball-on-disc apparatus by Xingsheng Guan, Su-Ming Zhu, Koji Shibata and Kunihiko Iwasaki (2002).

The graphite present in the specimen itself acts as the solid lubricant in addition it also provides hardness to the specimens, it is observed in the experiment that with the increase of graphite content in the specimen. The sintering temperature selection also plays important role in achieving better wear resistance of the specimens and the selection of sintering temperature is also very important to get the fully dense structure of the specimens. After sintering process the samples was cleaned and polished the get a better surface finish and appearance, some carbon deposits was also found on the surface of the specimen containing higher amount of graphite content which is illustrated in the experiment.

In this paper, the experimental study was conducted for the effect of sintering temperature and graphite content on wear and frictional properties and microstructure obtained for the specimen were examined using pin-on-disc apparatus and SEM (scanning electron microscopy).

II. Experimental Procedure

a) Materiel Preparation

For the experiment the sample was prepared press sinter path, the methods used are discussed below. The iron and graphite powder was purchased for

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Author Ѡ: C.I.A.E Bhopal.

G.I.D.C. Industrial Estate Nandesari, Vadodara, Gujarat.
Qualikems Fine Chemicals PVT. LTD. Plot No 68/69,

- *Iron powder specification*

Atomized IRON powder of purity 99.5% and finer than 44µm was used throughout the experiments with 300 mesh size.

Element	Fe	HCl (insoluble)	As	Cu	Mn	S	Ni	Pb	Zn
Wt%	99.5	0.05	0.0005	0.005	0.05	0.02	0.05	0.002	0.01

- *Graphite powder specification*

Electrolytic Graphite powder of purity 98.8% and 325 mesh was used throughout the experiment.

Element	C	Fe	H_2O (insoluble)	Others
Wt%	98.0	0.045	0.5	1.45

Four groups of 20g of iron and graphite powder were stirred well and mixed uniformly. Then, four groups of powder mixture were produced and their graphite contents were 0.5%, 1%, 1.5% and 2%, respectively. These powder mixtures were used to make specimen used in the experiments.

b) Powder Blending

For the experiment iron and graphite of varying percentage was needed. The percentage of graphite was varied with different weight percentage, these percentages are 0.5%, 1%, 1.5%, 2%. Then, the samples were taken and blended together properly using a pestle and mortar for 30 minutes to ensure uniform distribution of the graphite particles throughout the iron matrix.

c) Sample Preparation

- *Cold Compaction*

A cylindrical die with a diameter of 12.5 mm was adopted to compact the powder. The cotton with acetone used to wipe and clean the mold wall. Powder mixture of 20g of weight is taken and put into the die. A UTM (universal testing machine) hydraulic press is used to compact the powder and the load put on the die is 100 KN and the holding time is 15 minutes. Then, the green compact was ejected from the die.

- *Green Compact Sintering*

The specimens were sintered in a muffle furnace. Every single sample three temperature ranges 800°C, 900°C, 1050°C, holding time is 20 minutes and cooling with the furnace.

- *Finishing operation*

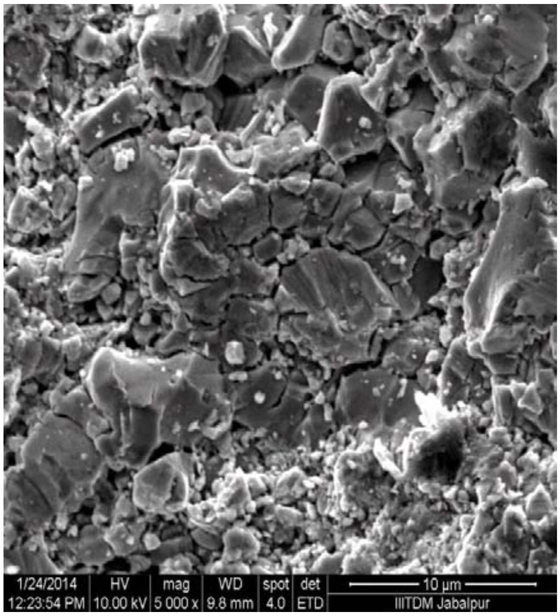
Grinder, Amery paper is use in operation of minimizing mechanical surface damage that must be removed by subsequent polishing operations. The metallographic specimens were polished and then etched by nitric acid and alcohol solution.

Figure 1 : Finished specimen

III. Experiment & Result Discussion

a) Microstructure observation

The microscopic structure of specimen by Scanning Electron Microscope has been analyzed. It is done to find the structure formed after sintering. . The specimens were produced at three sintering temperatures, 800°C, 900°C and 1050°C, respectively, and with four graphite contents, 0.5%, 1%, 1.5% and 2%, respectively. The polished and etched specimens were examined by scanning electron microscopy (SEM) and the magnification 10 to 40µm. The effects of temperature and graphite content on the microstructure of the iron-based powder sintered products by metallographic analysis were shown



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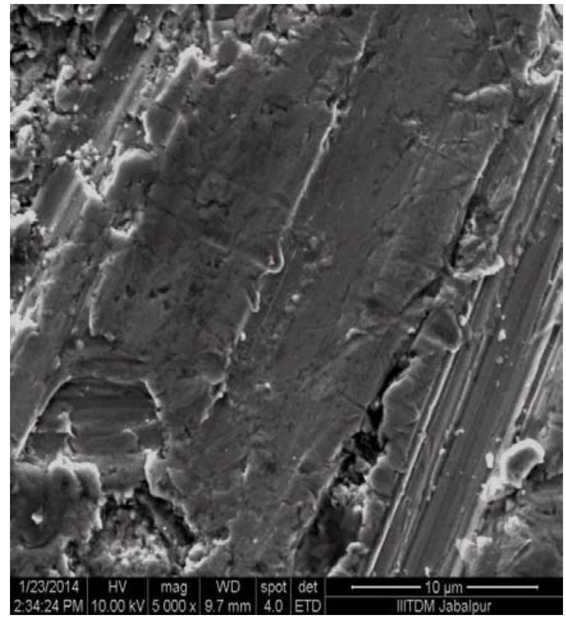
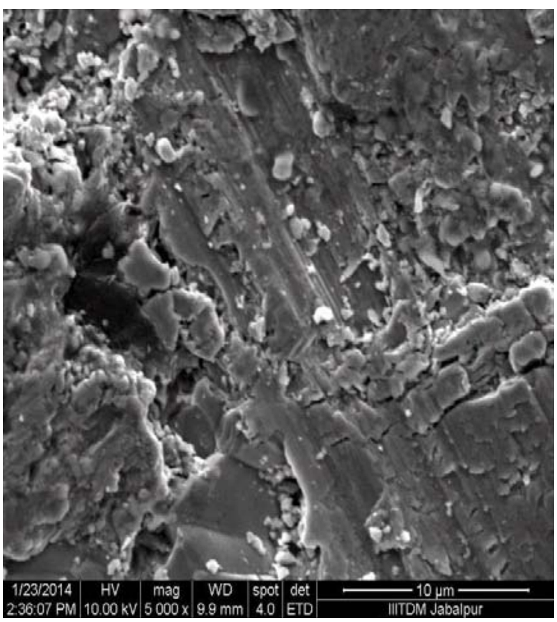
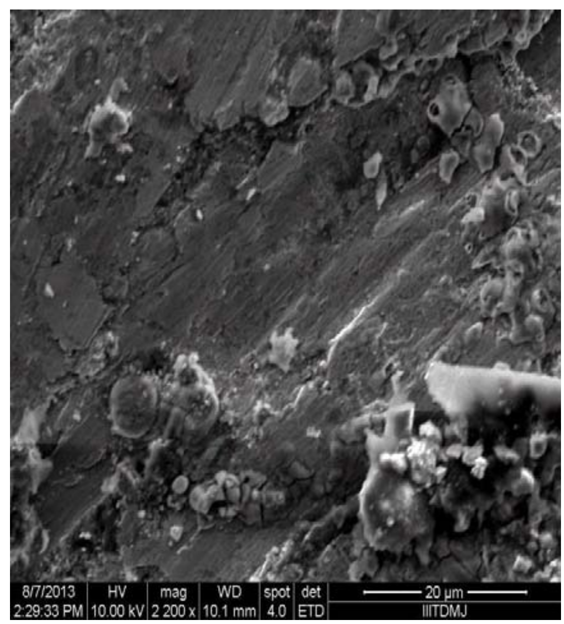


(b)

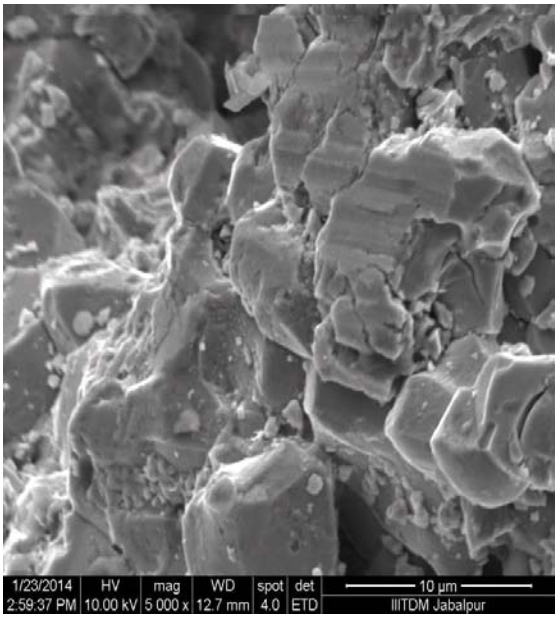


(c)



(d)

Figure 2 : Microstructure of the iron- based PM parts sintered at 800°C with different graphite content (a) 0.5%, (b) 1%, (c) 1.5% and (d) 2%



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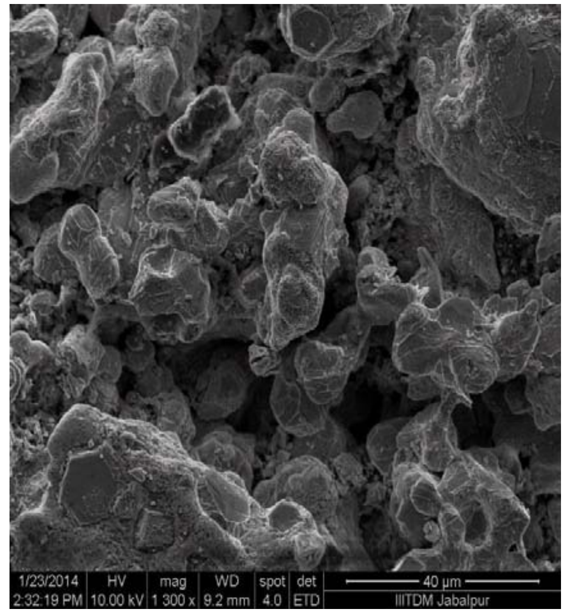

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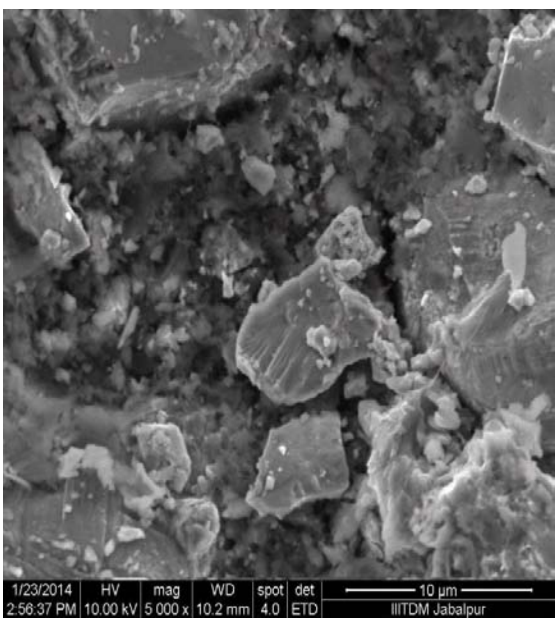

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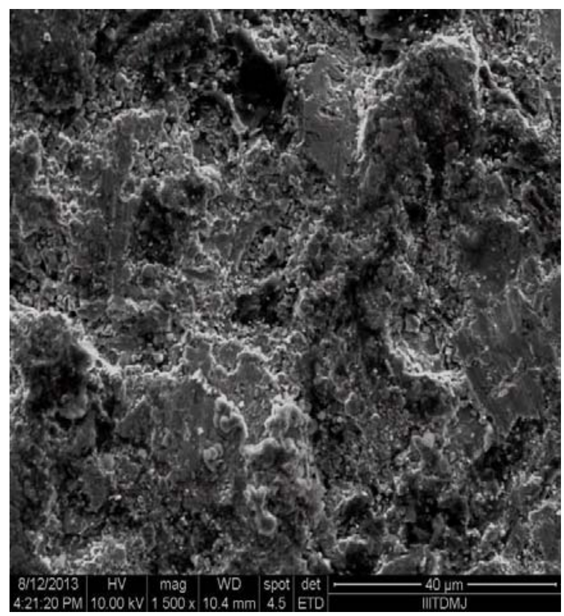
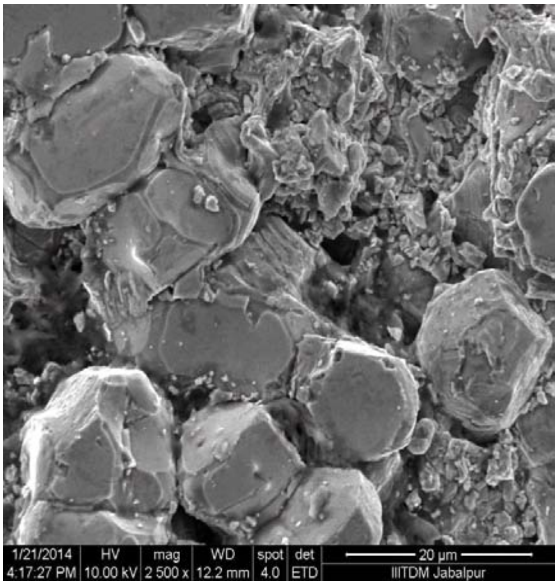


(d)

Figure 3 : Microstructure of the iron-based PM parts sintered at 900°C with different graphite content (a) 0.5%, (b) 1%, (c) 1.5% and (d) 2%



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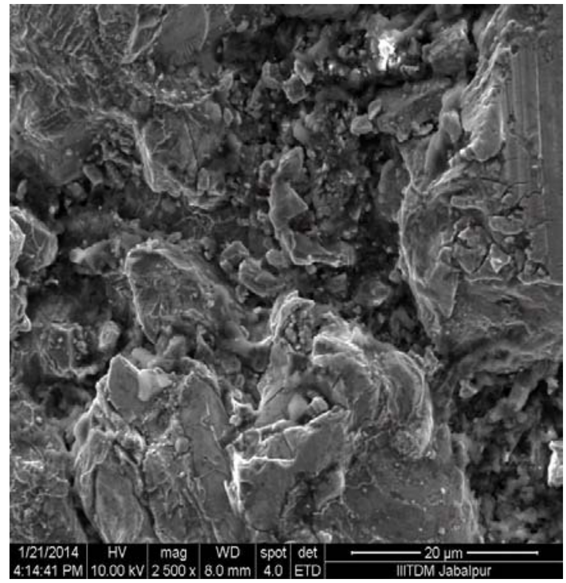

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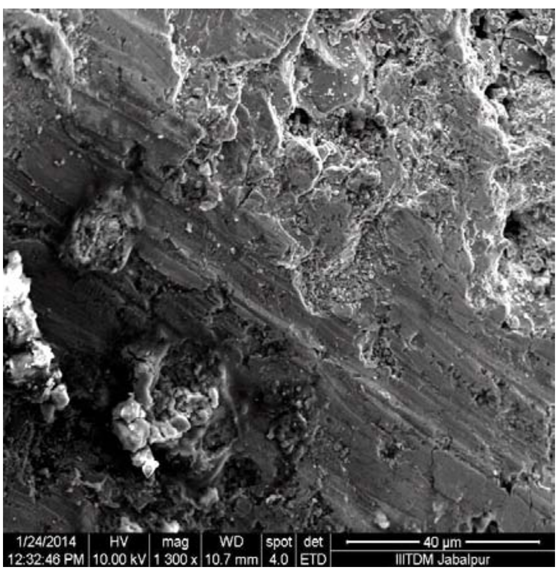

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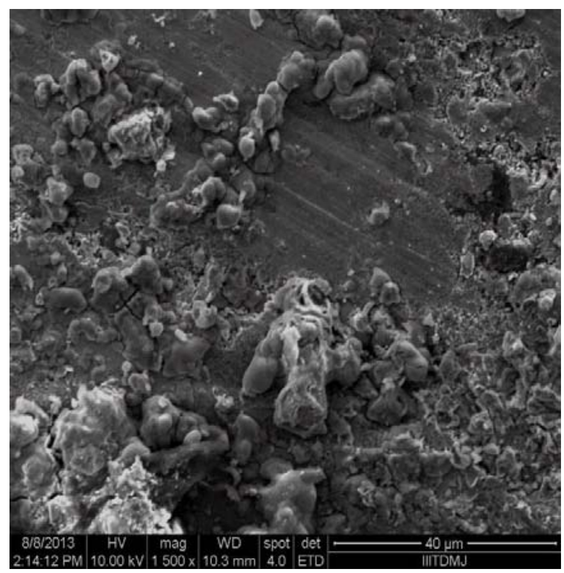

(d)

Figure 4 : Microstructure of the iron-based PM parts sintered at 1000°C with different graphite content (a) 0.5%, (b) 1%, (c) 1.5% and (d) 2%

The microstructures of the sintered specimens with the graphite content from 0.5% to 2% were shown in above images. It can be seen that as the graphite content increases from 0.5% to 2%, the microstructure of the iron-based powder sintered specimen changes gradually from ferrite (white microstructure) and a small amount of pearlite (black and white lamellar microstructure) to pearlite and a small amount of ferrite. A small amount of cementite (Fe_3C) also appeared in the microstructure when the graphite content increased to 1%. It can also be seen that the grain size decreases gradually when the graphite content increases, the decrease in grain size shows that the structure is denser and with the more dense structure wear of the specimen will be less. This is because, degree of superheat increases as the graphite content increases when the sintering temperature is constant, thus contributing to the growth of austenite grain. In 1% and 1.5% specimen we can see that there is some pocket formation and micro cracking observed in the structure which is eliminated in 2% specimen therefore less wear in 2% specimen and a denser microstructure and spheroidal structure increases from 0.5% to 1.5% graphite content specimen. In 2% samples some carbide formation can also be seen which gives a hard structure formation in the sample and thus reducing the wear of 2% specimen. As the graphite percentage increases to 2% some flakes are observed in the microstructure images in form of black spots. The reason is increased graphite percent is not properly absorbed by the iron specimen.

Compare the microstructures of the sintered specimens at 800°C to 1050°C by SEM images. It can be concluded that as the sintering temperature increases, the micro structures of the sintered interface become uniform. This is mainly because of the formation of many meshes of grain boundary and their interactions with the interwoven pores. The excess vacancies at the edge of the sintering neck and on the surface of micro-pores are easy to pass the adjacent grain boundary and diffuse or absorb. The higher the sintering temperature, the greater the coefficient of the atomic diffusion within the particle, and the faster the sintering carried out. As percent of graphite increases the micro cracking gradually increases.

III. Wear and Friction Test

The dry sliding wear tests for the binary powder performs of Iron-Graphite have been conducted using pin-on-disc machine model TR-20 supplied by M/S Ducom, Bangalore (India). The tests have been conducted in ambient condition of 29⁰C to 32⁰C temperature and a humidity of around 60% to 65%. Wear tests have been conducted using cylindrical samples of Ø 12.3 mm (avg. value) 28±1 mm in length that had flat surfaces in contact region and the rounded corner. The pin is held stationary against the counter face of a 10 mm. The control parameters for the wear tests are the normal, track radius and the rotational speed of the disc. Composition of the counter face is of following proportion, Fe- I.3-1.6, Cr,-0.95-1.1, C-0.2-0.35, Si-0.25-0.45, Mn-0.025, P-O.O25S (AISI 52100). The Disc was used be cleaned after every single experimentation. Figure below is the photograph of the wear testing machine.

Figure 5 : Pin-on-disc wear tester

The variation of wear and friction change with the change in sintering temperature and graphite content are discussed below.

Fig 6, Fig 7 and Fig 8 shows the experimental testing carried out for 1050°C, 900°C and 800°C sintered specimen with graphite content of 0.5%, 1%, 1.5% and 2%. The load applied was 40 N and track radius was selected 40 mm for 1500 seconds which means the track distance 6000 m, selected for test. As the test started the specimen got started rubbing with the disc of wear tester, this rubbing generated intense noise and sparks. From the above figures it is visible that the specimen with graphite content of 2% for all sintering temperature shows the maximum wear resistance as compared to other percentage of graphite content. The samples sintered at 1050°C for all graphite percentage when compared to 900°C and 800°C shows good wear resistance. Thus hard and dense samples were obtained for 1050C sintered with was also seen in the microstructural analysis of the samples by SEM analysis (Fig 2, Fig 3 and Fig 4). The average wear of the specimens studied was

It is clearly visible from the above Fig 9 that the average wear of the samples decreases with the increase in graphite content for same sintering temperature and wear resistance of the samples increases with the increase in sintering temperature.

IV. Conclusion

- As the sintering temperature increases from 800°C to 1050°C the microstructure of the specimen shows the dense and harder structure.
- With the increase of graphite content the microstructure of the specimen shows better bonding of the particles thus micro cracks of the specimen is reduced with the increase of the graphite percentage from 0.5% to 2%.
- With the increase of graphite percentage of the specimen it is observed in the microstructure that the graphite particles are deposited in freeform on the surface of the specimen.
- Wear resistance of the specimens was increased with the increase in graphite content.
- Average wear rate of the specimens was decreased with the increase in sintering temperature. The best result was obtained with the specimen of 2% for all sintering temperature and least wear was found in specimen with sintering temperature 1050°C and 2% graphite content.

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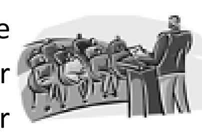

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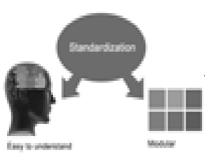

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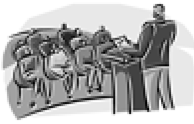

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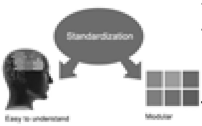

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Review papers: These are concise, significant but helpful and decisive topics for young researchers.

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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:

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(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.

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(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.

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References

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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.

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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.

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Key points to remember:

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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.

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· Present your points in sound order

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· Use past tense to describe specific results

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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.

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- To the point depiction of the research
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- Present a justification. Status your particular theory (es) or aim(s), and describe the logic that led you to choose them.
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- Materials may be reported in a part section or else they may be recognized along with your measures.

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- Report the method (not particulars of each process that engaged the same methodology)
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What to keep away from

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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.

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- Sum up your conclusion in text and demonstrate them, if suitable, with figures and tables.
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- Present a background, such as by describing the question that was addressed by creation an exacting study.
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- Not at all, take in raw data or intermediate calculations in a research manuscript.
- Do not present the similar data more than once.
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Approach

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- 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.

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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

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