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Highlights

- Study of Steel Industry
- Plant Recycling Process
- Optimal Layout Design
- Marshall Design Procedure

Discovering Thoughts, Inventing Future

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Integration of Reverse Logistics Network into an in- Plant Recycling Process: A Case Study of Steel Industry

By Syimun Hasan Mehidi, Nayan Chakrabarty, Avishek Barua & Dr. Tarapada Bhowmick

Khulna University of Engineering & Technology (KUET), Bangladesh

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Keywords: reverse logistics, recycling, steel industry, environmental impact, TORA.

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INTEGRATIONOFREVERSELOGISTICSNETWORKINTOANINPLANTRECYCLINGPROCESSACASESTUDYOFSTEELINDUSTRY

Strictly as per the compliance and regulations of:

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Syimun Hasan Mehidi [α], Nayan Chakrabarty [σ], Avishek Barua [ρ] & Dr. Tarapada Bhowmick [Ѡ]

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I. Introduction

The use of secondary resources, waste management and sustainable product policy has great impact in modern industrial societies to reduce environmental pollution, thus increasing of recycling activities and use of secondary resource decline mining and smelting industries. So it is necessary to focus these type of product in which 100 % recycling possible. In these cases we can consider the steel material which is totally recycled [1]. In the production of steel 99.9% scrap melted is consumed in the new steel while producing negligible environmentally unwanted waste.

Thus Recycling of steel has becoming more Important to maximize the resource efficiency and reduce the environmental pollution. Iron, which includes its refined product steel, is most widely used of all metals. Consumption of iron and steel scrap and the health of the scrap industry depend directly the health of the steelmaking industry [2].

In this case study we incorporated reverse logistics in a steel industry. One of the most pragmatic issues in environmental economics and ever increasing steel scrap in steel recycling reverse logistics network is applied to maximize the efficiency of overall steel industry recycling process.

The reverse logistics process might be best understood as an "architectural innovation," because it changes the way that components of a process are linked together, while leaving the basic components design either untouched or incrementally altered (Handerson and clark, 1990). We would expect established firms and highly institutionalized industries (DiMaggio and Powell, 1983) to resist architectural innovation such as reverse logistics, while favoring "component" innovation [3]. Bangladesh is the ninth most populous country and twelfth most densely populated countries in the world. In particular, the projected urban population growth rate from 2010 - 2015 is 3%. With this population growth, there is an increasing problem of waste management particularly in the larger cities. Transport of steel materials is also energy intensive: fossil fuels are required for energy to transport materials at every stage of the product life cycle. This includes from mine-site to manufacturing facility to retail outlet to waste management facility. Every ton of recycled steel saves 1131kg of iron ore, 633kg of coal and 54 kg of limestone2 [4]. Among the support activities of any waste management actions, the optimal transport and logistics processes are essential in order to assure time and cost-effective recycling scheme. Transportation costs represent very important part of overall recycling costs balance. There are three ways to put the economic importance of transportation costs in perspective: by examining 1) transportation costs relative to the value of the goods being moved; 2) transportation costs relative to other known barriers to trade, like tariffs; and 3) the extent to which transportation costs alter relative prices [5]. Transport costs depend both on the infrastructure (road, rail, airports, or ports) and on the vehicle used (truck versus car, for road transport for instance). Energy represents

Author α σ ρ Ѡ: Department of Industrial Engineering and Management (IEM), Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh. e-mails: mehidikuet09@gmail.com, nayan.barty@gmail.com, ivaankuet@gmail.com, drtpb@me.kuet.ac.bd

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the first source of costs leading to variations across transport odes. Other operating costs, as those related to the wages of vehicle operators/crew or to the vehicle maintenance, share the same feature [6].

The methodology we developed linear model for two different transportation models which is based on the real transport network and encompasses other distance and transport technology of the transport industry. We apply this methodology to France and road transport by truck, the most common mode for commodities in this country.

In the 1950s and 1960s, demand for high quantity steel encouraged the steelmaking industry to produce large quantities. Large, integrated steel mills with high capital costs and limited flexibility were built in the U.S. . Integrated steel plants produce steel by refining iron ore in several steps and produce very high quality steel with well controlled chemical compositions to meet all product quality requirements. The energy crisis of the 1970s made thermal efficiency in steel mills a priority [7]. The furnaces used in integrated plants were very efficient; however, the common production practices needed to be improved. The large integrated plants of the 1950s and 1960s tend to produce steel in batches where iron ore was taken from start to finish. This causes some equipment to be idle while other equipment was in use and a lot of heat losses. To help reduce energy used up during the idle time, continuous casting me thuds were developed. By keeping blast furnaces continually feed with iron ore, in this way heat is used more efficiently.

During the 20th century, the consumption of steel increased at an average annual rate of 3.3%. In 1900, the United States was producing 37% of the world's steel. With post war industrial development in Asia that region now (at the start of the 21st century) accounts for almost 40%, with Europe (including the former Soviet Union) producing 36% and North America 14.5%. Steel consumption increases when economies are growing, as governments invest in infrastructure and transport, and as new factories and houses are built. Economic recession meets with a dip in steel production as such investments falter. After being in the focus in the developed world for more than a century, attention has now shifted to the developing regions. In the West, steel is referred to as a sunset industry. In the developing countries, the sun is still rising, for most it is only a dawn. Towards the end of the last century, growth of steel production was in the developing countries such as China, Brazil and India, as well as newly developed South Korea. Steel production and consumption grew steadily in China in the initial years but later it picked up momentum and the closing years of the century saw it racing ahead of the rest of the world. China produced 220.1 million tons in 2003, 272.2 million tons in 2004 and 349.36 million tons in 2005. That is much above the production in 2005 of Japan at 112.47 million tons, the USA at 93.90 million tons million tons [8]. Recycling of steel has been a common practice in human history, with recorded advocates as far back as Plato in 400BC. During that period when resources were scare, archaeological studies of ancient waste dumps shows less household waste such as ash, broken tools and pottery. This implies that more waste was being recycled in the absence of new materials. In the pre-industrial times, there is evidence of scrap bronze and other metals being collected in Europe and melted down for perpetual reuse [9]. In Britain, dust ash from wood and coal fires was collected by dustmen and down cycled as a base material used in brick making .The driver for this type of recycling was the economic advantage of obtaining recycled feedstock instead of acquiring virgin material as well as lack of public waste removal in ever more dense populated areas. The use of recycling in the manufacturing process of metals has been a main driver of improvements in energy efficiency within the industry. Primary production, in which steel is made from iron ore and aluminum from bauxite ore, is energy intensive. However, secondary production, which involves the use of recycling scrap to make steel and aluminum, is much more energy efficient.

The Environmental Protection Agency estimates that secondary steel production uses about 74% less energy than the production of steel from iron ore, while the US Department of Energy reports that secondary aluminum production requires 90% less energy than primary production. Secondary production accounts for nearly 60% of US aluminum production (counting both old and new scrap), while primary production accounts for almost 40%. Similarly, recycling is used in most steel production. According to the US Geological Survey (USGS), 40% of US steel production in 2011 came from basic oxygen furnaces (BOF), whose inputs are almost 80% pig iron (molten iron), whereas 60% of production came from electric arc furnaces (EAF), which use more than 90% scrap. Primary production of steel usually involves using a blast furnace to produce molten iron from iron ore, coal and coke, using fluxing agents such as limestone to remove impurities. The molten iron (pig iron) is then converted into steel by a BOF. Secondary production facilities typically use an electric arc furnace (EAF), with scrap providing the main input. In an EAF, scrap is melted using electric arcs, which can be supplemented with natural gas fueled combustion. The high energy use of a blast furnace is eliminated by secondary production, with the exception of small quantities of pig iron used as an input along with scrap. Another alternative to using a blast furnace to produce pig iron is using direct reduced iron (DRI), a process typically fueled by natural gas. Scrap continues to be the primary raw material used in EAFs, but DRI may become a larger component in the raw materials mix [10].

II. Research Objectives

- To Study Existing Reverse Logistics Network
- To Reduce the Overall Internal Steel Scrap Transportation cost.
- To Propose Transportation Model
- To Improve Environmental Impact.

III. Case Study- Steel Industry

a) Overview of in-Plant Steel Recycling Process

In this study the linear model developed in order to reduce the extent of transportation cost internal steel scrap and also for the purpose of minimizing the transport emission (carbon dioxide). To implement this model we chose *Bangladesh Steel Re Rolling Mills Ltd (BSRM)*, Chittagong and the model based on the real situation and all data which is used to validate model is not based on fictional situation.

The process of steel manufacturing and internal flows are presented in fig.1. From the fig it can be seen that the scraps which are generated into the production process are collected and then gathered in a cast house and from these cast house the scarps are transported to the reprocessing unit. The dotted line indicates the flow of internal scrap. Internal transportation represents the most complex situation of manufacturing process under the study. Consequently, reverse logistics model is also put on that particular problem. However, it is worth mentioning that such approach could also be applicable for transport optimization from any other production unit. From this production process it is possible to define five different sources where steel scrap generated. First when the raw material that means Billet is charged in the furnace. The second and third place where scrap is generated are crop crank shear and crop shear. The fourth and fifth sources of scrap are cut in multiple lengths of bars at dividing shear and Static cold cutting to- length services and shear.

In this case we formulate two different models depending on the five sources and also some other factors which influenced on the transportation model. The other factors are collection site, scrap quantity, transportation distances and reprocessing unit. Here we represented the collection site by the symbol *I* and the reprocessing site by the symbol *j* and for the transported quantity and transported distance respectively are *Q* and *d*.

The existing model fig. 2 used two collection site for accumulate the internal scrap. The first one is for collecting scrap from source one and the second is used for collecting scrap from other sources and for the proposed modelfig.5. we used only one collection site for collecting scrap From Source 1 and source 5. The number of reprocessing unit for two model are same which is Three.

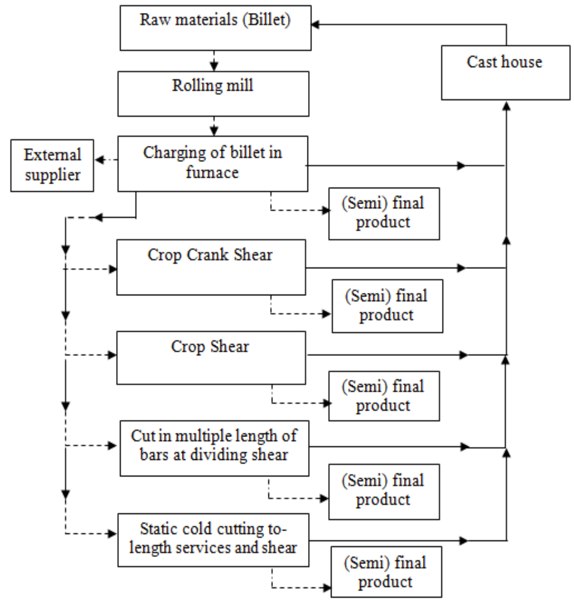


Fig. 1 : Steel Manufacturing Plant Scheme (Bold line indicates flows of in-plant recycling)

IV. Methodology

a) Optimization Model of in-Plant Steel Recycling

To reduce internal steel scrap transportation cost we formulate linear transportation model which is expressed below.

The objective function is defined as:

$$\text{minimize}\, z = \sum_{i=1}^{k} \sum_{j=k+1}^{m} c_{ij}\, x_{ij} + \sum_{i=1}^{m} \sum_{j=m+1}^{n} g_{ij}\, x_{ij} \qquad (1)$$

Where, $m = k + r_1$, $n = m + r_2$

k = number of sources where scrap is generated

r_1 = number of collection site

r_2 = number of reprocessing units

c_{ij}= unit transport cost between source *i* and collection site *j*

g_{ij}= unit transport cost from source *i* or collection site *j* to reprocessing unit *j*

x_{ij}= quantity of scrap transported from source *i* or collection site *j* to reprocessing unit *j*.

b) The Constraints

From the transportation model we can see that as the assumption regarding the recycling capacities, the total sum of scrap quantities transported from source *i* and collection sites and to reprocessing units would be equal to the quantities of scrap generated in source *i i.e.*

$$\sum_{j=k+1}^{n} x_{ij} = Q_i \quad i = 1, \ldots \ldots, k \qquad (2)$$

Where Q_i expressed the quantity of scrap generated at source i, for $i = 1, \ldots, k$. and x_{ij} is the quantity of scrap transported from source i or collection site j to reprocessing unit j and the quantities transported from collection site j to reprocessing unit would be equal to quantities transported to this same collection site. Thus,

$$\sum_{i=1}^{k} x_{ij} - \sum_{i=m+1}^{n} x_{ij} = 0 \quad j = k+1, \ldots\ldots m \tag{3}$$

The quantities transported to reprocessing unit j should not exceed its capacity. Thus,

$$\sum_{i=1}^{k} x_{ij} \leq Q_j \quad j = m+1, \ldots\ldots n \tag{4}$$

Where, Qj expresses the capacity of reprocessing unit j, for $j=m+1,\ldots, n$.

$$\text{minimize } z_1 = \sum_{i=1}^{k} \sum_{j=m+1}^{n} g_{ij} x_{ij} + f_1 \tag{5}$$

Subject to

$$\sum_{j=m+1}^{n} x_{ij} = Q_j \tag{6}$$

$$\sum_{i=1}^{k} x_{ij} \leq Q_j \quad j = m+1, \ldots\ldots n \tag{7}$$

Where, g_{ij} the unit transport cost from source i or collection site j to reprocessing unit j and x_{ij} is the quantity of scrap transported from source i to collection site j or to reprocessing unit j.

The optimal way of transport with minimum transport costs for the second transport model is obtained by the model-

$$\text{minimize } z_2 = \sum_{i=1}^{k} \sum_{j=k+1}^{m} c_{ij} x_{ij} + \sum_{i=k+1}^{m} \sum_{j=m+1}^{n} g_{ij} x_{ij} + f_2 \tag{8}$$

Subject to Constraints,

$$\sum_{j=k+1}^{m} x_{ij} = Q_i \quad i = 1, \ldots\ldots, k \tag{9}$$

$$\sum_{i=1}^{k} x_{ij} \leq Q_j \quad j = m+1, \ldots\ldots n \tag{10}$$

$$\sum_{i=1}^{k} x_{ij} - \sum_{i=m+1}^{n} x_{ij} = 0 \quad j = k+1, \ldots\ldots m \tag{11}$$

By using those equations we get optimum transportation cost for in- plant recycling process in steel industry [3].

c) Existing Transportation Model

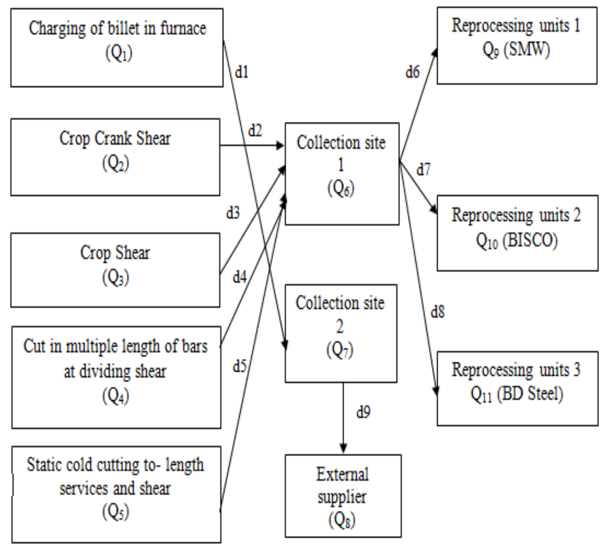


Fig. 2 : Scheme of Existing Transportation Model with Several Separated Scrap Collection Sites and Reprocessing units (transport model 1); d_{ij} is the distance between location i and location j

Table I : Total Generated Scrap

Sources of scrap Qi	Total scrap generated (ton/day)	Total scrap generated (ton/year)
Q_1	15	5040
Q_2	10	3360
Q_3	8	2688
Q_4	9	3024
Q_5	1	336

Table II : Capacity of Reprocessing Unit

Reprocessing unit Q_j	Capacity (Ton/day)	Capacity (Ton/year)
Q_9	400	134400
Q_{10}	600	201600
Q_{11}	500	168000

d) Data used for Existing Transportation Model

Table III : Calculation for Existing Transportation Model

Transportation distance d_{ij}	Transportation distance (km)	Transportation cost (C_{ij})	Transportation cost/ton C_{ij}(tk)
d_{17}	0.1	C_{17}	4.5
d_{26}	0.2	C_{26}	8.5
d_{36}	0.19	C_{36}	8
d_{46}	0.18	C_{46}	7.5
d_{56}	0.17	C_{56}	7
d_{78}	12	C_{78}	500
d_{69}	7	C_{69}	292
d_{610}	5.5	C_{610}	230
d_{611}	12	C_{611}	500

Let us assume that f_j are the annual fixed cost caused by the investment needed for the transportation model. The optimal transportation model is developed below-

From equation (1), (2), (3), (4) the model is written by,

$$\text{minimize } z = \sum_{i=1}^{5}\sum_{j=6}^{7} c_{ij}\, x_{ij} + \sum_{i=6}^{8}\sum_{j=9}^{11} g_{ij}\, x_{ij} + f_1$$

Or, minimize $z = 4.5\,X_{17} + 8.5X_{26} + 8X_{36} + 7.5X_{46} + 7X_{56} + 500X_{78} + 292X_{69} + 230X_{610} + 500X_{611} + 25000.$

Subject to Constraints,

$$X_{17} = 5040 \tag{i}$$

$$X_{26} = 3360 \tag{ii}$$

$$X_{36} = 2688 \tag{iii}$$

$$X_{46} = 3024 \tag{iv}$$

$$X_{56} = 336 \tag{v}$$

$$X_{78} \leq 5040 \tag{vi}$$

$$X_{69} \leq 134400 \tag{vii}$$

$$X_{610} \leq 201600 \tag{viii}$$

$$X_{611} \leq 168000 \tag{xi}$$

$$X_{17} + X_{26} + X_{36} + X_{46} + X_{56} - X_{78} - X_{69} - X_{610} - X_{611} = 0 \tag{x}$$

$$X_{ij} \geq 0,\ Q_{ij} \geq 0$$

This Model is written by,

$$\text{Minimize } z = 4.5X_1 + 8.5X_2 + 8X_3 + 7.5X_4 + 7X_5 + 500X_6 + 292X_7 + 230X_8 + 500X_9 + 25000.$$

For solving this model annual depreciation cost was evaluated BDT 25,000tk and the optimum solution of optimization model was calculated by computer program TORA.

e) TORA Implementation for Existing Model

The Optimum solution of existing transportation model is solving by using TORA software which is given below-

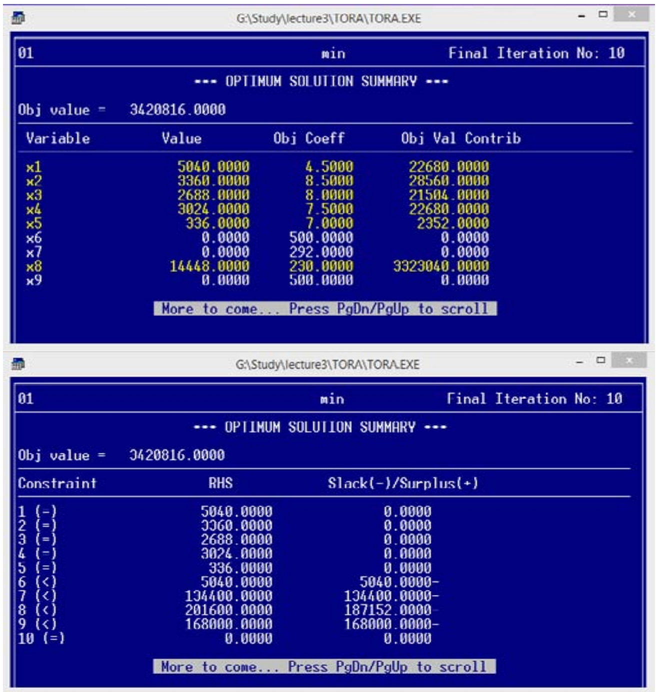


Fig. 3 : Linear Programming Solution by Using TORA Software

So the Objective value is, $Z = 3420816 + f_1$.

Here, annual fixed cost = 25000 BDT /year (Let).

So Z = 3445816 BDT.

f) Proposed Transportation Model

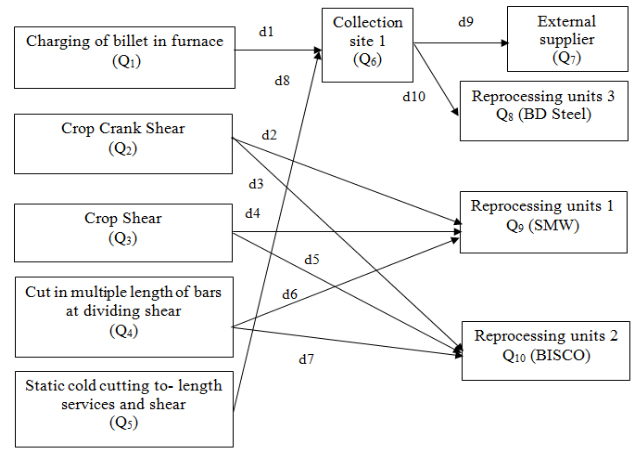


Fig. 4 : Scheme of Proposed Transportation Model with Several Separated Scrap Collection Sites and Reprocessing Units (Transport Model); d_{ij} is the distance between location *i* and location *j*

Table IV : Calculation For Proposed Transportation Modeel

Transportation distance d_{ij}	Transportation distance (km)	Transportation cost (C_{ij})	Transportation cost/ton C_{ij}(tk)
d_{16}	0.2	C_{16}	8.5
d_{29}	7.05	C_{29}	295
d_{39}	7	C_{39}	291
d_{49}	6.9	C_{49}	287
d_{210}	5.6	C_{210}	233
d_{310}	5.5	C_{310}	229
d_{410}	5.4	C_{410}	225
d_{56}	0.3	C_{56}	12.5
d_{67}	12	C_{67}	500
d_{68}	12	C_{68}	500

From equation (8), (9) and (10) the model is written by-

$$\text{minimize } z = \sum_{i=1}^{5}\sum_{j=6}^{6} c_{ij}\,x_{ij} + \sum_{i=6}^{7}\sum_{j=7}^{10} g_{ij}\,x_{ij} + f_2$$

$$\text{or, minimize } z = 14\,X_{16} + 295X_{29} + 291X_{39} + 287X_{49} + 233X_{210} + 229X_{310} + 225X_{410} + 12.5X_{56} + 500X_{67} + 500X_{68} + 25000.$$

Subject to Constraints,

$$X_{16} = 5040 \quad \text{(i)}$$

$$X_{56} = 336 \quad \text{(ii)}$$

$$X_{29} \leq 134400 \quad \text{(iii)}$$

$$X_{39} \leq 134400 \quad \text{(iv)}$$

$$X_{49} \leq 134400 \quad \text{(v)}$$

$$X_{210} \leq 201600 \quad \text{(vi)}$$

$$X_{310} \leq 201600 \quad \text{(vii)}$$

$$X_{410} \leq 201600 \quad \text{(viii)}$$

$$X_{67} \leq 168000 \quad \text{(ix)}$$

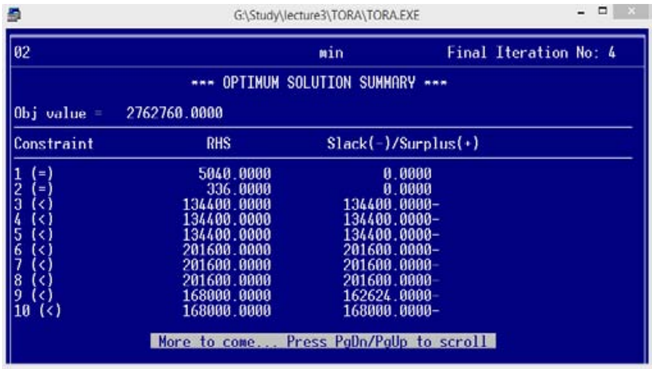
$$X_{68} \leq 168000 \quad \text{(x)}$$

$$X_{16} + X_{56} - X_{67} - X_{68} = 0 \quad \text{(xi)}$$

$$X_{ij} \geq 0,\ Q_{ij} \geq 0$$

g) TORA Implementation for Proposed Model

The Optimum solution of existing transportation model is solving by using TORA software which is given below-



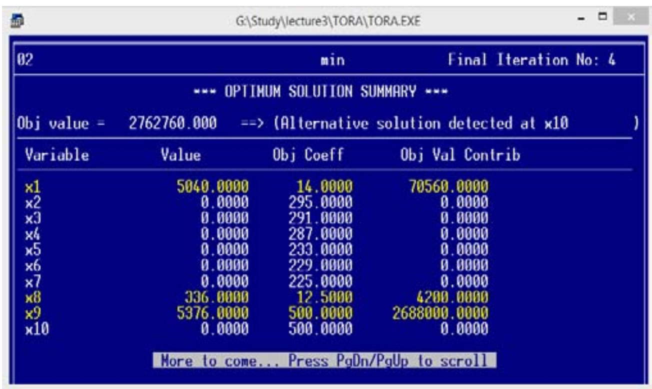


Fig. 5 : Linear Programming Solution by Using TORA Software

So the Objective value Z = 2762760+ f_1 where, f_1= annual fixed cost.

So Z = 2762760 + 25000 = 2787760 BDT.

h) Environmental Impact Estimation

i. *Measuring of Transport Emissions (carbon dioxide)*

The development of a carbon reduction strategy it is necessary to analyze the main sources of CO_2 emissions and identify those activities upon which carbon mitigation measures should be targeted. For measuring transport emission, one may apply either a fuel-based or distance-based methodology to Calculate CO_2 emissions. In the fuel-based approach, fuel consumption is multiplied by the CO_2 emission factor for each fuel type. This emission factor is developed based on the fuel's heat content, the fraction of carbon in the fuel that is oxidized (generally approximately 99% but assumed to be 100% in this tool), and the carbon content coefficient. Since this approach uses previously aggregated fuel consumption data, it is considered "fuel-based." Fuel based approach can be used also when vehicle activity data and fuel economy factors are available that enables calculation of fuel consumption. The other is distance based. In this study we calculate the CO_2 emission Depending on the transportation distance and transported quantity.

ii. *The Activity–based Method uses the following Formula*

In the absence of energy data; it is possible to make a rough estimate of the carbon footprint of a transport operation by applying a simple formula:

CO_2 emissions = Transport volume by transport mode x average transport distance by transport mode x average CO_2-emission factor per ton-km by transport mode.

[Tones CO_2 emissions = tones x km x g CO_2 per ton-km / 10, 00,000].

iii. *Emission Factor for Road Transport Mode*

The average CO_2 -emission factor recommended by McKinnon for road transport operation is 62g CO_2 /tonne-km. This value is based on an average load factor of 80% of the maximum vehicle payload and 25% of empty running. It is assumed that the above condition is fulfilled by the steel industry. Depending on the availability of data and differences between individual supply chains, companies may disaggregate and differentiate this calculation by region, country, business unit and/or product group. The following table provides a calculation of "overall CO_2 emission for two models using the activity-based approach [11].

iv. *Existing Transportation Model CO_2 Calculation*

Sample Calculation:

For route 1-7 CO_2 emission $= \frac{5040 \times 0.1 \times 62}{1000000} = 0.03124$ gm/ton

For route 2-6 CO_2 emission = 0.0416 gm/ton

Similarly for all route, CO_2 emission are calculated which are shown in table v –

Table V : Co_2 Calculation for Existing Transportation Model

Route	Transport distance	Transport Volume	CO_2 emission (gm/ton)
1-7	0.1	5040	.03124
2-6	0.2	3360	.0416
3-6	0.19	2688	.03166
4-6	0.18	3024	.0337
5-6	0.17	336	.0035
6-9	12	5408	3.7
6-10	7	3000	1.736
6-11	5.5	1000	1.364
7-8	12	5040	1.07
			Total = 8.0517

v. *Proposed Transportation Model CO_2 Calculation*

Table VI : Co_2 Calculation for Proposed Transportation Model

Route	Transport distance	Transport Volume	CO_2 emission (gm/ton)
1-6	0.2	5040	.0624
2-9	7.05	1000	.4371
3-9	7	1200	.5208
4-9	6.9	1512	.6468
2-10	5.6	1360	.829
3-10	5.5	1488	.507
4-10	5.4	1512	.506
5-6	0.3	336	.00624
6-7	12	5040	3.74
6-8	12	336	.2499
			Total=7.49

V. Result Analysis

In this case study to evaluate minimum annual transportation cost of in-plant recycling, the linear optimization model was applied. The optimum solution of optimization model was calculated by computer program TORA. Data used to validate the model are presented in table v and table vi. Depending on data we got optimal solution for both existing and proposed model respectively. For existing and proposed transportation model, it was seen that the optimal objective value is 3445816 and 2787760 respectively. From this result it was found that the optimal objective value objective value for model 2 would be minimally decreased by 19% than model 1.

Table VII : Comparison of Internal Transportation Cost for In-Plant Recycling Process

Transportation Model	Optimal Objective Value
Existing model (1)	3445816.00
Proposed model (2)	2787760.00

To optimize the system on both economic and environmental performance the tradeoff between cost and environmental objective must be established [12].Corporate environmental performance indicators are usually divided into three main categories: 1) environmental impact (toxicity, emissions, energy use, etc.); 2) regulatory compliance (non-compliance status, violation fees, number of audits, etc.); and 3) organizational processes (environmental accounting, audits, reporting, Environmental Management System, etc.) [13].

In this case we measured CO_2 emission to evaluate the environmental performance. The value of minimal transportation cost and minimal CO_2 emission depend on same variables that is transported quantity and transported distance. We calculated CO_2 emission for existing and proposed model and it was found that CO_2 emission for model 2 was minimally decreased 7% of existing model which is shown in Table 6.2. CO_2 Emission was calculated on the basis of data for used transportation obtained by BSRM (2014).

Table VIII : Total Co_2 Emission for In-Plant Recycling Process

Transportation model	CO_2 emission (gm/ton)
Existing model (1)	8.0517
Proposed model (2)	7.49

VI. Conclusions & Recommendations

a) Conclusions

In conclusion, recycling has many positive effects for both the environment and the livelihoods of people with little to no negative impacts. Steel is one of the world's most recycled products. In fact, it is 100 percent recyclable which means its life cycle is potentially continuous. Steel scrap is a necessary component in the production of new steel [14]. Steel recycling has also important benefits regarding reduced environmental impact. In our research we applied reverse logistics model in steel industry. To minimize internal steel scrap transportation cost in in-plant recycling process, we proposed a transportation model with respect to existing transportation model. We showed which aspects influence reverse logistics model for in-plant recycling. Efficient implementation of recycling networks requires appropriate logistical structures for managing the reverse flow of materials from users to producers. This study proposed a new method for assessing a selected reverse logistics network for steel recycling [15]. In this case our measure integrates the characteristics of in-plant steel scrap transportation which means that the most important factors are transported quantity, distance, variable cost and fixed cost. In this case study five sources are used where scrap are transported to collection site to reprocessing units. The result obtained in this study proves that the transportation cost can be substantially reduced by using linear optimization model.

In in-plant recycling of steel scrap, the important factors like variable transport costs which depend on quantity, distance and volume of steel scrap and other cost associated in this case study. It was also found out that transported quantities and distance vary from sources to reprocessing units of in-plant recycling process. The model, developed in the present study, can also apply other in-plant recycling process. In this study we also improved environmental impact in in-plant recycling of steel scrap. In a steel industry CO_2 and fuel emission is most common emission which effect environmentally inside and outside the industry respectively. For measuring transport emission, one may apply either a fuel-based or distance-based methodology to Calculate CO_2 emissions. In proposed transportation model CO_2 substantially reduced as compared with existing transportation model. Actually CO_2 emission depends on distance and transported quantity. In in-plant steel recycling, to reduce environmental hazard air pollution control (APC) can be used which is most effective in a steel industry.

b) Recommendations

Bangladesh Steel industry is emerging as one of the major industrial sectors of the country. It consists of small up to the largest scale of steel melting and re-rolling factories across the country that mostly produce deformed bar rod of different grade (40, 60, 500), angel, channel and coil for the construction industry. Though the history of Steel Industry is not older one but it can make a glorious future. Many steel producing companies have gained reputation as a brand. Among them, BSRM, KSRM, Anwar Steel, AK steel, Rahim steel, Abul khayer Group is worth mentioning. Today the highest steel producing company is BSRM. They are doing business for 60 years. Their production is almost six and half lakh ton per year which meets 26% demand of the local market. Now grade 60 rods are being slowly replaced by g500 rods which a number of rolling mills in our country are now manufacturing. With g500, the real estate builders and developers can also save minimum 15% further quantity of steel than g60 but then they have to maintain good quality of concrete [15].

In these cases recycling will be among the most important activities of steel industry in the future. Each year, steel recycling saves the energy equivalent required to electrically power about one-fifth of the households in the United States (about 18 million homes) for 1 year [16]. So the utilization of in plant steel scrap will maximize the resource efficiency and save the energy. Steel recycling has also important benefits to reduce environmental impact. In the case study we analyzed the transportation route to minimize the transportation cost in plant recycling steel. From the case it was seen that the proposed model will be very efficient, if the billet manufacturing and rolling process is done on the same plant. It will reduce transportation cost significantly. It will also manage the internal scrap very effectively. The internal scrap that is generated during the production shall not be underestimated. Because the following case study (BSRM) was shown that the amount internal scrap generated per year is approximately 14500 ton that will have a great impact for an industry. A company can be benefited from the utilization of resources.

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Calculation of the Strength Reliability of Parts under Random Loading

By V. N. Syzrantsev, K. V. Syzrantseva & L. A. Chernaya
Tyumen State Oil and Gas University, Russia

Abstract- The most important characteristics of many engineering objects are their strength and reliability. To determine the probability of an object failure according to the strength criterion, it is necessary to know the laws of distribution of the actual and ultimate stresses. However the processing of actual data on the acting and ultimate stresses indicates that these data cannot be described by the known laws of the parametric statistical theory.

This paper proposes a new approach to the solution of the problem, which is based on the application of the mathematical apparatus of nonparametric statistics. The considered approach of calculating the probability of a failure and the quantile estimates of the safety factor of machine parts are universal. They allow estimation of the strength reliability of items regardless of the complexity of the laws of distribution of random values of the actual and ultimate stresses.

Keywords: stresses, strength, reliability, failure, methods of nonparametric statistics, distribution density function, parzen-rosenblatt method.

GJRE-G Classification : FOR Code: 290502p

CALCULATIONOFTHESTRENGTHRELIABILITYOFPARTSUNDERRANDOMLOADING

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Calculation of the Strength Reliability of Parts under Random Loading

V. N. Syzrantsev [α], K. V. Syzrantseva [σ] & L. A. Chernaya [ρ]

Abstract- The most important characteristics of many engineering objects are their strength and reliability. To determine the probability of an object failure according to the strength criterion, it is necessary to know the laws of distribution of the actual and ultimate stresses. However the processing of actual data on the acting and ultimate stresses indicates that these data cannot be described by the known laws of the parametric statistical theory.

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I. Introduction

At present, when solving the problems associated with an increase in the manufacturing efficiency, improvement of the diagnostics of diseases, statistical data processing in insurance and financial mathematics, one has to deal with experimental data. The distribution density functions (DDFs) for these data are most frequently unknown and are not described by the laws of distribution of random quantities that were developed in the theory of mathematical statistics. Therefore, the main trend in the development of the statistical science involves the elaboration of methods for processing experimental data that allow the actual laws of distribution of random quantities to be taken into account. In the second half of the last century, an approach to estimation of many functionals on the basis of a nonparametric estimate of the probability density was proposed in [1, 2, 3]. To date, owing to the development of the computer engineering, this approach has gained significant development for solving various problems in economics and medicine [4, 5, 6, 7]. Nonparametric methods became widespread in solving identification and regression-analysis problems [8, 9, 10].

The most important characteristics of numerous engineering objects are their strength and reliability. Up to now, these characteristics are determined on the basis of the laws that are considered in the theory of parametric statistics [11, 12]. At the same time, it was shown in [13, 14, 15] that the DDFs of the actual and ultimate stresses, on the basis of which the probability of no-failure operation of an item is determined, are seldom described by the laws that were studied in the statistical theory. This study considers the solution of the problem of calculating the probability of no-failure operation of several engineering objects on the basis of applying methods of nonparametric statistics.

II. Statement of the Problem

Calculated estimates of the strength reliability of parts are currently obtained using two fundamentally different approaches. According to the first one [11, 12], the probability of a failure of a part is calculated as

$$Pr\left[y = (\sigma - s) \geq 0\right] \tag{1}$$

where σ - are the effective stresses (MPa) at a hazardous place of the part,

s - the permissible stresses (MPa) for its material.

Problem (1) requires knowledge of the distribution density function (DDF) $f_\sigma(\sigma)$ of the random quantity and the DDF $f_S(s)$ of the random quantity s. If the functions $f_\sigma(\sigma)$ and $f_S(s)$ are known to within parameters, the solution of problem (1) reduces to the calculation of the integral

$$Q = \frac{1}{F_\sigma \cdot F_s} \int_0^\infty \left(\int_0^\infty f_\sigma(u+t) \cdot f_s(t)dt \right) du \tag{2}$$

where $F_\sigma = \int_0^\infty f_\sigma(u)du \;\; F_s = \int_0^\infty f_s(u)du$.

It is conventionally assumed that the density functions $f_\sigma(\sigma)$ and $f_S(s)$ are distributed according to a normal law, thus allowing the problem (1) to be solved on the basis of tables of the normal distribution. Papers [11, 12] presents the solutions of problem (1) for several laws of distribution of the random quantities σ and s that were studied in the theory of parametric statistics.

Despite the versatility of this approach, it is not always possible to obtain a quantitative estimate of the strength reliability of a studied part within its framework.

Author α σ: Tyumen State Oil and Gas University, Tyumen, Russia. e-mails: v_syzrantsev@mail.ru, kv.syzr@gmail.com,
Author ρ: Bauman Moscow State Technical University, Moscow, Russia. e-mail: chernayala@yandex.ru

This is confirmed by Fig. 1, which shows the functions $f_\sigma(\sigma)$ and $f_S(s)$ for one of the studied parts.

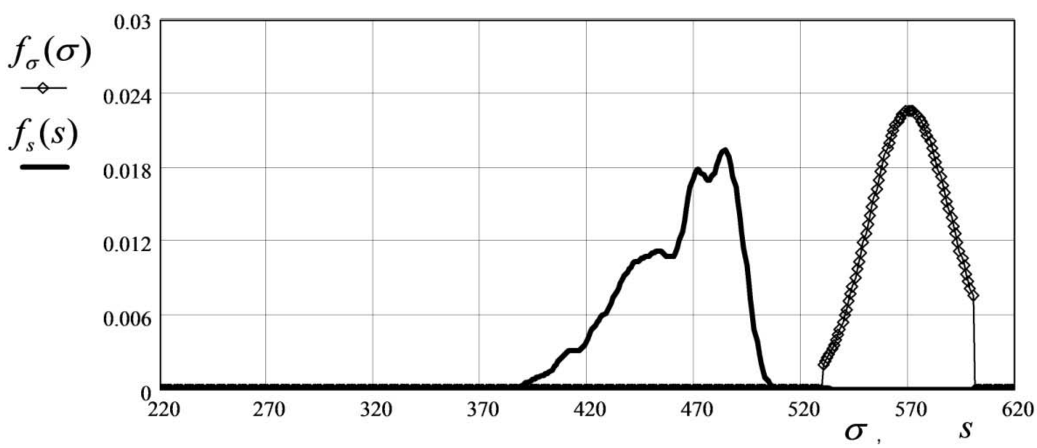

Fig. 1 : Density functions $f_\sigma(\sigma)$ and $f_S(s)$

It can be easily seen in Fig. 1 that the calculation of the probability of failure using formula (1) results here in the zero value of the probability of a failure. In this case, the problem of estimating the technical state of a part can be solved via realization of the second approach, which implies the calculation of quantile (n_σ^α) estimates of the safety margin (n_σ) at a specified probability α via the numerical solution of the equation

$$\int_0^{n_\sigma^\alpha} f_n(n_\sigma)dn_\sigma = \alpha \tag{3}$$

with respect to n_σ^α .

Here, $f_n(n_\sigma)$ is the DDF for n_σ , which is calculated from the dependence

$$n_\sigma = s/\sigma \tag{4}$$

As a rule, when the safety margin is calculated, the random character of σ and s is disregarded and only their average values are used. However, for a number of reasons, determining the characteristics of the random quantity n_σ on the basis of formula (4) is not a trivial problem [13]. For actual conditions of the use of parts, the random quantity σ is not described by the laws that were considered within the framework of parametric statistics. The analysis of the results of processing experimental data (yield stress, ultimate stress of pipe steels), which are used to calculate allowable stresses, shows that the use of a normal distribution law is not always correct here and more "flexible" laws should be used, e.g. the Gram-Charlier law. Because the samples $\sigma_i, i=\overline{1,m}$ and $\sigma_i, i=\overline{1,m}$ always have finite lengths, the left- and right-censored density functions $f_\sigma(\sigma)$ and $f_S(s)$ must be used in calculations using expression (4). The law of distribution of the random quantity n_σ is known only for some particular cases. For example, if the functions $f_\sigma(\sigma)$ and $f_S(s)$ obey a normal law, the distribution density function $f_S(s)$ corresponds to the Cauchy distribution, for which a mean value and a variance are generally absent. For the reasons that were presented above, problem (3) can be solved using conventional methods of parametric statistics only under serious assumptions. As a result, the correct calculation results are not guaranteed. Here, more powerful algorithms that operate regardless of the complexity of the functions $f_\sigma(\sigma)$, $f_s(s)$, and $f_s(s)$ must be applied. Exactly such algorithms, the possibility of realization of which is provided only by the achievements of the modern computer engineering and computer simulation methods, were developed within the framework of the theory of nonparametric statistics [13, 14, 15].

III. Used Theoretical Methods

For determination of probability of part failure in accordance with equation (2) it is necessary to solve two auxiliary problems.

Problem 1: Reconstruction of an unknown DDF on the basis of a sample of values of a random quantity

According to [13], on the basis of a sample of stresses $\sigma_i, i=\overline{1,m}$, the estimate of a left ($\sigma_{\min} = \min_i\{\sigma_i\}$) and right ($\sigma_{\max} = \max_i\{\sigma_i\}$) censored unknown DDF for stresses is represented in the form of the expansion (Parzen-Rosenblatt estimate with a normal kernel):

$$f_\sigma(\sigma) = \frac{1}{m \cdot h_\sigma \cdot \sqrt{2 \cdot \pi}} \sum_{i=1}^{m} \exp\left[-0{,}5\left(\frac{\sigma - \sigma_i}{h_\sigma}\right)^2\right] \cdot \frac{1}{c_\sigma} \quad (5)$$

$$c_\sigma = \frac{1}{m \cdot h_\sigma \cdot \sqrt{2 \cdot \pi}} \int_{\sigma_{\min}}^{\sigma_{\max}} \sum_{i=1}^{m} \exp\left[-0{,}5\left(\frac{\sigma - \sigma_i}{h_\sigma}\right)^2\right] d\sigma$$

in which

$$c_\sigma = \frac{1}{m \cdot h_\sigma \cdot \sqrt{2 \cdot \pi}} \int_{\sigma_{\min}}^{\sigma_{\max}} \sum_{i=1}^{m} \exp\left[-0{,}5\left(\frac{\sigma - \sigma_i}{h_\sigma}\right)^2\right] d\sigma$$

and the value of the spreading parameter h_σ corresponds to the maximum of the information functional:

$$\max_{h_\sigma} J = \max_{h_\sigma}\left\{\frac{1}{m}\sum_{i=1}^{m} \ln\left[\frac{1}{(m-1)h_\sigma}\sum_{j \neq i}^{m-1} \frac{1}{\sqrt{2 \cdot \pi}} \exp\left(-0{,}5\left(\frac{\sigma_i - \sigma_j}{h_\sigma}\right)^2\right)\right]\right\} \quad (6)$$

The solution of problem (6) allows determination of all parameters that are included in (5) and, thus, reconstruction of the function $f_\sigma(\sigma)$.

For a kernel function with a normal kernel, a close-to-optimal value of the parameter is defined from the dependence

$$h_\sigma = D_\sigma \cdot m^{-\frac{1}{5}} \quad (7)$$

where D_σ is the sample variance that is calculated on the basis of the available sample of values $\sigma_i, i = \overline{1, m}$:

$$D_\sigma^2 = \frac{1}{m-1} \sum_{i=1}^{m} \left(\sigma_i - \frac{1}{m} \sum_{i=1}^{m} \sigma_i\right) \quad (8)$$

Problem 2: Generation of a random-quantity sample in accordance with a known DDF.

This algorithm is a nonparametric generator of a random quantity. Let there be a random-quantity sample $s_j,\ j = \overline{1, n}$, on whose basis the DDF $f_s(s)$ is defined. As an example, let us assume that the random quantity obeys the left ($s_{\max} = \max\limits_j \{s_j\}$) and right ($s_{\min} = \min\limits_j \{s_j\}$) censored Gram-Charlier law:

$$f_s(s) = \frac{1}{\lambda_2 \sqrt{2\pi}} \exp\left[-\frac{(u_s)^2}{2}\right] \times \quad (9)$$

$$\times \left\{1 + \frac{\lambda_3}{6}\left[(u_s)^3 - (u_s)\right] - \frac{\lambda_4}{24}\left[(u_s)^4 - 5(u_s)^2 + 3\right]\right\} \cdot \frac{1}{c_s}$$

where

$$c_s = \int_{s_{\min}}^{s_{\max}} \left\{\frac{1}{\lambda_2 \sqrt{2\pi}} \exp\left[-\frac{(u_s)^2}{2}\right] \times\right.$$

$$\left. \times \left\{1 + \frac{\lambda_3}{6}\left[(u_s)^3 - (u_s)\right] - \frac{\lambda_4}{24}\left[(u_s)^4 - 5(u_s)^2 + 3\right]\right\}\right\} ds$$

$u_s = \dfrac{s - \lambda_1}{\lambda_2}$; λ_1 and λ_2 are the mean value and the standard deviation of the random quantity s , respectively; $\lambda_3 = \frac{1}{n-1}\sum_{j=1}^{n}(s_j - \lambda_1)^3$ and $\lambda_4 = \frac{1}{n-1}\sum_{j=1}^{n}(s_j - \lambda_1)^4 - 3$ are, respectively, the asymmetry and excess for the random quantity *s*.

Let us consider the algorithm for extending the sample s_j to a length $m > n$.

Let us specify a random quantity V with a normal distribution law. To obtain the random quantity s with the distribution function $F_s(s)$, it is necessary to use the equation [13]:

$$F_s(s) = V \quad (10)$$

Because $F_s(s) = \int_0^s f_s(s) ds$, on the basis of dependence (9), we obtain

$$F_s(s) = P_s(s) / c_F \ , \quad (11)$$

Where $c_F = \int_{s_{\min}}^{s_{\max}} P_s(s) ds$; $u_s = \dfrac{s - \lambda_1}{\lambda_2}$;

$$P_s(s) = \frac{1}{\lambda_2 \sqrt{2\pi}} \int_{s_{\min}}^{s} \exp(-0{,}5 u_s^2) ds - \frac{\lambda_3}{6}\left[u_s^2 - 1\right] \frac{1}{\lambda_2 \sqrt{2\pi}} \times$$

$$\times \exp\left(-0{,}5 u_s^2\right) + \frac{\lambda_4}{24}\left(u_s^3 + 3u_s\right) \frac{1}{\lambda_2 \sqrt{2\pi}} \exp\left(-0{,}5 u_s^2\right)$$

By solving transcendent equation (10) at a fixed value of the random quantity $V = const$ from the range [0, 1], we determine a new value of the random quantity s with the DDF $f_s(s)$. This procedure is repeated, and the sample *s* is extended to the required size.

The algorithm for generating a sample of a random quantity that, e.g., has the DDF in the form of (5) is constructed quite analogously. This algorithm is called the nonparametric random-number generator [13, 14,15].

IV. Computer Experiments Realizing Developed Approach

Example 1. It is required to determine the probability of a failure of a pipe that is exposed to an internal pressure and a temperature during operation. The pipe diameter is 1420 mm, its wall thickness is 16.5 mm, the pipe material is 17GS steel, and the permissible stresses for the pipe material obey a normal distribution law.

In order to reconstruct the DDF $f_\sigma(\sigma)$, samples of the pressure p_i , $i = \overline{1, m}$ and temperature

t_i , $i=\overline{1,m}$, which were registered every day during a year ($m=365$), were used. By realizing the algorithm of the *auxiliary problem* 2, we reconstructed the pressure and temperature DDFs $f_p(p)$ and $f_t(t)$) (see Fig. 2).

For each pair of values p_i ,t_i, $i=\overline{1,m}$ calculations of the effective stress σ_i in the pipe were performed and allowed us to obtain the sample σ_i , $i=\overline{1,m}$, using which the DDF for the acting stresses $f_\sigma(\sigma)$ was reconstructed.

The function $f_s(s)$ for steel 17GS is taken in the form (9) with the following parameters: λ_1 = 570.9 MPa, λ_2 = 19.3 MPa, λ_3 = 0.1480, λ_4 = 0.0209, $S_{\min}$ = 530 MPa, and $S_{\max}$ = 600 MPa. The graphic illustration of the functions $f_\sigma(\sigma)$ and $f_s(s)$ is shown in Fig. 3, from which it follows that, in this case, the probability of a failure, i.e., the solution of problem (2), is zero ($Q=0$).

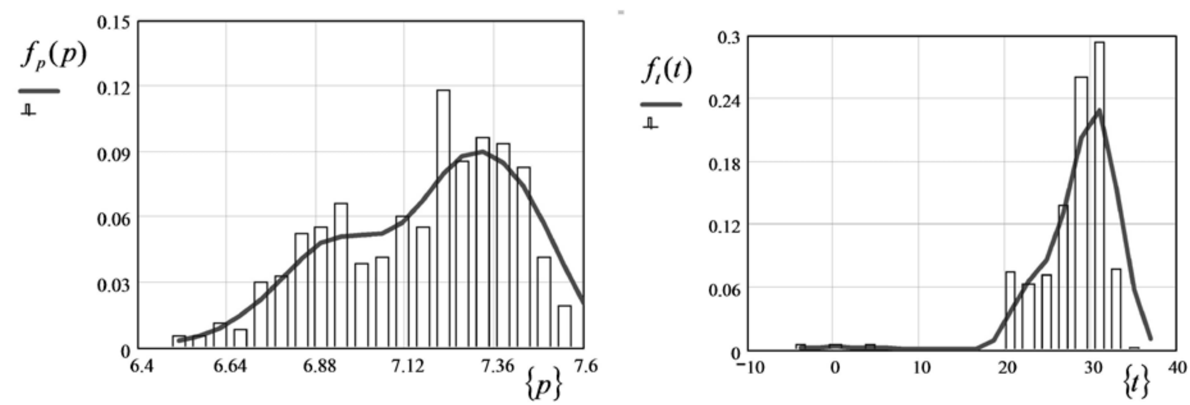

Fig. 2 : Functions $f_p(p)$ and $f_t(t)$.

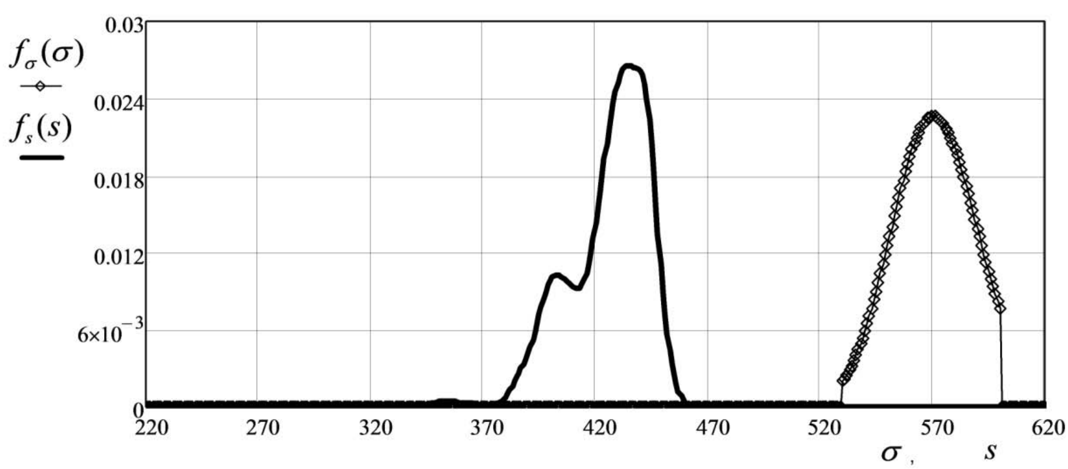

Fig. 3 : Functions $f_\sigma(\sigma)$ and $f_s(s)$

Example 2. For the data of example 1, it is required to determine quantile estimates of the safety margin.

Let us use the sample σ_i , $i=\overline{1,m}$. For the known function $f_s(s)$, the sample s_i , $i=\overline{1,m}$ is obtained using the algorithm of *auxiliary problem 2*. If the values of σ_i and s_i are known, formula (4) is used to calculate the sample $n_{\sigma i}$, $i=\overline{1,m}$. By realizing the algorithm of auxiliary problem 1, we determine the density function $f_n(n_\sigma)$. This function is shown in Fig. 4.

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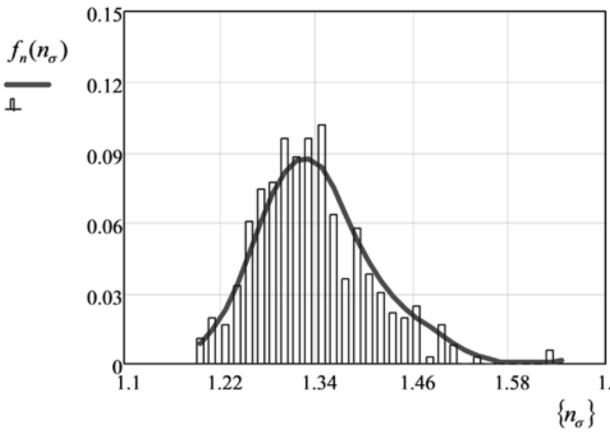


Fig. 4 : Density function $f_n(n_\sigma)$

In order to calculate quantile ($\alpha = 0{,}01;\ 0{,}05;\ 0{,}50$) estimates of the safety margin (n_σ^α), it is necessary to solve equation (4). The resulting values are $n_\sigma^{0{,}01}$ =1,19417; $n_\sigma^{0{,}05}$ =1,23122; $n_\sigma^{0{,}50}$ =1,33403. If it is required to estimate the probability that the safety margin is <1.2, it is sufficient to calculate the integral

$$Pr[n_\sigma \le 1{,}2] = \int_0^{1{,}2} f_n(n_\sigma) dn_\sigma = 0{,}01348. \qquad (12)$$

Example 3. It is required to determine the no-failure operation of a helical gearing. The torque at the pinion gear (T_{1H}^* , Н·м) changes in accordance with the β -distribution (heavy-duty operation), in accordance with the γ -distribution (light-duty operation), and according to a bimodal law.

The dependence for calculating the contact stresses σ_H (MPa) that act in the engagement of teeth of helical gearings has the form

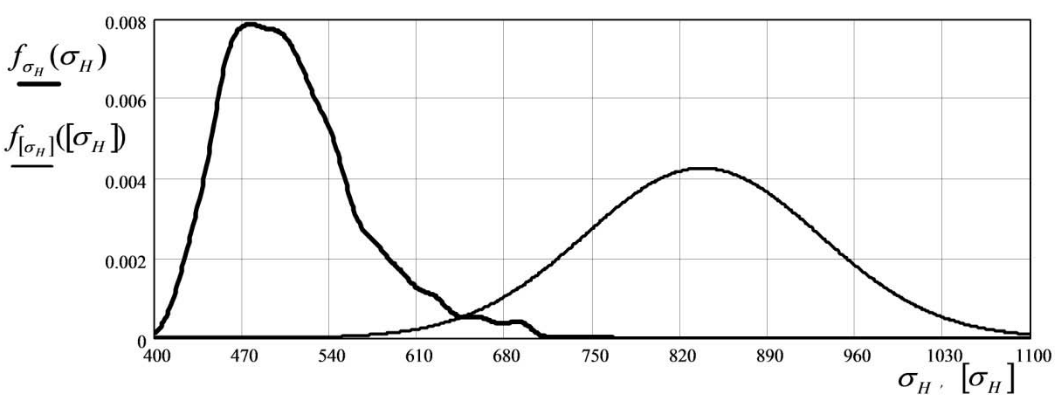
$$\sigma_H = 6{,}13 \cdot 10^3 \cdot Z_H \frac{1}{a_W} \sqrt{\frac{T_{1H}^*}{b_W} \cdot \frac{(u+1)^3}{u} \cdot K_{H\Sigma}}\ , \qquad (13)$$

where Z_H is the coefficient that accounts for the shapes of the mated surfaces; a_W is the interaxial distance of the helical gearing (mm); b_W is the working width of the gear rim (mm); u is the gear ratio; and $K_{H\Sigma}$ is the load factor, which is related to T_{1H}^* via a nonlinear dependence.

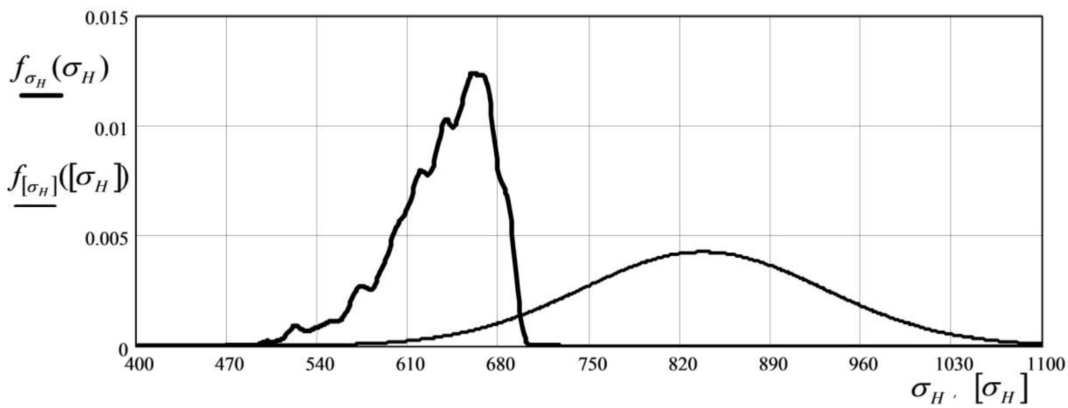
It follows from (13) that the dependence of σ_H on T_{1H}^* is essentially nonlinear. Thus, even if the random quantity T_{1H}^* obeys a normal law, the law of σ_H distribution of cannot be determined.

The results of calculating the DDFs for the actual σ_H and permissible $[\sigma_H]$ stresses (a normal distribution law for $[\sigma_H]$ was adopted in the calculations) using the above-considered algorithms are presented in Fig. 5.

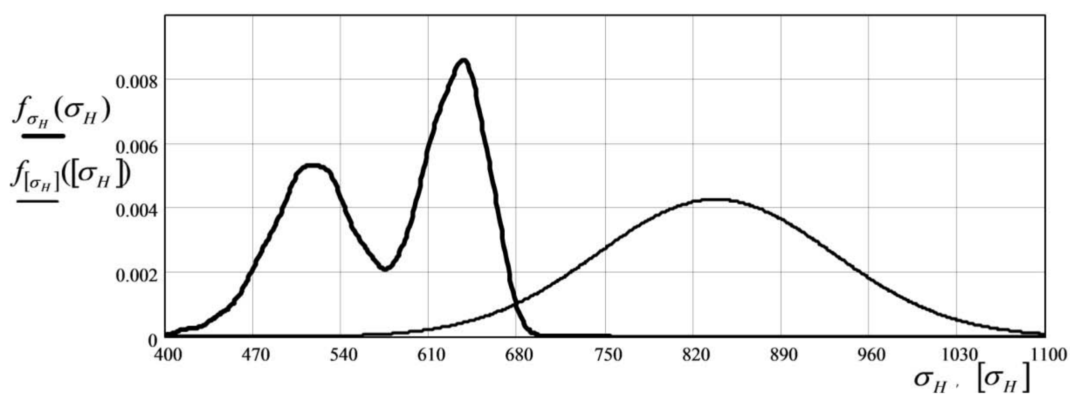
The gearing parameters are as follows: the number of teeth of the gear Z_1 = 32, the number of teeth of the wheel Z_2 = 64, the coefficient of displacement of a gear tooth χ_1 = 0, the coefficient of displacement of a wheel tooth χ_2 = 0, the pitch m = 5 mm, the width of the gear rim b_W = 60 mm, and the tilt angle of the tooth trace β = 16°15'. For light-duty operation, heavy-duty operation, and torque changes according to a bimodal law, the probabilities of no-failure gearing service are 0.9980, 0.9780, and 0.9911, respectively.



a) light-duty operation



b) heavy-duty operation



c) the torque changes according to a bimodal law

Fig. 5 : Distribution density functions σ_H and $[\sigma_H]$

V. Results and Discussion

In the conventional approach to the solution of the considered problems for each random quantity using the fitting criteria (chi-square, omega-square, Kolmogorov-Smirnov), a distribution law must be selected. However, this law can be adopted only with a certain probability. The value of this probability is not a priori known. In this case, there is a risk of adopting a distribution law that is actually not realized (error of the second kind). Thus, the reliability of the result of solving the problem is an uncertain value.

The use of methods of nonparametric statistics for solving problems makes it possible to eliminate the aforementioned uncertainty.

VI. Conclusion

The approach considered in this study and the mathematical apparatus for calculating the probability of no-failure operation or a failure and quantile estimates of the safety margin of machine components and structures is universal. It allows estimation of the strength reliability of articles regardless of the complexity of the laws of distribution of random values of actual and limiting stresses.

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Implémentation Pratique

By Selatnia Mourad

Abstract- Le but de chaque commande synthétisée dans le domaine de la recherche est d'être implémentée sur des systèmes réels afin de résoudre les problèmes qu'ils présentent et de donner une amélioration pour ces systèmes. C'est à partir de ce principe qu'on va présenter ce chapitre. En effet la commande par logique floue entre autres est une technique relativement nouvelle et prometteuse qui commence à trouver son application dans le domaine industriel.

Les simulations qu'on a élaboré ont prouvé l'efficacité des commandes synthétisées. Il nous semble opportun d'implémenter ces résultats sur le système qui existe dans l'entreprise où on a effectué le stage pratique.

Avant toute implémentation pratique une analyse détaillée sur les outils matérielle et informatique fournies par le système de contrôle existant est indispensable. Dans cette direction on a fait une étude des différents organes nécessaires pour notre boucle de régulation. Le contrôle d'une colonne d'absorption industrielle exige la maitrise d'un certain nombre d'instruments et systèmes, à savoir: l'Analyseur de CO_2 (capteur), la vanne de circulation d'amine (actionneur), le système de control de processus DCS (contrôleur).

Les résultats de notre étude en matière de description des organes, leur fonctionnement, les contraintes pratiques ainsi que l'implémentation vont être présentés dans ce chapitre.

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IMPLEMENTATIONPRATIQUE

Strictly as per the compliance and regulations of:

Implémentation Pratique

Selatnia Mourad

I. Introduction

Le but de chaque commande synthétisée dans le domaine de la recherche est d'être implémentée sur des systèmes réels afin de résoudre les problèmes qu'ils présentent et de donner une amélioration pour ces systèmes. C'est à partir de ce principe qu'on va présenter ce chapitre. En effet la commande par logique floue entre autres est une technique relativement nouvelle et prometteuse qui commence à trouver son application dans le domaine industriel.

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Les résultats de notre étude en matière de description des organes, leur fonctionnement, les contraintes pratiques ainsi que l'implémentation vont être présentés dans ce chapitre.

II. Les Organes de la Boucle de Régulation

Dans cette partie on va présenter et analyser les différents outils nécessaires pour l'implémentation de notre commande. Vue la symétrie entre les deux trains de décarbonatation on a choisi le TR1 pour notre étude. *L'analyseur de CO_2 J028AT102*[1] représente l'outil de mesure pour notre boucle de régulation, *la vanne d'amine J028FV101* constitue l'actionneur de la boucle. Pour l'implémentation des algorithmes de contrôle on a profité du système *DCS yokogawa CS3000* de l'installation. Notre analyse consiste à déterminer les caractéristiques de chaque organe, les conditions de son fonctionnement et les contraintes qu'il présente. Après l'analyse on va proposer des solutions réalisables pour remédier à ces contraintes.

a) L'analyseur de Co_2 J028at102

Le rôle de l'analyseur est de donner une information sur la concentration du CO_2 dans le gaz sortant de l'absorbeur. Son fonctionnement est basé sur l'analyse NDIR[2] du gaz. Le modèle de L'analyseur est le *S720 Ex* fabriqué par *SICK MAIHAK,* Son installation (par la compagnie ATAC) exige la présence de plusieurs systèmes:

- *La probe:* le point de prise d'échantillon
- *Le préconditionnement:* ce système conditionne le gaz en terme de pression (réduction de la pression), température (constante dans la gamme 0-45°C) et filtrage.
- *Le conditionnement:* installé à l'entrée de l'analyseur ce bloc effectue l'opération de filtrage et régulation du débit rentrant dans l'analyseur.
- *L'analyseur lui-même:* effectue l'analyse spectrale du CO_2, affiche la valeur et envoie un signal 4-20 mA au système de control.

Author: e-mail: mouradselatnia@yahoo.fr

[1] J028AT102: est un tag (référence dans le DCS) qui décrit chaque instrument dans l'installation.
J: désigne le site de Krechba, 028: le code du système de décarbonation, AT: analyser transmitter, 102: le numéro de l'instrument.

[2] NDIR: Absorption infrarouge non dispersive (cellule optique, détecteur de semi-conducteur).

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Figure VI.1 : l'analyseur S720 Ex de SICK MAIHAK

Le facteur le plus important dans l'analyseur en vu de la commande de l'absorbeur est son temps de réponse [*response time*]. Aprés une anlyse du processus d'echantillonage et les graphes des reponses du système on s'est rendu compte que ce dernier présente un retard qui atteind les *5 minutes,* alors que d'après le design il ne doit pas depasser *79 secondes.* Cela est dù principalement à:

- La position de l'analyseur loin du point de prise d'echantillon
- Le debit reduit du gaz qui rentre à l'analyseur
- Non-conformité à l'étude du design

La *Figure VI.2* illustre ce retard. En effet:

- *Cgsexport:* représente la concentration du CO_2 à l'export (la sortie des 2 trains).
- *Cgsexportcal:* represente la concentration du CO_2 d'export calaculé à partir des données des deux analyseurs (somme pendérée).

On remarque bien que les deux graphes ont la même allure avec un retard pour le deuxième graphe (celui de Cgsexportcal) qui illustre bien ce retard.

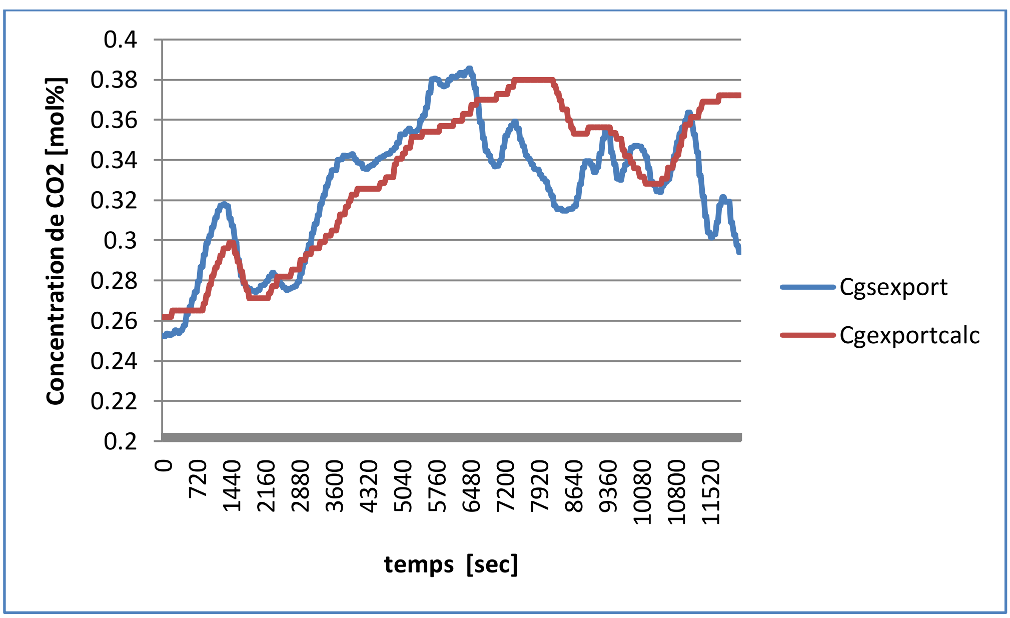

Figure VI.2 : Retard de l'analyseur de CO_2 [données extractées de l'exaquantum le 24 Mars 2010]

Plusieurs solutions technologiques sont proposées pour remidier à ce probleme:

i. *Augmentation du debit d'achantillonnage de l'analyseur*

Cette solution bien qu'elle présente un inconvenient qui consiste au torchage d'une quantité minime en plus du gaz (par rapport au debit du process) elle peut reduire le temps de réponse d'un facteur double ou triple selon l'augmentation du debit.

Pour verifier la faisabilité de cette solution on a consulté les debit toleré par l'analyseur et les genies filtres installées:

- D'après le document ATAC l'analyseur supporte jusqu'à 100 l/h, le debit actuel est de 6 l/h.
- Le genie filtre (A+ corporation model 101) avec une membrane Hi-Flow supporte jusqu'à 600 l/h, le debit actuel est de 106 l/h.

ii. *Installation d'une « fast loop »*

Cette solution est très reconnu pour les analyseurs installés loin du point d'échantillonnage (Figure VI.3), elle consiste à installer une derivation du pipe d'échantillonnage qui revient au processus pour *accelerer* le passage des particules. Cette configuration elimine toute perte additive du gaz du fait que le gaz revient au process. Pour verfier la faisabilité de cette technique on est allé au site pour verifier la disponibilité de points de racordement sur les gazoducs (pipes). Cette solution est montionnée même dans le document technique du constructeur.

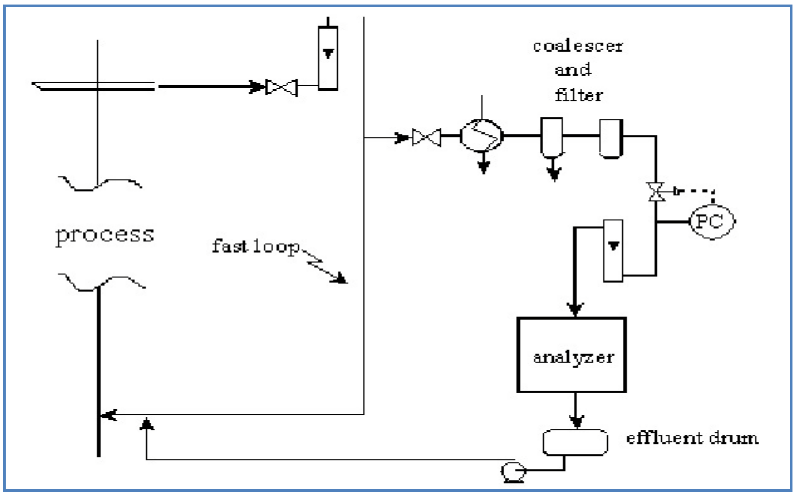

Figure VI. 3 : Principe du « fast loop »

iii. *Une derniére solution software consiste à implémenter un estimateur inspiré du modèle d'identification traité dans le Chapitre III. Un multimodèle qui utilise 3 entrées*

- Débit du Gaz
- Débit du liquide
- Concentration du CO_2 en entrée

Peut donner en deroulant l'algorithme du multimodèle la concentration du CO_2 en sortie en temps réel. Cet estimateur peut servir en commande (capteur logiciel) qu'au diagnostique (un capteur redandant). L'algorithme etabli va être présenté en details par la suite (§ VI.3).

b) La vanne de circulation d'amine J028FV101[3]

La variation du débit d'amine est assurée par une vanne de type *linéaire* (voir *Figure VI.4*). Elle possède un *Cv rate*[4] de 2000 et conçue pour travailler avec une différence de pression qui ne dépasse pas *5.5 bar* pour un débit de 960 t/h. Actuellement cette différence de pression est largement dépassée à cause de la chute de pression dans l'installation.

La régulation de débit (*J028FIC101*[5]) est assurée par un régulateur PI avec:

- BP = 600 %. (Bande proportionnelle)
- I = 400 sec. (temps d'intégration)

Dans les conditions de fonctionnement actuelles ce régulateur n'arrive pas à contrôler le débit, et cela est présenté par un pompage de la vanne lors d'un fonctionnement en mode automatique.

Figure VI.4 : la vanne d'amine J028FV101

3 J028FV101: Flow Valve.

4 Cv rate: le coefficient de la vanne, représente le débit (en gallons) pour une chute de pression de 1 psi le long de la vanne.

5 J028FIC101: Flow Indicator and Controler.

Plusieurs solutions peuvent être envisagées pour mettre fin à ce problème:

i. *Agir sur les paramètres du contrôleur*

Les valeurs actuelles du PI ne peuvent assurer un fonctionnement stable de la régulation dans de telles conditions. A cause des perturbations que le système reçoit, ses paramètres changent rapidement. Des valeurs fixes des paramètres du régulateur PI ne peuvent pas assurer une bonne robustesse. Un PID auto-ajustable disponible dans la bibliothèque des régulateurs de YOKOGAWA CS3000 va fournir les paramètres adéquats en temps réel. On a affaire à une régulation adaptative.

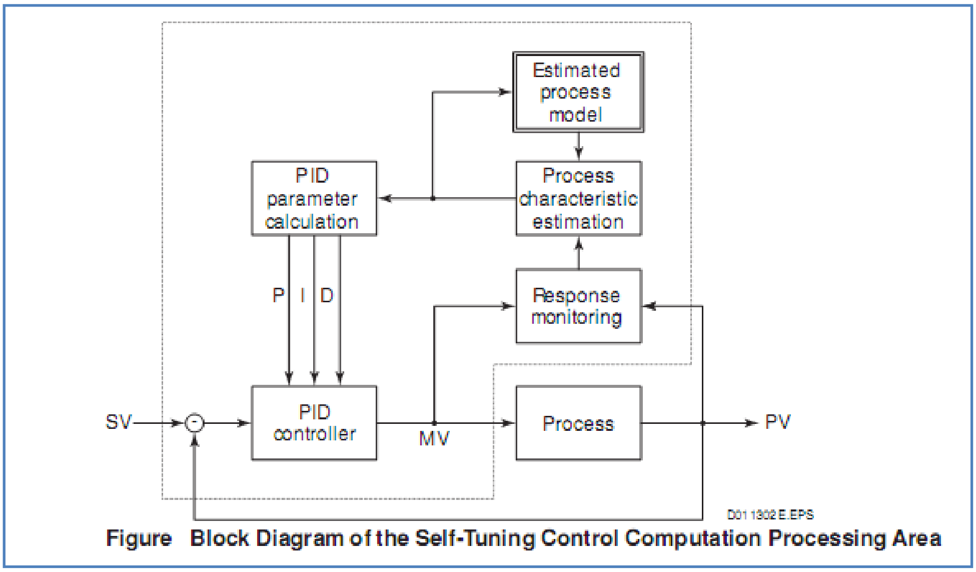

Figure VI. 5 : Schéma du PID self-tuning

ii. *Changement de la vanne*

La vanne doit assurer un débit entre 900 t /h et 1200 t/h, la vanne linéaire est conçue pour travailler dans tous l'intervalle de 0-1200 t/h. pour assurer de bonnes performances dans de telles conditions il faut avoir un positionneur de haute précision, chose qui n'est pas disponible.

Une vanne de type « *Quick open* » bien dimensionnée pour travailler dans l'intervalle 800-1200 t/h va assurer le bon fonctionnement du contrôle. En effet, cette vanne a un fonctionnement stable et lisse vers les hauts débits, ainsi le contrôleur peut arriver à stabiliser le débit. (Voir Figure VI.6).

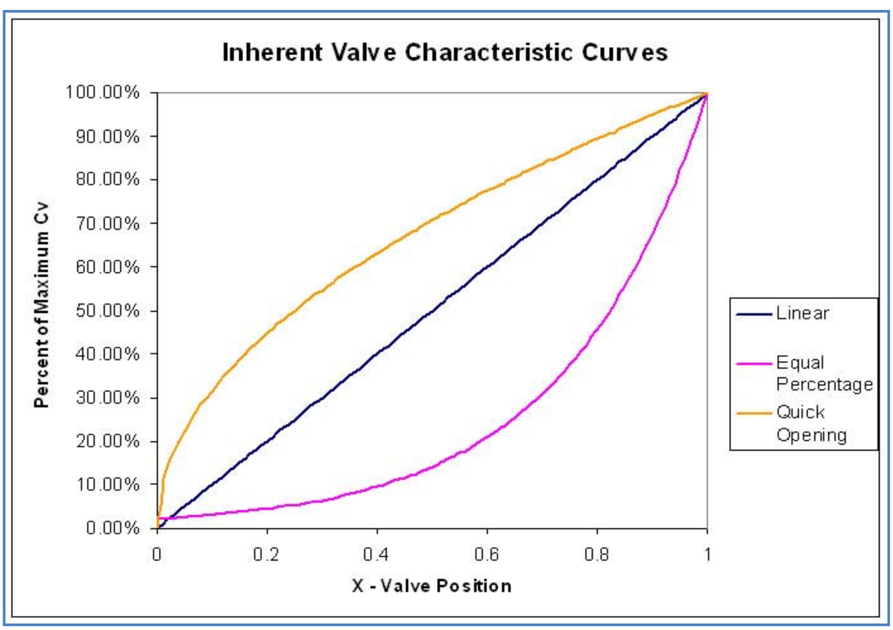

Figure VI. 6 : Les différents types de vannes de régulation

iii. *Montage split range*

Bien qu'elle demande un changement significatif dans la tuyauterie « piping », cette solution est la plus recommandée pour ce type de problème.

Elle consiste à installer deux vannes en parallèle, chaque vanne pour un intervalle de fonctionnement, exemple :

- La vanne 1 travaille dans l'intervalle 0-900 t /h
- La vanne 2 travaille dans l'intervalle 900-1200 t/h

Avec cette configuration la vanne 1 sera totalement ouverte et la vanne 2 va assurer la régulation avec les performances demandées

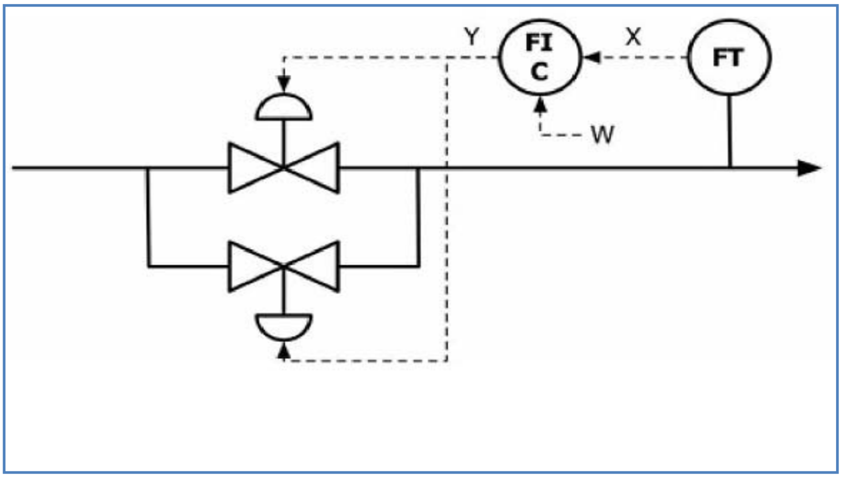

Figure VI. 7 : Régulation split range

iv. *Le Dcs de Yokogawa cs 3000*

Le système DCS *(Ditributed Control System)* CS3000 de YOKOGAWA est installé dans le CPF *(Control Process Facilities).* Le système contient deux sous systèmes qui fonctionnent en parallèle et qui se communiquent entre eux:

- Le PCS : le « *Process Control System* »
- Le ESD/F&G : le « *Emergency Shutdown System /Fire and Gas* »
- Le système est installé dans le CER *(Control Equipement Room)* et communique avec l'extérieur via des modules I/O et des protocoles de communication.

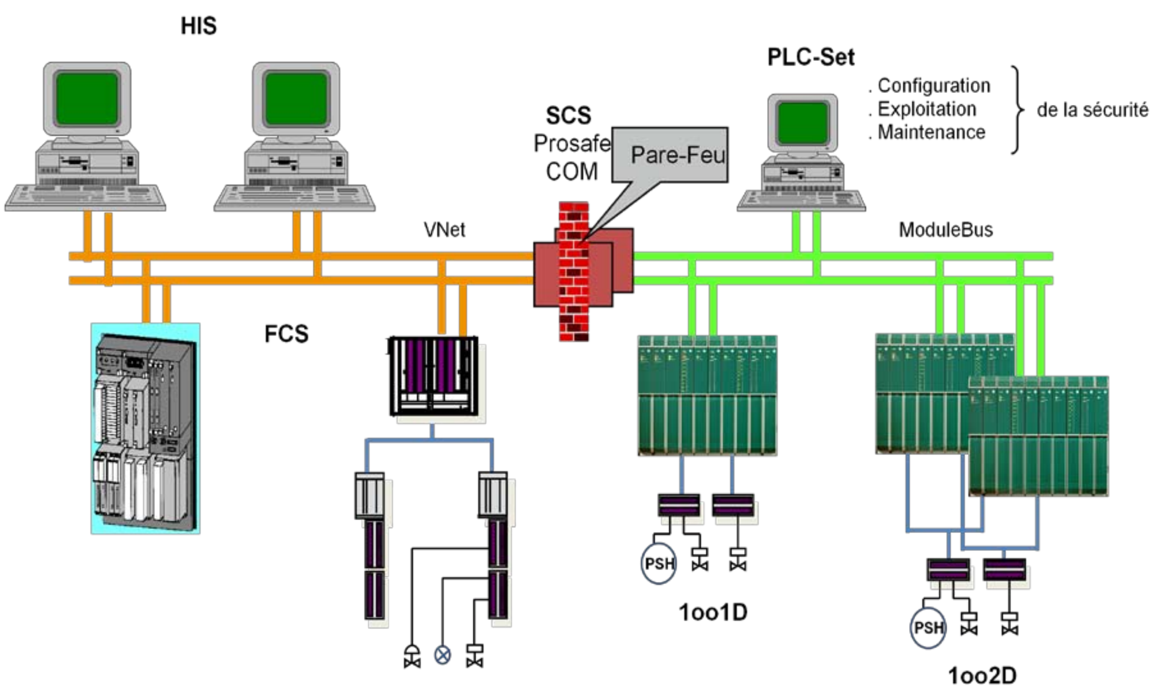

Figure VI. 8 : l'architecture générale du DCS CS3000

Le PCS est le système qui s'occupe des boucle de régulation du processus, il est composé de: [29]

- *HIS (Human Interface Station):* Principalement utilisée comme poste de conduite de l'opérateur. Cette station peut également supporter les fonctions ingénieur de configuration et de maintenance. Grâce aux interfaces DDE[6] ou OLE[7] intégrées dans son système d'exploitation, elle peut également transférer toutes sortes d'informations ou de données à un ordinateur de supervision ou à une station de travail.
- *FCS (Field Control Station):* réalise les fonctions de contrôle (régulation continue ou séquentiel). Elle gère les entrées et les sorties du procédé et peut être reliée à un automate de sécurité (PLC). Les stations de control utilisée en CPF sont du modèle PFCS.
- *V Net:* bus de contrôle temps réel, permet aux stations de communiquer entre-elles.
- *BCV (Bus converter):* permet de se relier à un autre système Yokogawa (exemple : ESD).
- *CGW:* passerelle de communication, permet à une station de travail (sous UNIX ou autre) de lire ou d'écrire des variables procédé contenues dans une FCS grâce à des Primitives Yokogawa.
- Le logiciel utilisé pour la programmation et la supervision est le *« System View ».*

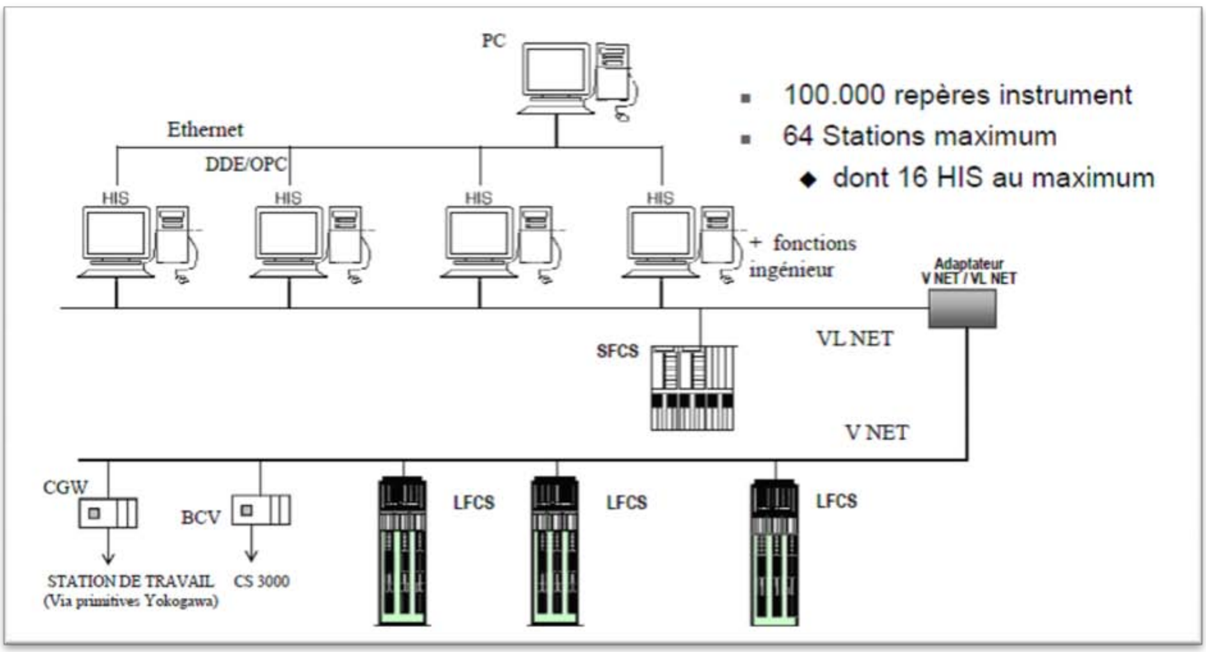

Figure VI.9 : Architecture du système PCS (Process Control System)

III. Implémentation Des Algorithmes

Pour implémenter les algorithmes et solutions proposées on a fait appel au *« System View ».* Cette application développée par YOKOGAWA constitue le logiciel qui gère le système DCS en termes de:

- Création de projets
- Configuration du matériel (FCS, ACG, HIS,.)
- Programmation et compilation (Control Drawing Builder, Graphic Builder, etc)
- Supervision et monitoring (interface homme-machine)

Notre tâche consiste une modification qui rend le système automatique. Pour cela on a utilisé les deux modules suivants:

- Le *« Control Drawing Builder »*: pour implémenter les contrôleurs
- Le *« Graphic Builder »*: pour l'interface homme-machine

La FCS qui gère le système d'absorption du CO_2 (système 28) est le *FCS0106* qui appartient au projet ISG. Pour faire les simulations on a utilisé la fonction *« test function »* disponible dans le menu du *« System View »,* qui consiste à simuler le fonctionnement des contrôleurs hors line avant de les implémenter on line avec le process.

La *Figure VI.10* représente la fenêtre du *« System View »,* tandis que la *Figure VI.11* illustre le lancement du mode *« test function ».*

[6] DDE: dynamic data exchange (Microsoft protocol)
[7] OLE: Object linking and embedding (Microsoft protocol)

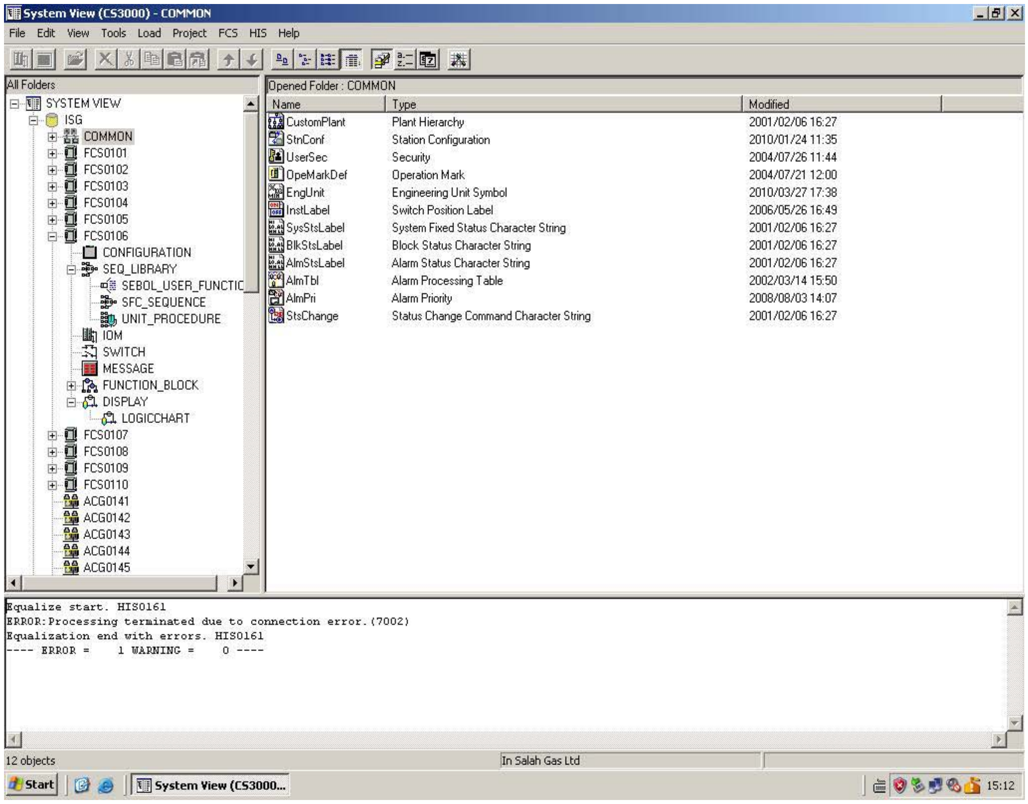

Figure VI.10 : Le System View

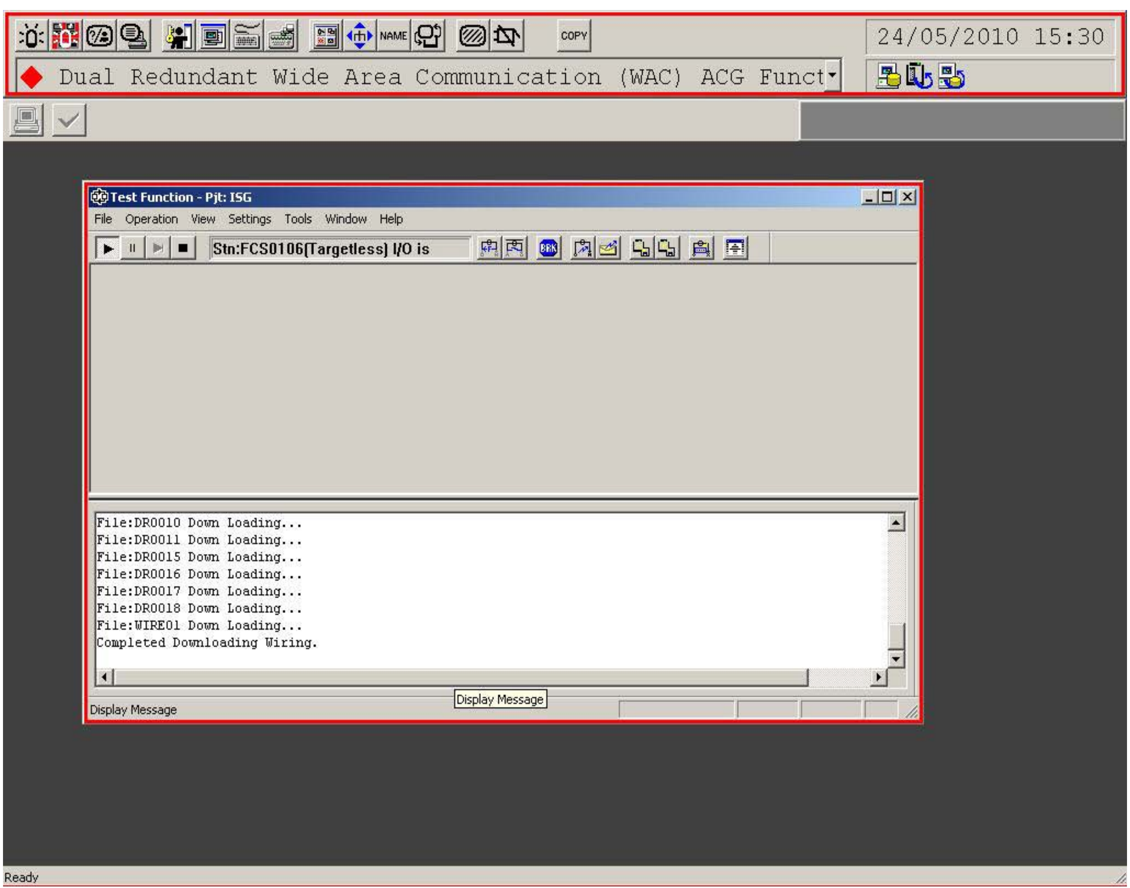

Figure VI.11 : test function

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a) *Le « Control Drawing Builder »*

Le « *Control Drawing Builder* » a pour but de configurer les fonctions de contrôle de base de la FCS. Avec « Control Drawing Builder », des opérations telles qu'enregistrer des blocs fonctionnels dans le fichier de dessins. Le flux des données entre ces blocs peut être effectué graphiquement. [29]

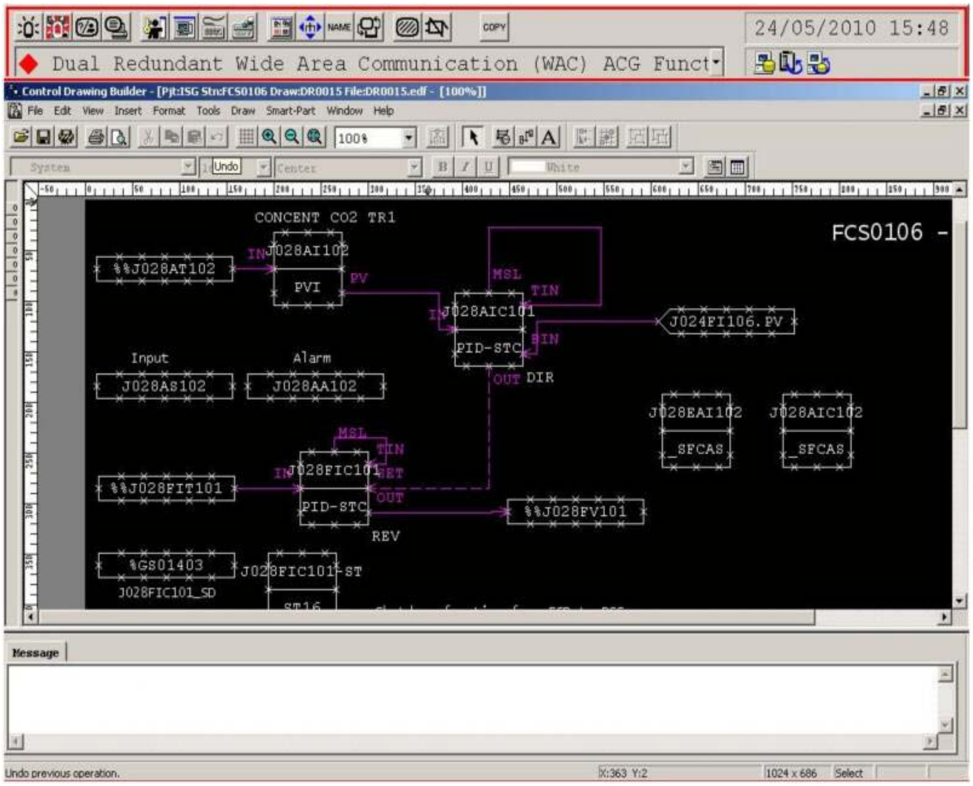

Figure VI.12 : Le control drawing

Les éléments principaux dans un *control drawing* sont les blocs fonctionnels. YOKOGAWA propose plusieurs types de blocs selon le besoin du programmeur, exemple: les blocs de régulation, blocs de calcul, blocs SFC,…

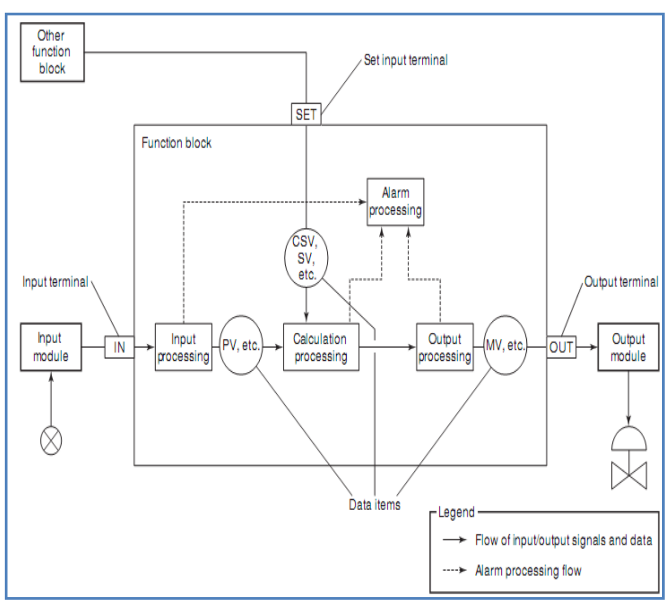

Figure V. 4 : les « *function blocks* »

Les contrôleurs qu'on a implémenté sont détaillés dans la suite du chapitre.

b) le Contrôleur PID j028aic101[8]

Pour implémenter notre contrôleur PID on a utilisé le bloc PID de la bibliothèque du *« control drawing».*

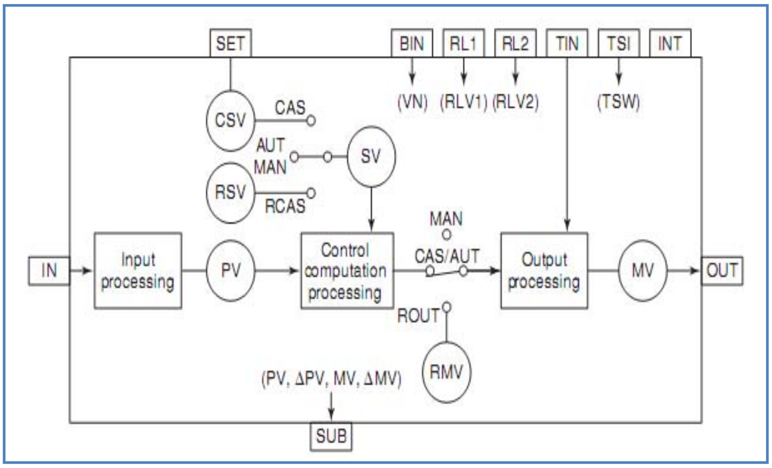

Figure VI.13 : Le bloc PID

Le bloc PID créé (*J028AIC101*) reçoit la mesure de la concentration du CO_2 à partir du bloc PVI[9] (J028AI102[10]) et le débit du gaz (pour calculer l'action feedforward) à partir du bloc d'entrée *« Link Block »* (*J024FI106*[11]), en faisant le traitement avec l'algorithme PID, il envoie une consigne de débit au contrôleur (*J028FIC101*) qui prend en charge la régulation du débit, ainsi on obtient une boucle de régulation en cascade.

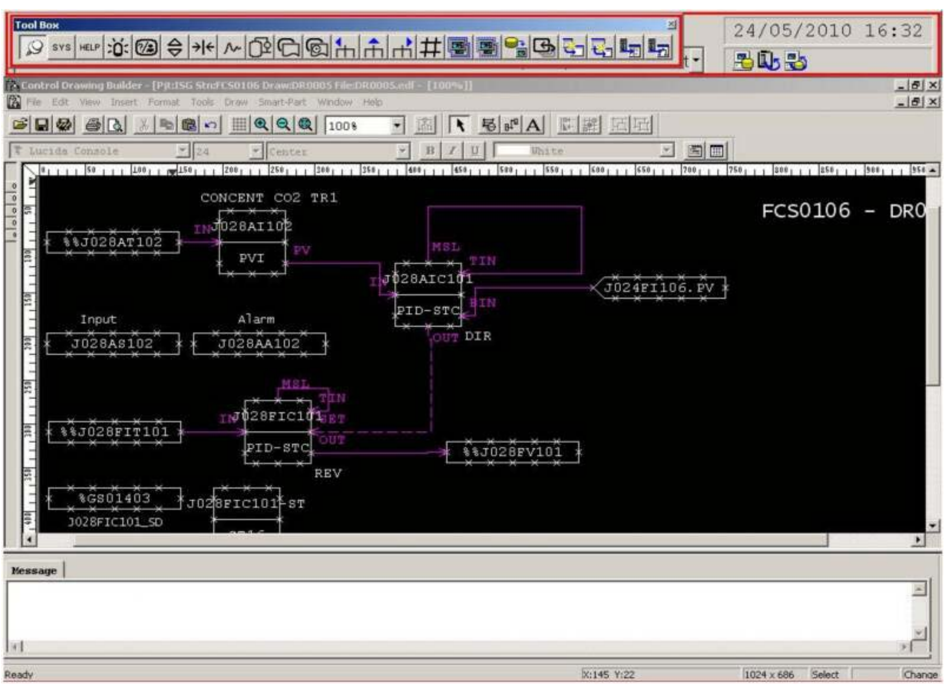

Figure V.6 : Contrôle PID-Feedforward

[8]J028AIC101: Analyze Indicator and Controler.
[9] PVI: Process Value Indicator
[10] J028AI10: Analyze Indicator
[11]J024FI10: Flow Indicator

c) Le Contrôleur Flou-Feedforward J028aic102

Pour implémenter notre contrôleur flou-Feedforward on a utilisé le langage de programmation *SEBOL*. Le *SEBOL* est un langage issu du langage C en rajoutant des fonctions prédéfinis, YOKOGAWA a adapté ce langage pour ses applications.

On a essayé d'utiliser le bloc *CALC*[12], mais on a constaté que son utilisation est très limité (nombre de variables et fonctions limité). En fait ce bloc est utilisé pour des calculs relativement simples, exemple: calcul des débits compensés:

L'outil (le bloc) le plus adéquat pour cette application est le bloc « *_ SFCAS* [13] » qui se base sur le concept du Grafcet. L'algorithme est devisé en deux parties:

- La partie *initialisation:* ou tous les paramètres initiaux et constantes sont déclarés
- La partie *contrôle:* ou l'algorithme de contrôle est exécuté.

La *Figure VI.14* représente l'implémentation du contrôleur dans le bloc *_SFCAS* et la *Figure VI.15* représente l'organigramme de contrôle.

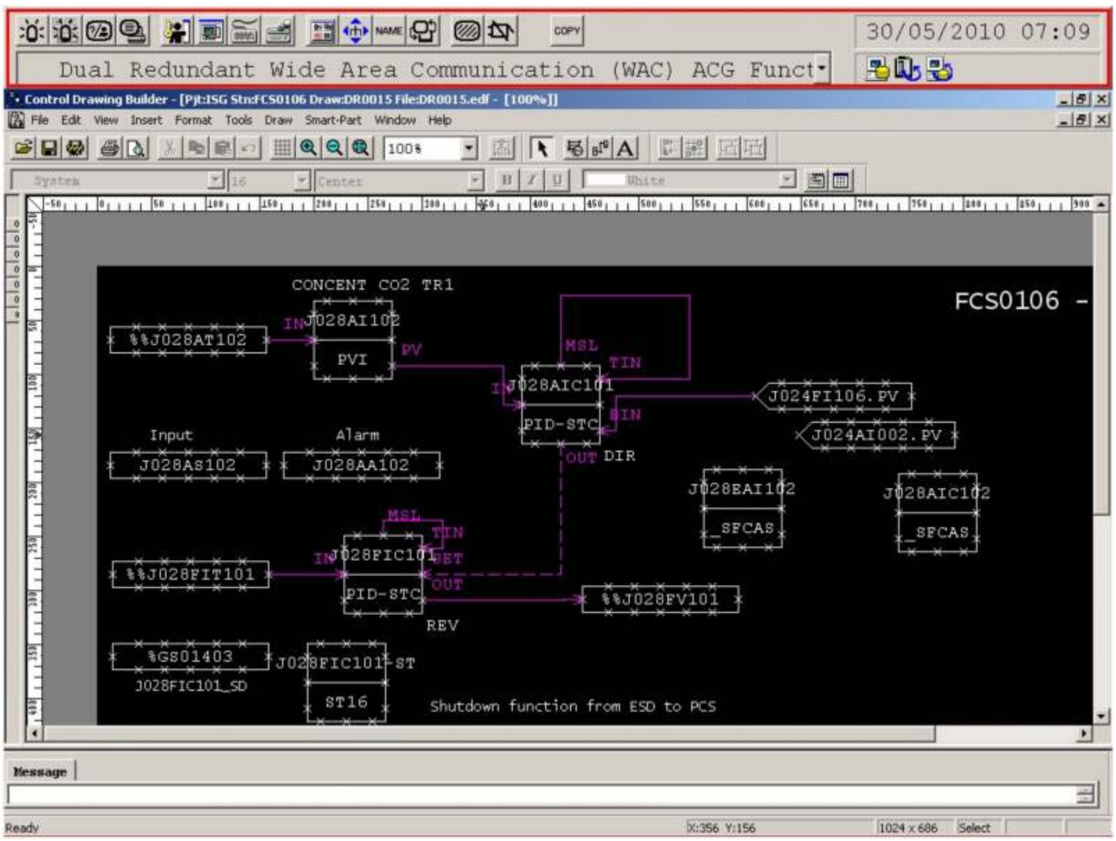

Figure VI.14 : le contrôleur Flou-Feedforward

12 CALC: Bloc de calcul (pour les calculs simples)

13 _SFCAS: Sequential Flow Chart with Analog Signa

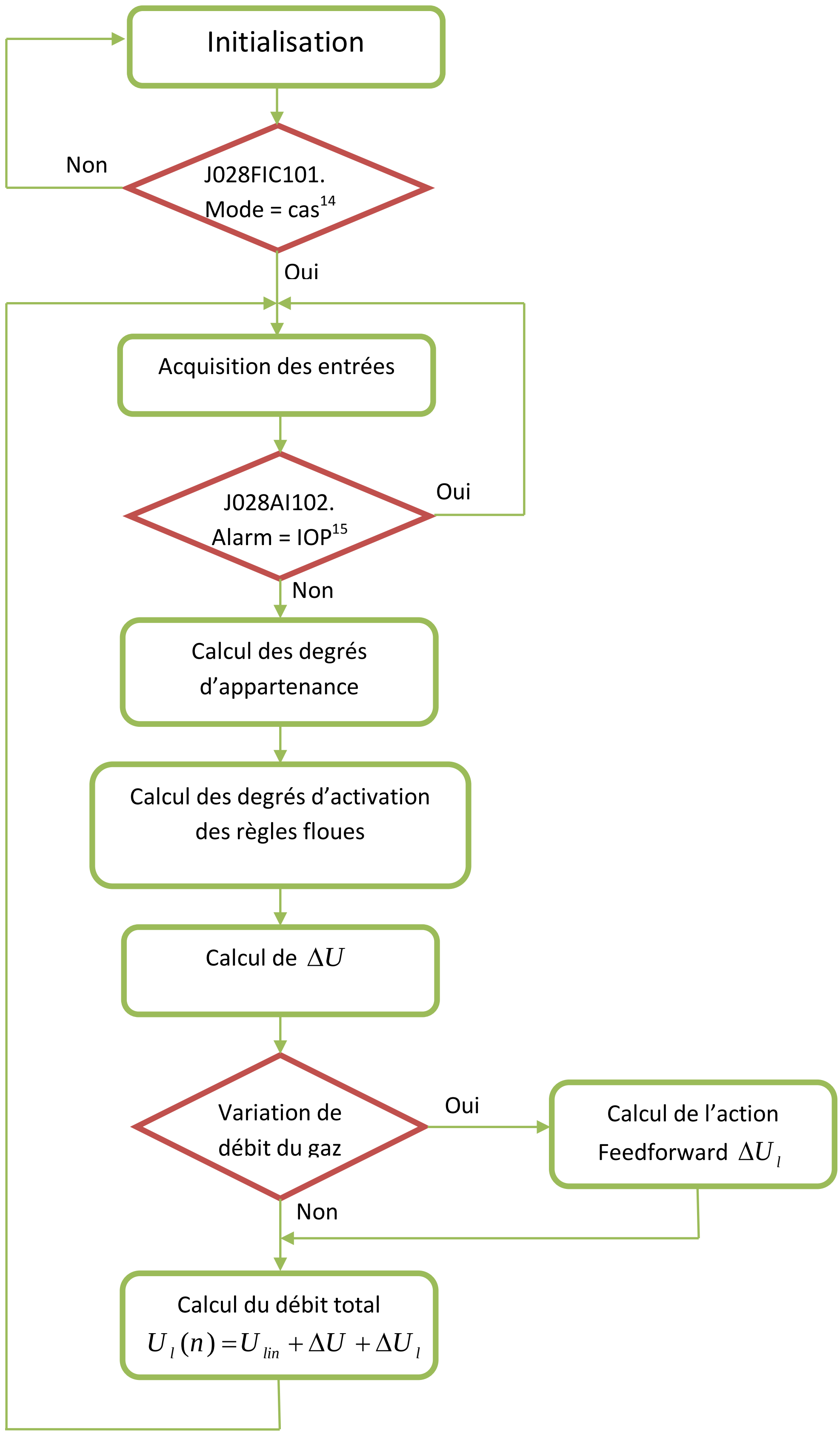

Figure VI.15 : L'organigramme du contrôleur Flou-Feedforward

[14] Cas: mode cascade
[15] IOP: Input Open (absence du signal du capteur)

d) L'estimateur de Concentration J028EAI102

Pour remédier au problème du retard de l'analyseur on a proposé une solution software qui consiste à un estimateur basé sur l'approche multimodèle.

- Cet estimateur reçoit 3 mesures:
- Concentration du CO_2 en entrée (non disponible actuellement, car le capteur n'est pas installé)
- Débit du gaz (*J024FI106*).
- Débit d'amine (*J028FIT101*).

En faisant un traitement de ces données l'estimateur va nous fournir la concentration du CO_2 en temps réel avec un pas d'échantillonnage de 10 secondes. L'implémentation de cet algorithme est faite à travers le bloc *« _SFCAS»*, l'algorithme contient deux phases:

- *Initialisation:* on a attend jusqu'à ce que la concentration atteint son régime permanant
- *Estimation:* un traitement des données donne la concentration estimée

L'algorithme de l'estimateur est inspiré de celui de l'identification (apprentissage) (§III.4.1), avec quelques modifications il est présenté dans la *Figure VI.17,* et La *Figure VI.16* représente l'implémentation de l'estimateur dans le bloc *_SFCAS.*

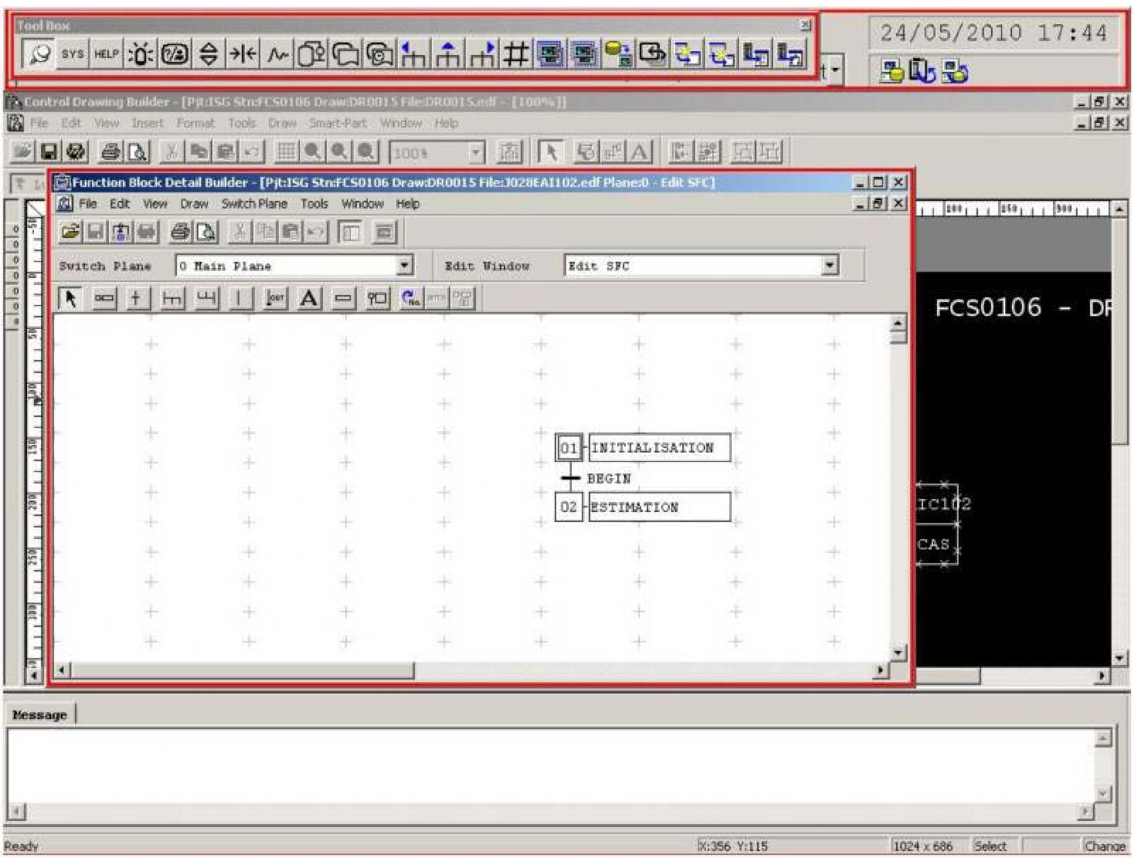

Figure VI. 16 : L'estimateur de la concentration du CO_2

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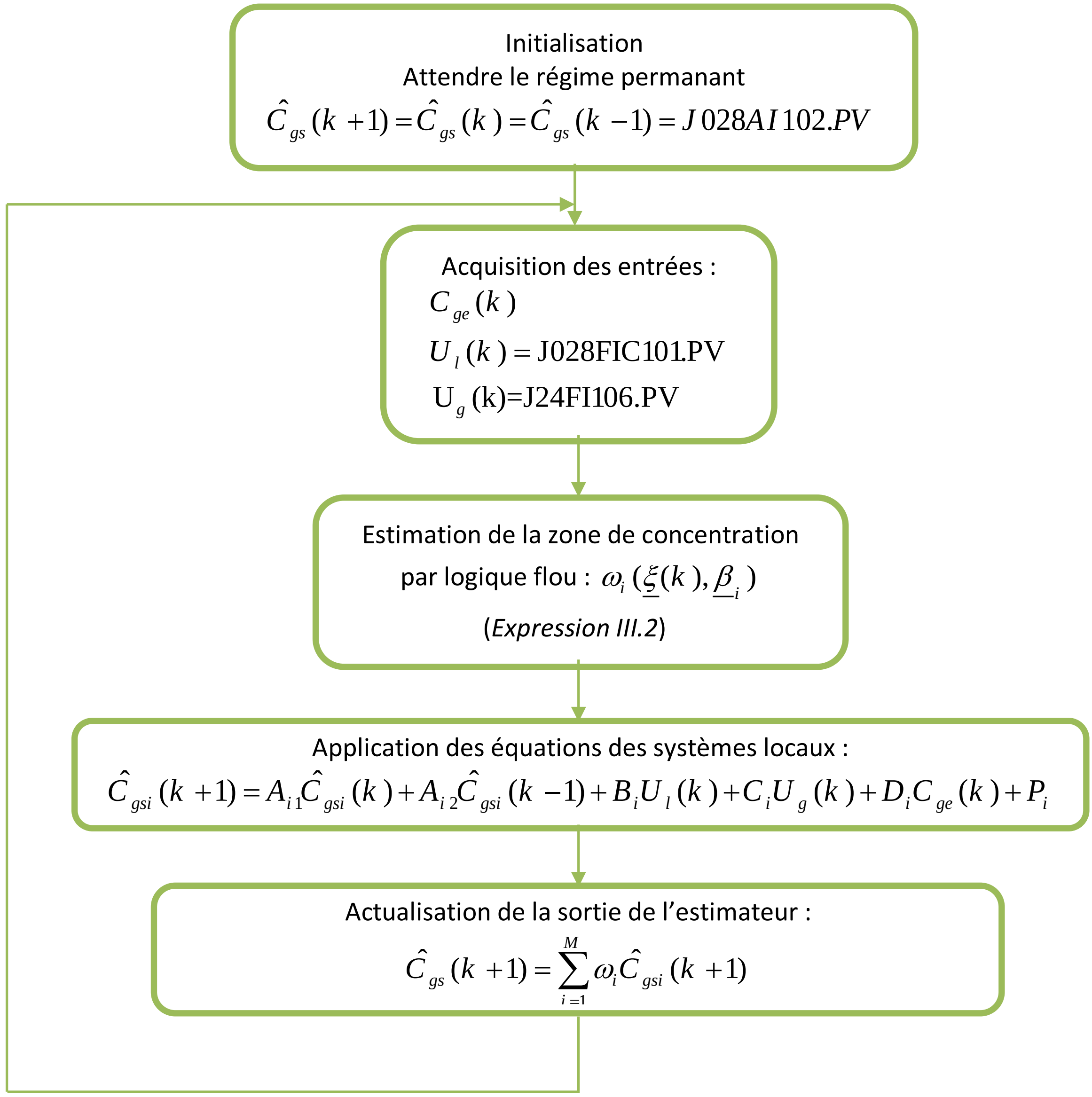

Figure VI.17 : L'organigramme de l'estimateur de concentration du CO_2

IV. L'Interface Graphique

En utilisant l'outil « *Graphic Builder* » la boucle de régulation en cascade peut être visualisée. On a fait des modifications sur l'interface graphique existante pour rajouter les contrôleurs qu'on a implémenté: Le contrôleur (*J028AIC101*) reçoit la mesure de l'indicateur (*J028AI102*). Après traitement il envoie la référence du débit au contrôleur (*J028FIC101*). La boucle en cascade est visualisée sur deux écrans, le premier écran (*Figure VI.18*) pour le contrôleur J028AIC101 (*Master*) et le deuxième (*Figure VI.19*) pour le contrôleur de débit J028FIC101 (*Slave*). La *Figure VI.20* représente une vue générale des blocs synthétisés.

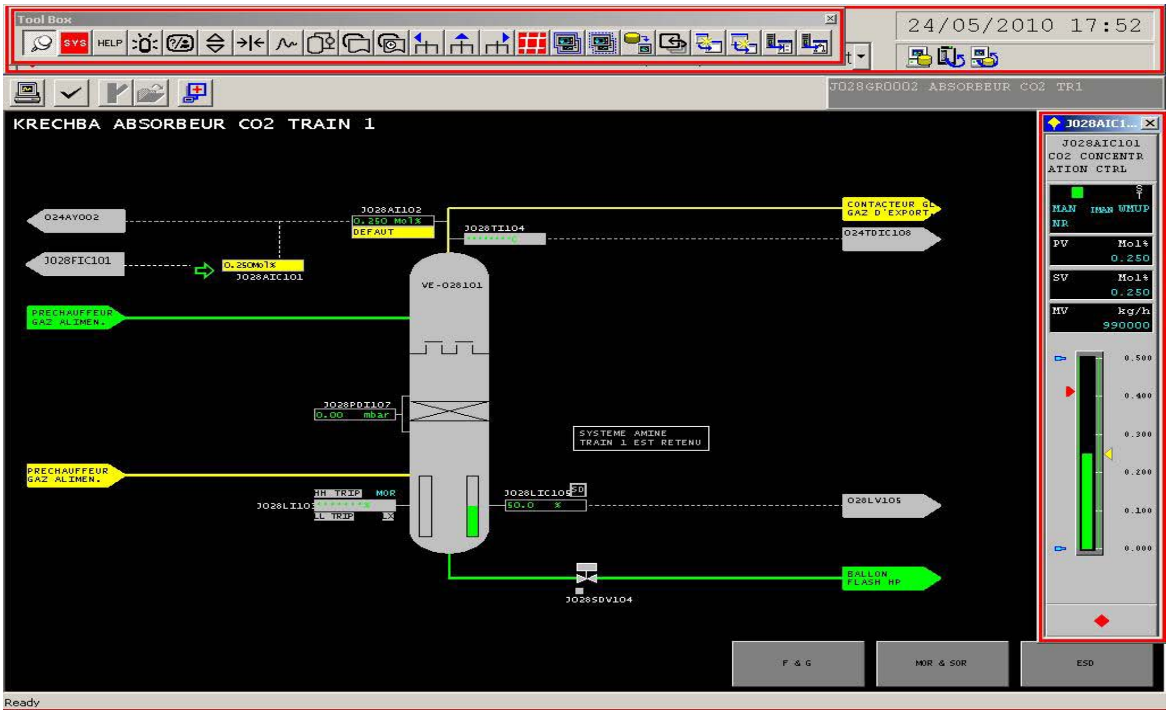

Figure VI.18 : Interface graphique de l'absorbeur

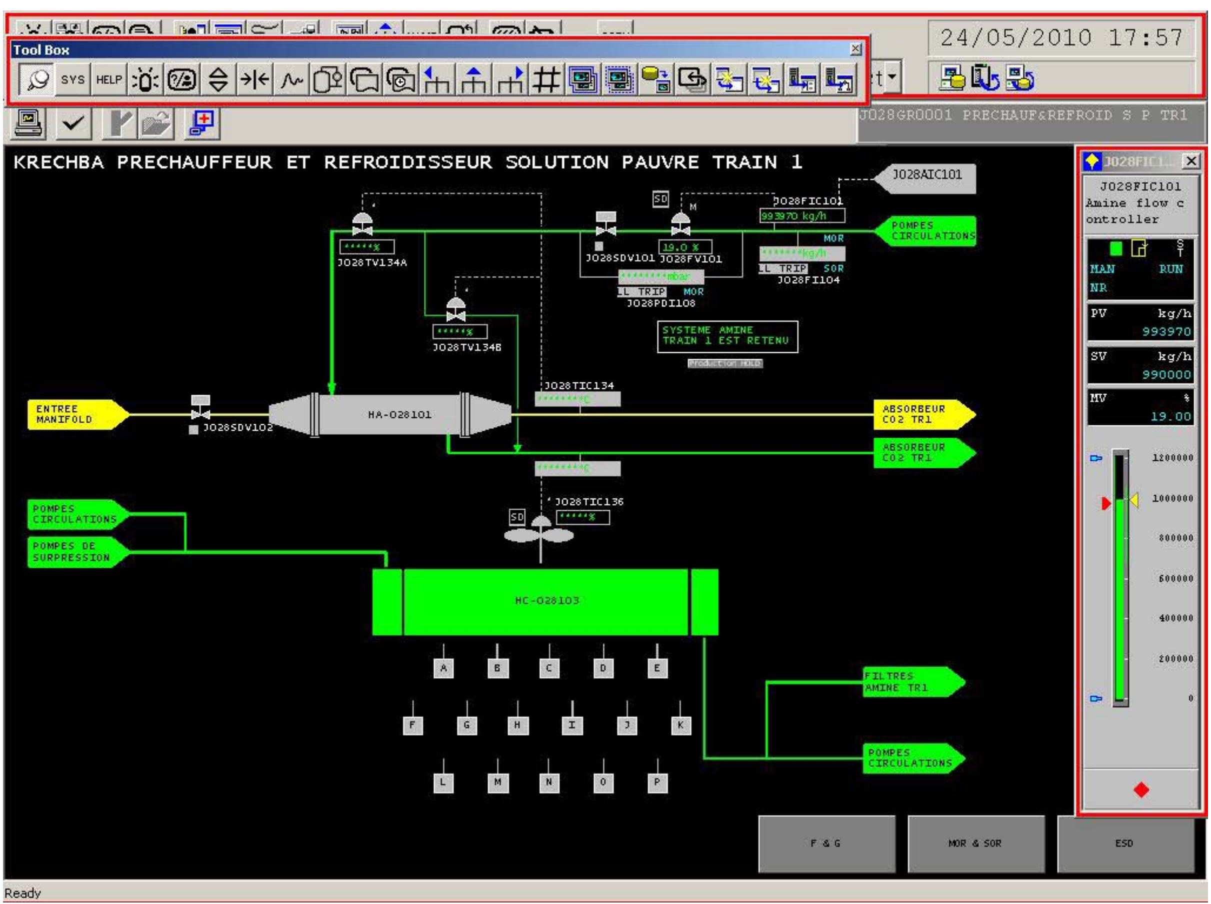

Figure VI.19 : Le contrôleur de débit d'amine

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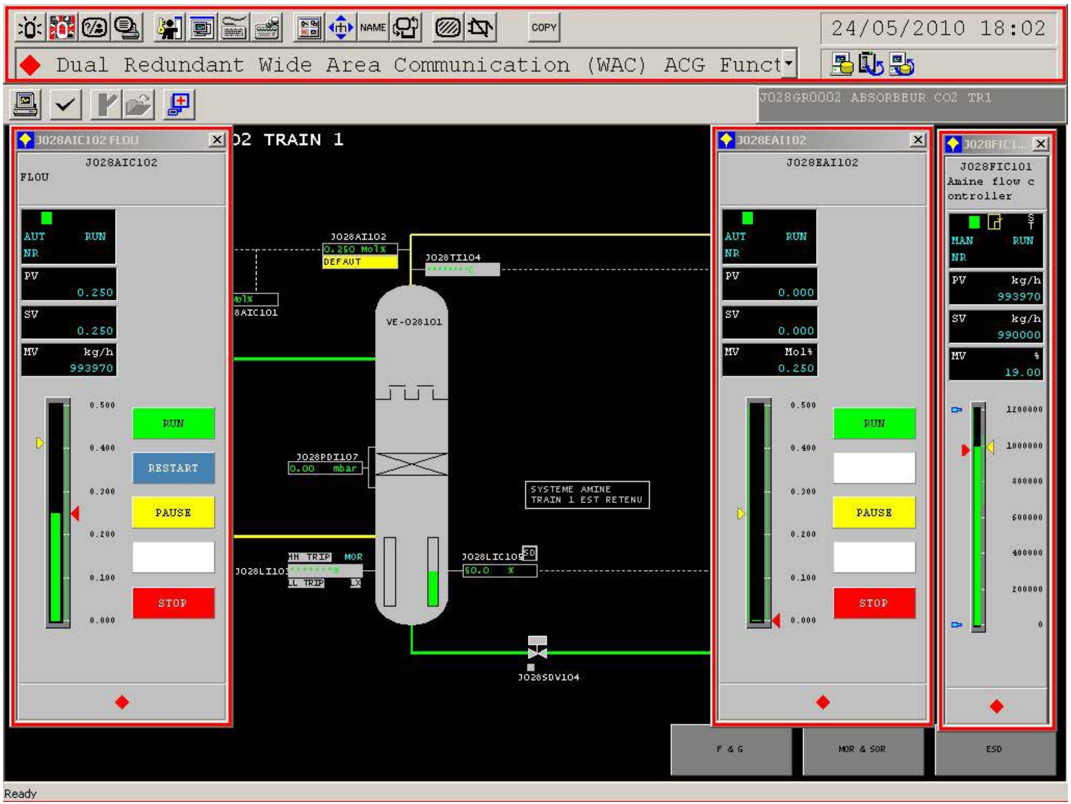

Figure VI. 20 : Vue générale des blocs synthétisés (*J028EAI102 et J028AIC102*)

V. Conclusion

Dans ce chapitre plusieurs systèmes liés à l'absorbeur ont été analysé, à savoir l'analyseur de CO2 et la vanne de circulation d'amine. Malgré les contraintes que ces systèmes présentent, on a essayé de proposer des solutions pratiques après une recherche et une analyse approfondie sur chaque système. Les lois de commande développées, qui ont été simulé avec MATLAB pour vérifier leurs performances et ajuster leurs paramètres afin d'atteindre les objectifs voulus, sont implémenter dans le *DCS YOKOGAWA CS3000* en se servant de son application *« SYSTEM VIEW »*. Le langage *SEBOL* était d'une grande utilité pour l'implémentation des lois de commande, en particulier lorsqu'il est utilisé dans les blocs *SFC*.

Les algorithmes ont été testés avec l'outil *« test function »*, afin de vérifier leurs performances avant de les connecter en ligne avec le process. Utiliser ces algorithmes en ligne demande un protocole spécial (démarches administratives) à cause de la sensibilité du système, en effet, si l'un des algorithmes génère un faux signal vers le process (exemple: un débit inadmissible) ces tout le train de décarbonation qui va tomber en panne. Pour cela, le changement qu'on a apporté doit être approuvé par d'autres ingénieurs.

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An Optimal Layout Design in an Apparel Industry by Appropriate Line Balancing: A Case Study

By Md. Mominul Islam, H.M. Mohiuddin, Syimun Hasan Mehidi & Nazmus Sakib

Khulna University of Engineering & Technology (KUET), Bangladesh

Abstract- The layout design problem is a strategic issue and has a significant impact on the efficiency of a manufacturing system. Much of the existing layout design literature that uses a surrogate function for flow distance or for simplified objectives may be entrapped into local optimum; and subsequently lead to a poor layout design. The present study explores the use of appropriate line balancing to facilitate a good layout design. Construction of a quality garment requires a great deal of know-how, a lot of coordination and schedule management. Clothing manufacturing consists of a variety of product categories, materials and styling. Dealing with constantly changing styles and consumer demands is so difficult. Furthermore, to adapt automation for the clothing system is also so hard because, beside the complex structure also it is labour intensive. Overall, the important criteria in garment production is whether assembly work will be finished on time for delivery, how machines and employees are being utilized, whether any station in the assembly line is lagging behind the schedule and how the assembly line is doing overall. To achieve this approach, work-time study, assembly line balancing and simulation can be applied to apparel production line to find alternative solutions to increase the efficiency of the sewing line. In this paper we showed how a good layout can be designed and productivity can be increased by appropriate assembly line balancing.

Keywords: line balancing, layout, time study.

GJRE-G Classification : FOR Code: 290502p

ANOPTIMALLAYOUTDESIGNINANAPPARELINDUSTRYBYAPPROPRIATELINEBALANCINGACASESTUDY

Strictly as per the compliance and regulations of:

An Optimal Layout Design in an Apparel Industry by Appropriate Line Balancing: A Case Study

Md. Mominul Islam [α], H.M. Mohiuddin [σ], Syimun Hasan Mehidi [ρ] & Nazmus Sakib [Ѡ]

Abstract- The layout design problem is a strategic issue and has a significant impact on the efficiency of a manufacturing system. Much of the existing layout design literature that uses a surrogate function for flow distance or for simplified objectives may be entrapped into local optimum; and subsequently lead to a poor layout design. The present study explores the use of appropriate line balancing to facilitate a good layout design. Construction of a quality garment requires a great deal of know-how, a lot of coordination and schedule management. Clothing manufacturing consists of a variety of product categories, materials and styling. Dealing with constantly changing styles and consumer demands is so difficult. Furthermore, to adapt automation for the clothing system is also so hard because, beside the complex structure also it is labour intensive. Overall, the important criteria in garment production is whether assembly work will be finished on time for delivery, how machines and employees are being utilized, whether any station in the assembly line is lagging behind the schedule and how the assembly line is doing overall. To achieve this approach, work-time study, assembly line balancing and simulation can be applied to apparel production line to find alternative solutions to increase the efficiency of the sewing line. In this paper we showed how a good layout can be designed and productivity can be increased by appropriate assembly line balancing.

Keywords: line balancing, layout, time study.

I. Introduction

Layout design often has a significant impact on the performance of a manufacturing or service industry system and is usually a multiple-objective problem. Garment industries are experiencing a very competitive era like many others, thus striving hard to find methods to reduce manufacturing costs, improve quality etc. In garment production, until garment components are gathered into a finished garment, they are assembled through a sub-assembly process. The production process includes a set of workstations, at each of which a specific task is carried out in a restricted sequence, with hundreds of employees and thousands of bundles of sub-assemblies producing different styles simultaneously (Chan et al, 1998). The joining together of components, known as the sewing process which is the most labour intensive part of garment manufacturing, makes the structure complex as the some works has a priority before being assembled (Cooklin,1991). Furthermore, since sewing process is labour intensive; apart from material costs, the cost structure of the sewing process is also important. Therefore, this process is of critical importance and needs to be planned more carefully (Tyler, 1991). As a consequence, good line balancing with small stocks in the sewing line has to be drawn up to increase the efficiency and quality of production (Cooklin, 1991; Tyler, 1991; Chuter, 1988). An assembly line is defined as a set of distinct tasks which is assigned to a set of workstations linked together by a transport mechanism under detailed assembling sequences specifying how the assembling process flows from one station to another (Tyler, 1991). In assembly line balancing, allocation of jobs to machines is based on the objective of minimizing the workflow among the operators, reducing the throughput time as well as the work in progress and thus increasing the productivity. Sharing a job of work between several people is called division of labour. Division of labour should be balanced equally by ensuring the time spent at each station approximately the same. Each individual step in the assembly of product has to be analysed carefully, and allocated to stations in a balanced way over the available workstations. Each operator then carries out operations properly and the work flow is synchronized. In a detailed work flow, synchronized line includes short distances between stations, low volume of work in process, precise of planning of production times, and predictable production quantity (Eberle et al, 2004).

Overall, the important criteria in garment production is whether assembly work will be finished on time for delivery, how machines and employees are being utilized, whether any station in the assembly line is lagging behind the schedule and how the assembly line is doing overall.

II. Definition of Layout Problems

A facility layout is an arrangement of everything needed for production of goods or delivery of services. A facility is an entity that facilitates the performance of any job. It may be a machine tool, a work centre, a

Author α σ ρ Ѡ: Department of Industrial Engineering and Management (IEM), Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh. e-mails: sobuj47@gmail.com, hmm.mohi@yahoo.com, mehidikuet09@gmail.com, sakib.iem09@gmail.com

manufacturing cell, a machine shop, a department, a warehouse, etc. (Heragu, 1997). The layout design generally depends on the products variety and the production volumes. Four types of organization are referred to in existing articles, namely fixed product layout, process layout, product layout and cellular layout (Dilworth, 1996). These key organizations are sometimes discussed differently according to the authors. In Fixed product layout, the products generally circulate within the production facilities (machines, workers, etc.); in this particular type of layout, the product does not move, it is the different resources that are moved to perform the operations on the product. This type of layout is commonly found in industries that manufacture large size products, such as ships or aircrafts. Process layout groups facilities with similar functions together (resources of the same type). In this paper, we focused on process layout and tried to show the optimistic way of process layout.

III. Methodology

In the production of garment, at first garment model is designed. Then, according to model requirements, a sort of fabrics are cut as well as classified due to their sewing sequences.

Then, cut fabrics are sewn and assembled in order to form garment. After the sewing and pressing process, garment is controlled for eliminating sewing faults, and finally it is sent to package and expedition.

In this paper, to analyze the structure of garment assembly processes, a T-shirt sewing line was considered. The first step performed in this study was to understand T-shirts sewing processes' components and sewing line problems. The objective was to have a clear idea on how a T-shirts production-sewing process line flows and then, how the line can be balanced as well as the performance of production line can be increased.

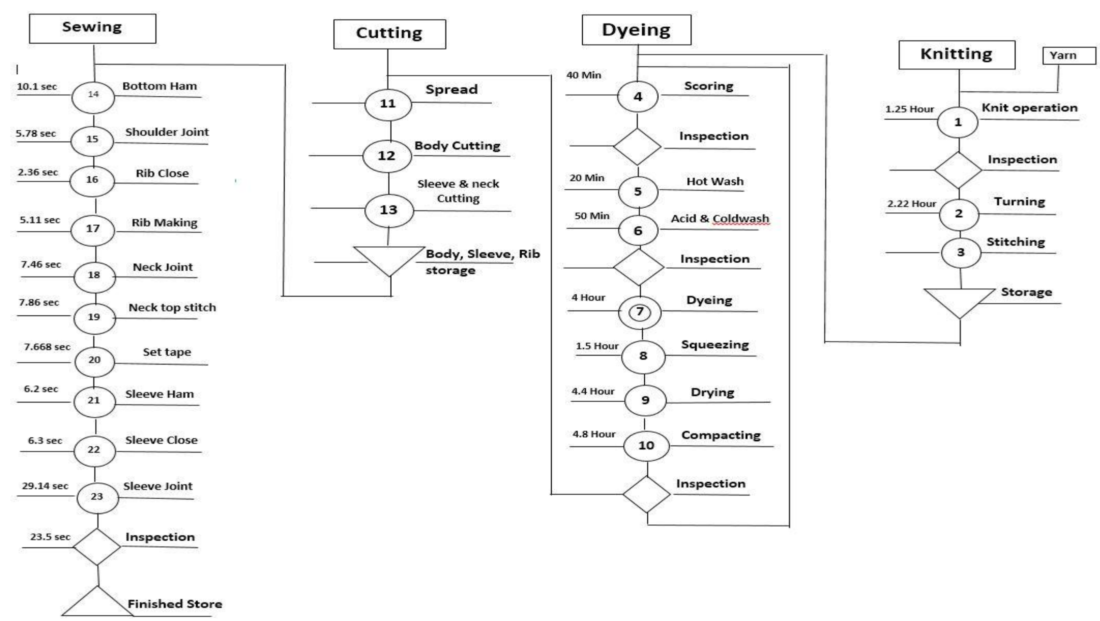


Fig. 1 : Processes required to produce T-shirt

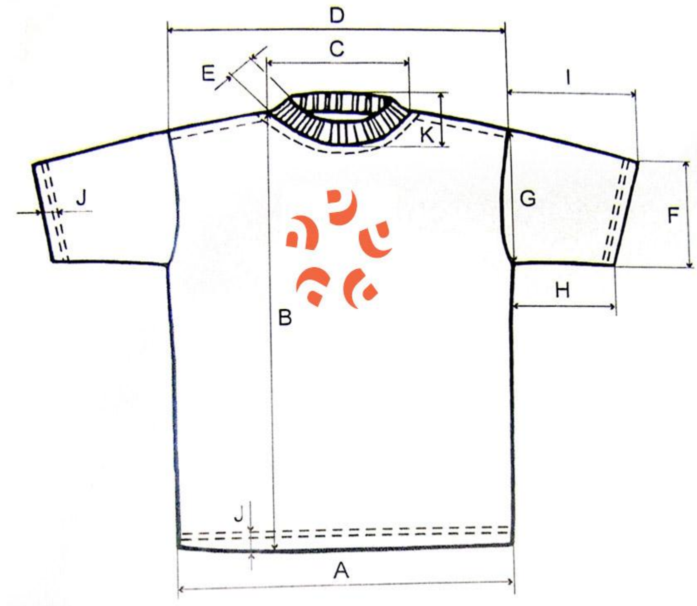
In this industry four processes are capable. The successive processes are knitting, Dyeing, Cutting and Sewing. Fig-1 showing the complete process maintained in this industry. Here total line balancing and optimized layout is obtained in sewing process.

The steps of sewing process are following:

a) Bottom ham
b) Shoulder joint
c) Rib close
d) Rib making
e) Neck joint
f) Neck top stitch
g) Set tape
h) Sleeve ham
i) Sleeve close & joint
j) Inspection

After making gray fabrics bar, this bar or roll is sent to cutting section. Here fabrics are cut with predetermined dimension. This cut input is sent to sewing line. This input is then distributed to bottom ham, Rib cutting and sleeve ham machine. Sewing work is started with three machine same time. Then remaining work is done according to the flow chart given bellow. Finished t-shirt is collected from process 9(sleeve close) for checking those and sent to rework if needed. After final checking, output is sent to packaging.

Measurement of T-shirt cutting used in Gildan Fabrics-



	A	B	C	D	E	F	G	H	I	J	K [cm]
S/158	46	63	17	44	3	16	20	12	17	2,5	8
M	54	73	19	52	3	19	25	17	22	2,5	9
L	56	75	19	54	3	20	26	18	23	2,5	9
XL	58	78	20	56	3	21	27	19	24	2,5	10
XXL	60	80	20	58	3	22	28	20	25	2,5	10
XXXL	68	84	22	65	3	24	30	21	26	2,5	11

Fig. 2 : Dimension for T-shirt

To obtain optimized layout a comparison is shown here between the conventional process and improved layout, here three scenarios are shown.

a) Scenario 1 (existing layout)

All the data shown here are collected from Gildan fabrics; the conventional process which is used in the industry is shown below:

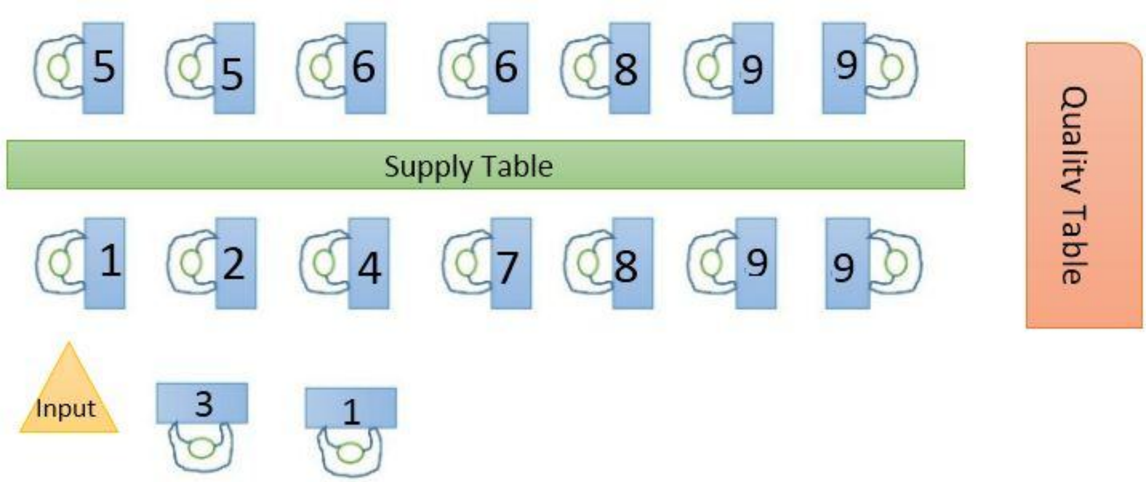


Fig. 3 : Existing layout of sewing (for T- Shirt)

The sewing process starts with bottom hamming which is shown by 1; then it is passed for shoulder joint, as bottom hamming is a long process, so extra worker is for process 1. Rib closing is done before shoulder joint in this process. Then the total rib is processed by folding and stitching. When rib is ready, it is with the main part of the fabrics and is known as neck joint which is shown by process 5 in the figure. Neck top stitch is done by process 6 and then a tape is attached in it .At last sleeve is processed. It includes sleeve hamming, closing and jointing and are shown by process 7, 8, 9. In this scenario four workers are occupied for sleeve closing and jointing. Three workers were applied for help. Total 23 workers were used. Doing all these steps a finished product is found and it is passed to quality table for checking. It is very important to inspect the finish product carefully. A huge amount of time is spent for this process. Here, three workers were applied for inspecting the finished product. The calculated time for each process is shown in the diagram. These were done by time study. By the sum of the time for each process, total time was calculated and it is shown by SAM. Total worker required was calculated. With the help of these data, efficiency of the layout was measured. The target output was predetermined.

The output of this layout & time study is shown below:

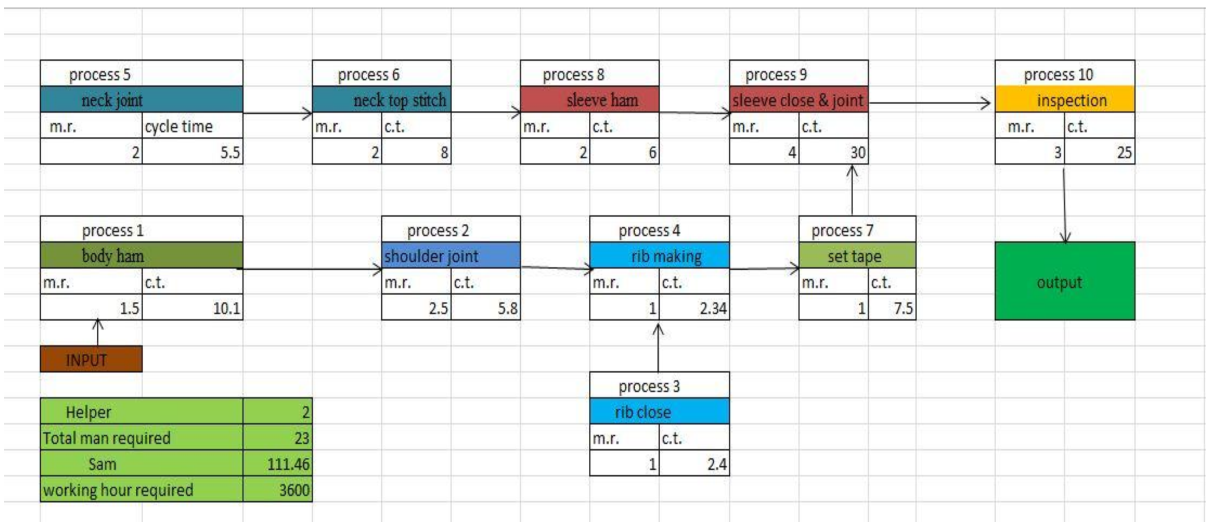


Fig. 4 : Time study for scenario 1

Table 1 : Data for existing layout

Process no.	Name of process	Man required	Cycle time
01	Bottom ham	1.5	10.1
02	Shoulder joint	1.5	5.8
03	Rib close	1	2.4
04	Rib making	1	2.34
05	Neck joint	2	5.5
06	Neck top stitch	2	8
07	Set tape	1	7.5
08	Sleeve ham	2	6
09	Sleeve close & joint	4	30
10	Inspection	3	25
		Helper =2	5
TOTAL		23	111.46

Efficiency can be measured as:

Efficiency = (Product target* SAM)/ (W.H.* M.R.)

Here, W.H. = working hour

M.R. = Man required

Target output was 370;

Now, efficiency= (370*111.46)/ (3600*23)

= 46.2%

b) Scenario 2(an alternative layout)

The whole process can be done in another sequence which is shown below. It is more efficient than the previous one or conventional one. Productivity is increased as well as the time is also optimized. In this case the following layout was done and it is look like closed loop system. In this process two supply tables were arranged and material was flowing in a loop. Here 22 workers were applied. No big change was made but efficiency was increased. It shows that only applying an appropriate layout efficiency of a process can be increased in a considerable level.

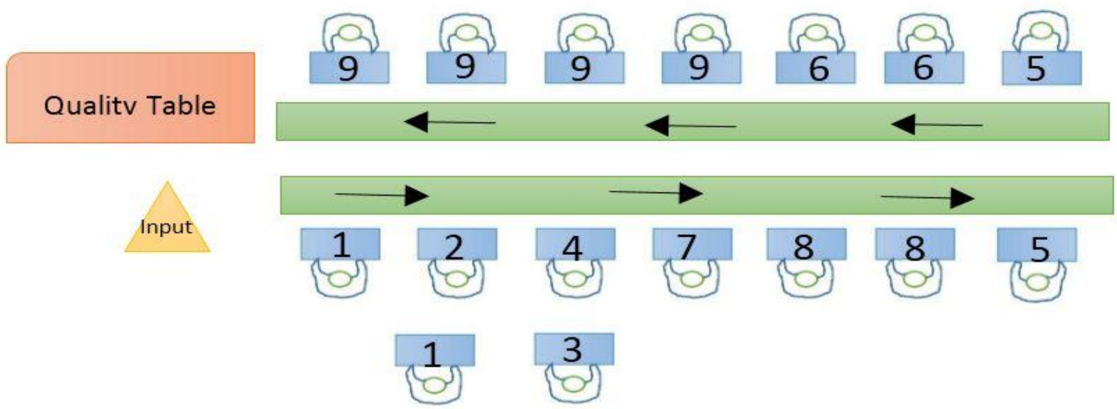


Fig. 5 : An alternative layout

The difference between this two is that, in second scenario there is no crossing in the process. Material is flowing in a U shaped path. By time study it is seen that, it is more optimized than 9 the previous one. Here, after bottom ham, shoulder joint & rib making, neck was made before sleeve and sleeve work was done at last as it was the most time consuming. By using this layout, productivity was increased which is shown later.

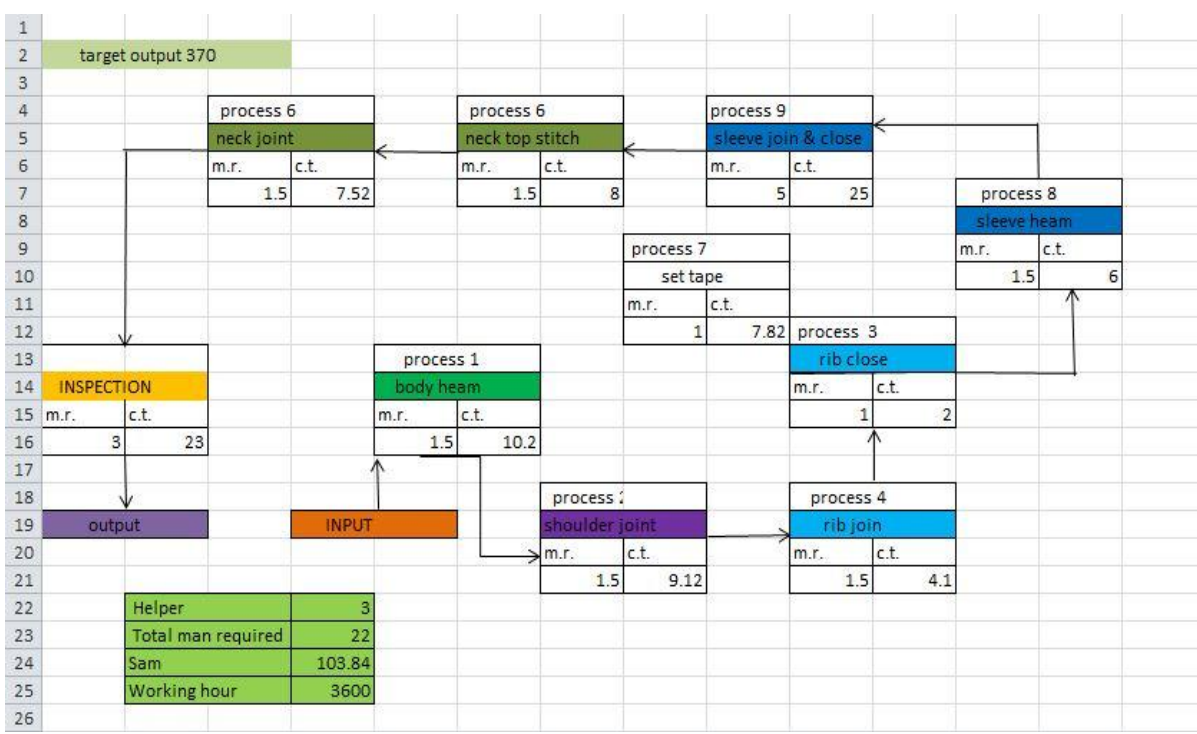


Fig. 6 : Time study for sceranio 2

Table 2 : Data for alternative layout

Process no.	Name of process	Man required	Cycle time
01	Bottom ham	1.5	10.2
02	Shoulder joint	1.5	6.12
03	Rib close	1	2
04	Rib making	1.5	4.1
05	Neck joint	1.5	5.5
06	Neck top stitch	1.5	8
07	Set tape	1	7.82
08	Sleeve ham	1.5	6
09	Sleeve close & joint	5	25
10	Inspection	3	23
		Helper = 3	5
TOTAL		22	103.84

In this case, the efficiency = (370*103.84)/ (3600*22)

= 48.5%

c) Scenario 3 (proposed layout)

By comparing the above layout, a combined layout was designed and it was seen that efficiency was further increased. This time the following layout was made.

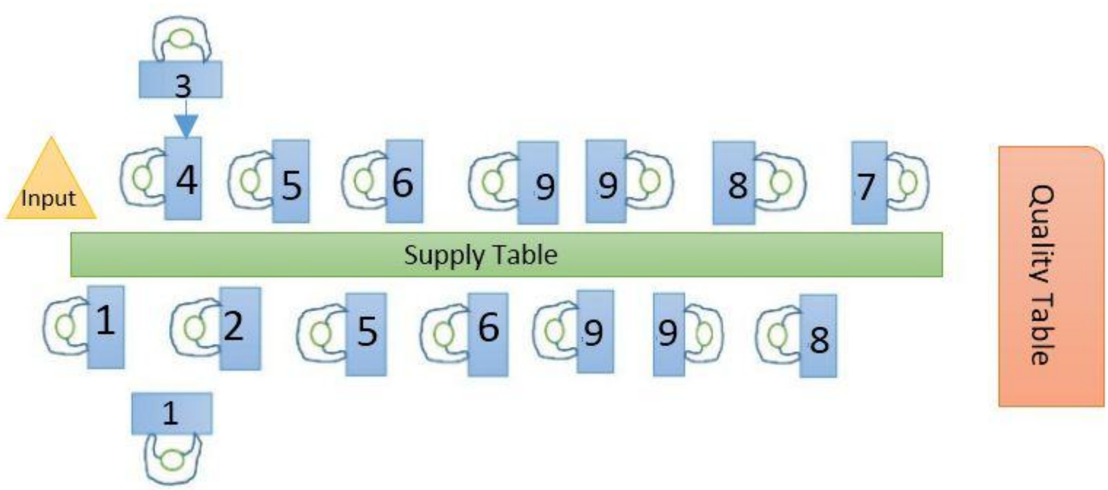


Fig. 7 : Optimal alternative layout

In this layout, an extra worker was added for process one. Worker doing same job were placed closer. The worker doing process three, was helping in process one. A supply table is used as a temporary storage. Here layout is done by the sequence of 1, 2,4,5,6,9,8,7. Bottom hamming was done first, then shoulder joint, rib making, neck making and at last sleeve joint. As the worker doing same process were arranged side by side, then materials were need not to pass a long distance like the previous one and time is also saved.

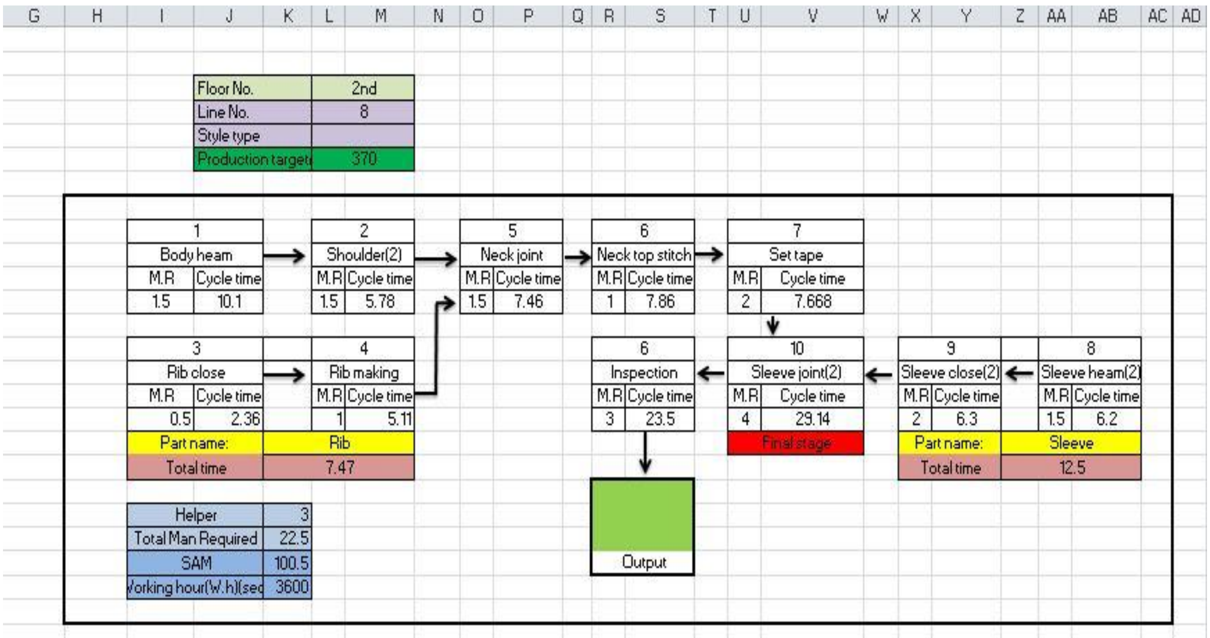


Fig. 8 : Time study of optimum layout

Table 3 : Data table for optimum layout

Process no.	Name of process	Man required	Cycle time
01	Bottom ham	1.5	10.1
02	Shoulder joint	1.5	5.7
03	Rib close	0.5	2.36
04	Rib making	1	4.1
05	Neck joint	1.5	7.4
06	Neck top stitch	1	7.81
07	Set tape	2	7.6
08	Sleeve ham	2	6.2
09	Sleeve close & joint	5	22
10	Inspection	3	23.5
		Helper =3	5
TOTAL		22	100.5

For this proposed layout efficiency becomes, (370*100.5)/ (3600*22)

= 50.9% 12

Table 4 : Output of the line

SN	Process Name	M/C Quantity	M/C Capacity per Hour	Worker	Actual Rate
1	Botom Ham	2	1416	2	1172
2	Shoulder Joint	2	2098	2	1778
3	Rib Close	1	1666	1	1287
4	Rib making	1	829	1	634
5	Neck Joint	2	1984	2	1723
6	Back neck top stitch	2	1000	2	737
7	sleeve Ham	1	1791	1	1345
8	sleeve close	2	7546	2	6243
9	sleeve Joint	4	1056	4	528
		Total = 17			

Floor No	4
Line No	23
Pd Target	370

Supporting Worker	
mark	=1
finish	=1
sort	=2
line man	=1
Total	=5

Total MR = 22
SAM =100.47 sec
Efficiency= 51%

IV. Analysis

From these scenarios it can be easily seen that, efficiency is increasing by exact positioning of machines. In the first scenario, overall 23 workers were applied but efficiency was 46%, sleeve closing & joint was the most time consuming process and 6 workers were applied for that.

In scenario 1 every machine is sequentially arranged. Here machine arranging is the main objective. An extra machine line is added to supply supporting jobs. First input storage is also added in this line. Here extra time is consumed to deliver the product after finishing from one machine to other. The total time required to process a finished product was measured by time study. It was seen that most time is consumed on sleeve processing and in inspection.

In scenario 2, another optimal layout was shown for the same process. Here machine arrangement was different from the previous one and a closed loop system was followed. By time study it was seen that the time needed for the process was reduced, man requirement was also reduced. By the calculated time study, efficiency was measured and it was seen that the efficiency was improved.

In scenario 3, our proposed layout was shown. It was based on first two scenarios and mainly focused on the sleeve processing and inspection as these two were the most time consuming of the whole process. It was tried to arrange a layout so that the time required for those scenarios can be reduced. By the proposed layout and its time study it was seen that the time required for the process was reduced but the man required was same as scenario 2 and finally from calculation improved efficiency was found.

V. Comparative Efficiency of the Layout

It is conspicuous from table 5 and figure 9 that the efficiency increased in the proposed layout with the decreasing in cycle time and man power. Cycle time in scenario 1 isestimated as 111.4 with a manpower requirement of 23. In the alternative layout it reduces the cycle time to 103.84 with manpower 22. At last the proposed layout shows 50.9% efficiency with efficiency increase at 10.173 % from the existing layout.

Table 5 : Efficiency for different scenarios

Name	Cycle time	Man required	Efficiency
Scenario1(Existing layout)	111.46	23	46.2%
Scenario2(Alternative layout)	103.84	22	48.5%
Scenario3(Proposed layout)	100.5	22	50.9%

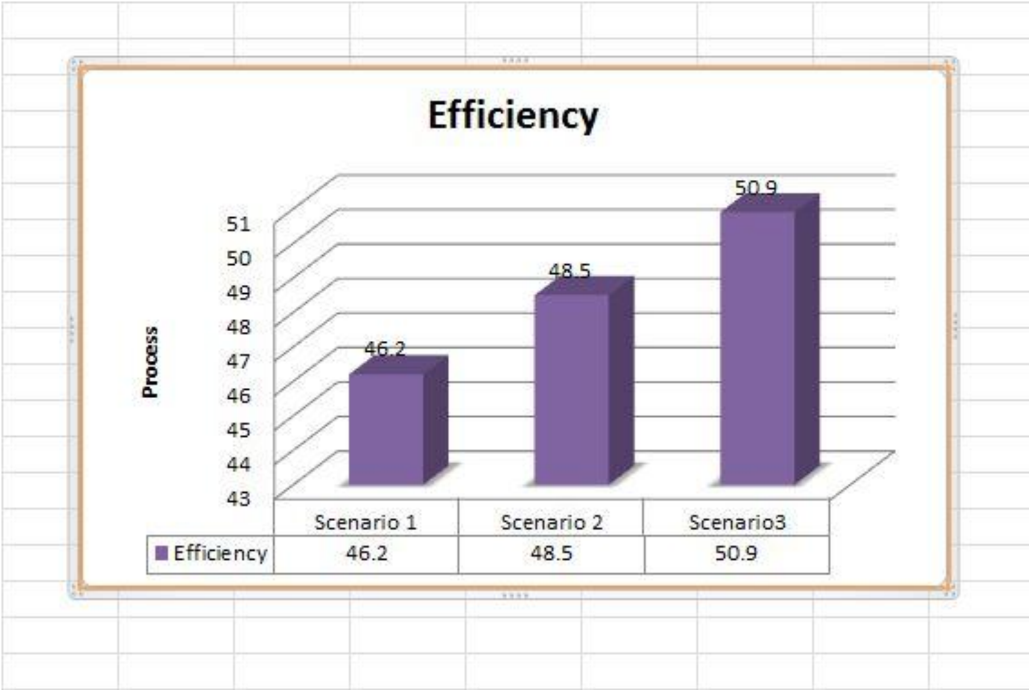


Fig. 9 : Comparative efficiency of layout

VI. Discussion

In this article, different layouts were shown for a common process and the efficiency for each of the process was measured. We actually tried to show that how an optimized layout can increase efficiency and reduce the nonproductive time. It was also shown how the same process with the same manpower can be more efficient by an appropriate layout. In this chapter, the structure of garment assembly line was analysed by simulation. A T-shirt sewing line was considered for simulation model. Firstly, the work flow of the line as well as the chronological sequence of assembly operations needed to transform raw materials into finished T-shirts were described in detail. Then, a detailed work and time studies were performed along the line. To set-up the model, all fitted data and allocation of operations to the operators with machines considering precedence constraints were transferred to simulation model. Due to model statistics, possible scenarios were formed by various what-if analyses in order to balance line as well as increase its efficiency. These scenarios can provide investment decision alternatives to company administrators. Moreover, in order to present more comprehensive decision alternatives, study can be enhanced by a cost analysis of the possible scenarios. To conclude, this chapter has demonstrated the use of simulation technique to solve assembly line balancing problem in a garment production. From this analysis, it appears that articles related to layout design continue to be regularly published in major research journals and that facility layout remains an open research issue.

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Superpave System Versus Marshall Design Procedure for Asphalt Paving Mixtures (Comparative Study)

By Bara' Al-Mistarehi

University of Stuttgart Geschwister-Scholl, Germany

Abstract- Over 98% of paved highways in Jordan have a surface course where asphalt cement is used as the binder agent. The prevalence of these pavements is constructed with hot-mix asphalt concrete. Asphalt concrete is a mixture of binder and aggregate under specified volume parameters. Based on empirical evidence, the volume of air used in the mix design process is four percent. Under the performance grade specifications of the Superior Performing Asphalt Pavement (Super Pave) method of mix design the base grade of binder is selected based on the range of pavement temperatures expected for pavements service conditions (McLeod et al. 1956). Aggregates used in asphalt concrete in Jordan are mainly crushed limestone. The asphalt used is mainly the (60/70) penetration grade. The performance of asphalt surface roads is directly affected by the quality of the asphalt concrete. Several methods have been developed for determining the quantities of aggregate and asphalt cement used in the asphalt concrete such as Marshall, Hveem and SuperPave System (Foeter et al. 2009). This paper aims to compare between Marshall, Hveem and SuperPave System to show the difference between them.

Keywords: superpave system, marshall mix design, binder, asphalt pavement, asphalt concrete.

GJRE-G Classification : FOR Code: 290502p

SUPERPAVESYSTEMVERSUSMARSHALLDESIGNPROCEDUREFORASPHALTPAVINGMIXTURESCOMPARATIVESTUDY

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Superpave System Versus Marshall Design Procedure for Asphalt Paving Mixtures (Comparative Study)

Bara' Al-Mistarehi

Abstract- Over 98% of paved highways in Jordan have a surface course where asphalt cement is used as the binder agent. The prevalence of these pavements is constructed with hot-mix asphalt concrete. Asphalt concrete is a mixture of binder and aggregate under specified volume parameters. Based on empirical evidence, the volume of air used in the mix design process is four percent. Under the performance grade specifications of the Superior Performing Asphalt Pavement (Super Pave) method of mix design the base grade of binder is selected based on the range of pavement temperatures expected for pavements service conditions (McLeod et al. 1956). Aggregates used in asphalt concrete in Jordan are mainly crushed limestone. The asphalt used is mainly the (60/70) penetration grade. The performance of asphalt surface roads is directly affected by the quality of the asphalt concrete. Several methods have been developed for determining the quantities of aggregate and asphalt cement used in the asphalt concrete such as Marshall, Hveem and SuperPave System (Foeter et al. 2009). This paper aims to compare between Marshall, Hveem and SuperPave System to show the difference between them.

Keywords: superpave system, marshall mix design, binder, asphalt pavement, asphalt concrete.

I. Introduction

The purpose of any asphalt mix design method is to determine the optimum proportions of aggregate and asphalt cement to be used in an asphalt pavement mix. Two empirical mix designs methods are traditionally used. These are Marshall and Hveem methods. Superpave method developed by the Strategic Highway Research Program (SHRP), is being considered for full implementation as a design method. The main advantage of Superpave over currently used mix design methods is that it is performance-based method that implies a direct relationship between Laboratory analysis and field performance after construction. Other design methods are empirical and therefore cannot accurately predict how a pavement will perform after construction (Anderson et al. 2007).

II. Overview of the Superpave Method (1987-2012)

Starting in 1987 (35), the Strategic Highway Research Program (SHRP) conducted research into developing new methods to specify, test and design asphalt materials and pavements. This lasted until 1993 when the Federal Highway Administration, FHWA, began implementing the SHRP research program. The Superpave design method, that was a direct result of the SHRP research, is becoming the standard for bituminous pavement design (FHWA 2006).

SHRP researches recognized that the Marshall method of mix design had been used for many years and those pavements have performed well, however, with increased traffic and heavier axle loads, it was decided that an improved method of design was needed. The Supepave mix design method was developed to fill this need. The SHRP researches envisioned a Superpave design system implemented at three levels. The level one method relied totally on volumetric analysis to determine mix proportions. The other levels of Superpave analyses require complex equipment and have not been implemented. There is ongoing research to refine Superpave with respect to quantifying the effects of aggregate size, type and gradation on the mixture and correlating these data with pavement performance. In addition, research is being conducted to develop tests for quantifying the asphalt concrete mechanical properties (Cominsky 1990).

The Superpave mix design process starts with aggregate evaluation. Aggregate characteristics are identified as either source properties or consensus properties. Source properties are defined by the purchasing agency. The WVDOH Marshall requirements in table 2.1 are used as the Superpave source property specifications, with the exception that flat and elongated property is treated as a consensus property. Consensus aggregate properties were defined by theSuperpave researches to ensure mixes made with the aggregate have good performance characteristics. The researcher envisioned that all agencies using Superpave would adopt these specifications without modification for local conditions (McLeod et al. 1956). The consensus aggregate properties are given in table 2.2.

WVDOH has implemented these specifications, but has augmented them with requirements for skid-resistant aggregates. The consensus aggregates properties are;-

a) Coarse aggregate angularity
b) Coarse aggregate flat and elongated

Author: M.Sc., Institute of Engineering Geodesy, University of Stuttgart Geschwister-Scholl, Stuttgart, Germany.
e-mail: bara.al-mistarehi@ingeo.uni-stuttgart.de

c) Fine aggregate angularity
d) Sand equivalency.

Table 2.1 : WVDOH Aggregate Requirements for the Marshall Mix Design Method[8]

Coarse Aggregate	
Gravel and Crushed Stone	Clean hard durable rock free from adherent coatings.
Thin or elongated particles (4:1)ratio	5% max
Shale	1% max
Coal and other lightweight materials	1.5% max
Friable particles	0.25% max
Percent water (LA abrasion)	40% max
Soundness	12% max
Additional Gravel and Crushed Particle Requirements	
Bituminous Base I	Min 80% one fractured face
All other asphalt concrete	Min 80% two fractured faces
Fine Aggregate	
Must meet requirements of ASTM D 1073, except gradation	

Table 2.2 : Superpave Consensus Aggregate Properties[8]

Mineral Filler Must meet requirements of ASTM D 242 except for gradation and must be free of harmful organic compounds				
Design Level	Course Aggregate Angularity (% min)	Fine Aggregate Angularity (% min)	Sand Equivalency (% min)	Flat and Elongated (% min)
Light Traffic	55%-	-	40%	-
Medium Traffic	75%-	40%	40%	10%
Heavy Traffic	85/80	45%	45%	10%

Superpave Consensus Aggregate Properties are shown as following:

a) Coarse Aggregate Angularity (CAA)

Coarse aggregate angularity is evaluated by the percent weight of aggregates with one and more than one fractured face. The test is performed on materials retained on the (4.75)mm sieve. This is somewhat different than the WVDOH Marshall requirements that specifies the minimum percent of material with two fractured faces.

Coarse aggregate flat and elongated is evaluated by the percent mass of aggregates whose ratio of longest dimension to smallest dimension is greater than (5). Superpave limits the amount of flat and elongated particles to less than (10%). The WVDOH Marshall specification limits flat and elongated particles to (5%) based on a (4:1) ratio (McLeod et al. 1956).

b) Fine Aggregate Angularity(FAA)

Fine aggregate angularity, FAA, is evaluated using the Uncompacted Void Content procedure, AASHTO T304 – 96 (AASHTO, 2000). The test is performed on material passing the (2.36)mm sieve. This test method was available prior to the development of Superpave, but was not a requirement for asphalt concrete mix design.

The purpose of the test is the test is to ensure the fine aggregates have sufficient angularity and texture to produce a rut resistant mix (McLeod et al. 1956).

c) Sand Equivalency Test(SE)

The sand equivalency test is used to evaluate the clay content of materials passing the (4.75)mm sieve. This test was implemented by some states prior to Superpave, but is a new requirement for the WVDOH (McLeod et al. 1956).

d) Flat and Elongated Particles Test

It is conducted according to the test method outlined in ASTM D4791. The particle is considered a flat and elongated particle if the ratio of the maximum to minimum dimension of the particle is (5:1) or more.

As a result CAA, FAA, elongated particles, and SE affect pavement resistance to rutting, fatigue cracking, and low-temperature cracking, and also affect production and laydown (McLeod et al. 1956). Table 2.3 shows criteria of Superpave system.

Table (2.3) : Criteria of Superpave System[9]

ESAL	*CAA*		*FAA*		*SE*	*F & E*
	<100	>100	<100	>100		
< 0.3	55/-	-/-	-	-	40	-
0.3-to<3	75/-	50/-	40	40	40	10%
3-to<10	85/80	60/-	45	40	45	
10-to<30	95/90	80/75	45	40	45	
>30	100	100	45	45	50	

The Coarse and fine aggregate shall be combined in such proportions to produce an asphalt mixture meeting all the requirements defined in this specification and shall conform to the gradation as defined in table 2.4. Gradation testing shall be conducted in accordance with AASTHO T-11 (-0.075 mm (NO.200) wash) and T-27.

Table 2.4 : Aggregate Gradation Broad Bands[10]

Sieve Size	*Superpave Mixture (Percent Passing)*					
	SP- 9.5(3/8") Nominal size A		SP-12.5 (1/2") Nominal size B		SP -19.0 (3/4") Nominal size C	
Gradation Max	Min	Max	Min	Max	Min	Max
25.0 (1")	-	-	-	-	100	-
19.0 (3/4")	-	-	100	-	90	100
12.5 (1/2")	100	-	90	100	-	90
9.5 (3/8")	90	100	-	90	-	-
4.75 (#4)	-	90	-	-	-	-
2.36 (#8)	32	67	28	58	23	49
0.075 (#200)	2	8	2	8	2	7

The Superpave gradation specifications bands represent a minor revision as compared to the Marshall requirements. However, the concept of a restricted zone in the aggregate gradation was added to the Superpave specification to control the amount of fine material of certain sizes used in pavement mixtures. The restricted zone was introduced to limit the potential for tender mixes. The restricted zone has been removed from the WVDOH Superpave specification, in accordance with national recommendations. The gradation requirements for the 9.5 mm, 12.5 mm, and 19.5 mm mixes are shown in table 2.5 below.

Table 2.5 : Recommended Aggregate Gradation Restricted Zone[10]

Sieve Size	Boundaries of Restricted Zone Superpave Mixture (Percent Passing)					
	SP- 9.5(3/8") Nominal size		SP-12.5 (1/2") Nominal size		SP -19.0 (3/4") Nominal size	
mm (inch)	Min	Max	Min	Max	Min	Max
2.36 (#8)	47.2	47.2	39.1	39.1	34.6	34.6
1.18 mm (#16)	31.6	36.6	25.6	31.6	22.3	28.3
0.60 mm (#30)	23.5	27.5	19.1	23.1	16.7	20.7
0.30 mm (#50)	18.7	18.7	15.5	15.5	13.7	13.7

The Superpave process requires identifying a design aggregate structure using stockpile blends, which meet both the gradation and consensus aggregate properties. The recommended practice is to select three blends. The Federal Highway Administration has prepared a Superpave Mix design workshop that covers the details of the analysis process as presentedin the following in figure 2.1 below (Harmon, et al., 2002).

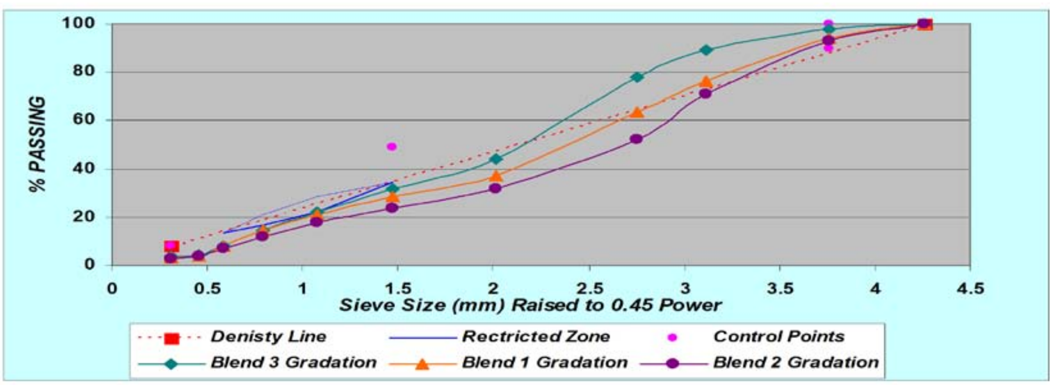


Figure 2.1 : Analysis Superpave Process of three blends[10]

The required asphalt content for each blend is estimated by using general steps to estimate trial (initial) binder content as following:-

1-Estimate Gse

$$Gse=Gsb+0.8*(Gsa-Gsb) \qquad (2.1)$$

Where Gse:-effective speaific gravity of aggregate blend
Gsb:-Bluk specific gravity of aggregate blend
Gsa:-apparent specific gravity of aggregate blend

2-Estimate Vba

$$Vba=(Ps(1-Va))/((Pb/Gb)+(Ps/Gse))*((1/Gsb)-(1/Gse)) \qquad (2.2)$$

Where Vba:-Volume of absorbed binder
Va:-Volume of air voids, (assumed 4%)
Pb:- Percent of binder (assumed 5%)
Ps:- Percent of aggregate (assumed 95%)
Gb:-Specific gravity of binder
3-Estimate Vbe

$$Vbe=0.176-0.067 \log (Sn) \qquad (2.3)$$

Where Vbe= Volume of effective binder (by volume of mix)
Sn= Nominal maximum sieve size of aggregate blend

4- Estimate Pbi:-

$$Pbi= 100*((Gb(Vbe+Vba))/(Gb(Vbe+Vba))+Ws) \qquad (2.4)$$

Where Pbi= Percent of binder by mass of mix

For each aggregate blend, two samples are prepared for compaction and two samples are prepared for determining the maximum theoretical specific gravity. Superpave samples are compacted using the gyratory compactor developed during the SHRP research. The number of the revolutions of the gyratory compactor regulates the amount of compaction effort.

Three levels of compaction effort are used in the Superpave procedure; initial; design and maximum, Ni, Nd, and Nmax, respectively. The initial level is reflective of the ability of the mixture to consolidate under low forces and is used to identify "tender" mixes. The design level compaction simulates the density of the mix immediately after construction. The maximum density level simulates the density of the asphalt after 5 to 10 years of service (Cominsky 1990). The number of gyration depends on the design situation as presented in Table 2.6.

Table 2.6 : Number of Gyrations at Specific Traffic Levels[8]

<table>
<tr><th colspan="5">Traffic Level</th></tr>
<tr><th colspan="5">(ESALmillions)</th></tr>
<tr><th></th><th><0.3</th><th>0.3 to 3</th><th>3 to 30</th><th>>30</th></tr>
<tr><td>Ni</td><td>6</td><td>7</td><td>8</td><td>9</td></tr>
<tr><td>Nd</td><td>50</td><td>75</td><td>115</td><td>125</td></tr>
<tr><td>Nmax</td><td>75</td><td>100</td><td>160</td><td>205</td></tr>
</table>

The bulk specific gravity is measured for the compacted samples. This is used with the measured maximum specific gravity for the volumetric analysis. The Superpave method uses the same equations as the Marshall methods for voids in the total mix, voids in the mineral aggregate and voids filled with asphalt. The Superpave method defines the dust to binder ratio as the percent aggregate passing the (0.075) mm sieve divided by the percent effective binder. The percent effective binder content is the difference between the total binder content and the absorbed binder as three following equations:-

$$Pba = 100((GseGsb)/(GsbGse))*b \qquad (2.5)$$

$$Pbe = Pb - (Pba/100)*Ps \qquad (2.6)$$

$$\text{Dust Ratio} = (PD/Pbe) \qquad (2.7)$$

The adjusted volumetric parameters are compared to the Superpave acceptance criteria shown in Table2.7. The aggregate blend that produces the best compliance with the criteria is selected as the design aggregate structure for determining the design binder content. (Harmon, et al., 2002). If none of the aggregate blends produce a design aggregate structure with acceptable volumetric characteristics, a new aggregate blend and subsequent testing must be selected and evaluated. Table 2.8 shows example of blend (3), and figure 2.8 shows % of AirVoid, % VFA, and %VMA respectively v.s % of Asphalt Binder[8]

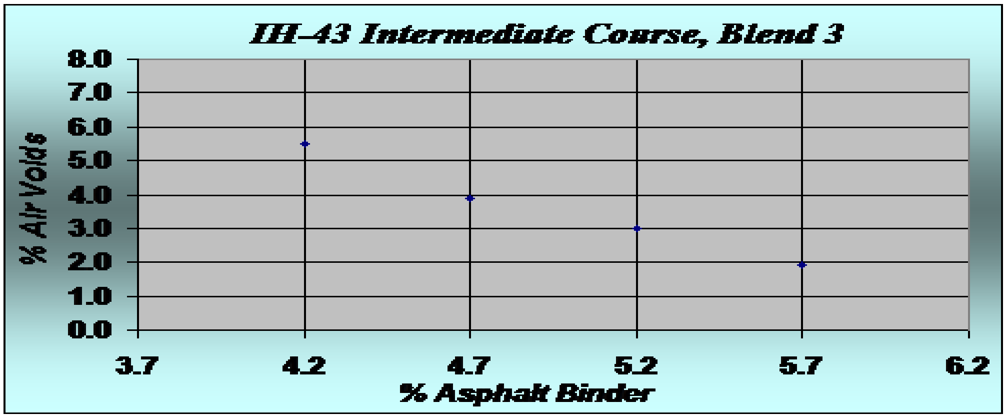
Table 2.7 : Superpave Mix Design Criteria [9]

<table>
<tr><th rowspan="2">ESAL)(millons</th><th colspan="3">% Gmm</th><th rowspan="2">VMA</th><th rowspan="2">VFA</th><th rowspan="2">Air Void</th><th rowspan="2">Dust Ratio</th></tr>
<tr><th>Nini</th><th>Ndes</th><th>Nmax</th></tr>
<tr><td><0.3</td><td><91.5</td><td rowspan="6">96.0</td><td rowspan="6"><98.0</td><td rowspan="6">NA</td><td>70-80</td><td rowspan="6">4%</td><td rowspan="6">0.6-1.2</td></tr>
<tr><td><1</td><td><90.5</td><td>65-78</td></tr>
<tr><td><3</td><td><90.5</td><td>65-78</td></tr>
<tr><td><10</td><td><89.0</td><td>65-75</td></tr>
<tr><td><30</td><td><89.0</td><td>65-75</td></tr>
<tr><td>>30</td><td><89.0</td><td>65-75</td></tr>
</table>

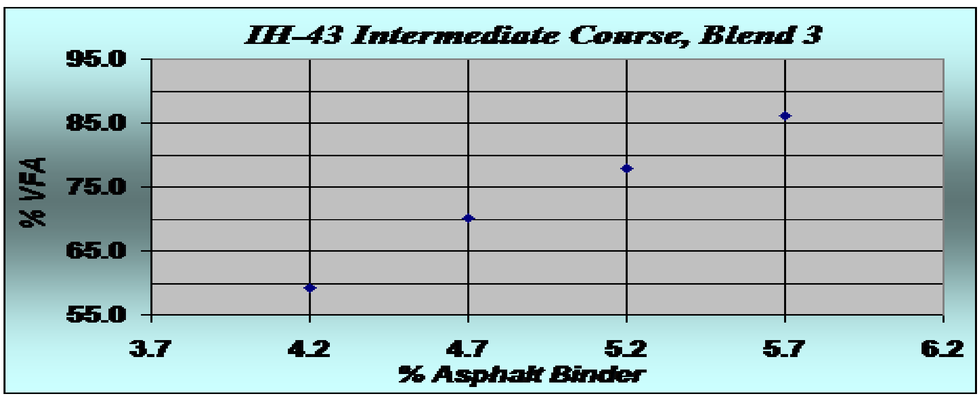
For example for IH-Intermediate Course, Blend (3)

Table 2.8 : Example of Blend (3)8

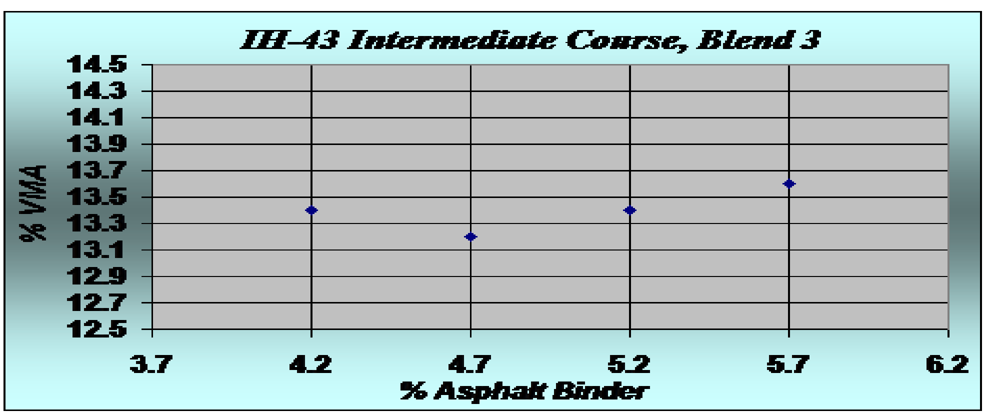
% AC	% Air Voids	%VMA	%VFA
4.2	5.5	13.4	59.3
4.7	3.9	13.2	70.1
5.2	3.0	13.4	77.9
5.7	1.9	13.6	86.2



(a)



(b)



(c)

Figure 2.8 : (a) % of AirVoid, (b) % VFA , (c) % VMA respectively v.s % of Asphalt Binder[8]

Finally, the moisture susceptibility of the mixture is evaluated, Six samples are prepared at the design aggregate structure and optimum binder content. Three samples are conditioned. The tensile strength of all samples is measured (Huber et al. 2007).

III. Overview of the Marshall Method (Kandhal et al. 1985)

a) Seieving the aggregate

Put all sieves above each other in familiar order, then put the sample on the sieves and shaking use the mechanical shaker for you , after that make the graded of aggregate to get the mix of aggregate that meets specification.

b) Mixing Asphalt with aggregate

Put the asphalt cement in an oven for (2 hr), then put aggregate mixture in container, and make check if the aggregate to be with compliance to specifications then heated to (110°), after that add the asphalt to aggregate in a pan and mixed through until all aggregate mixed with asphalt.

c) Compaction

Mould painted with oil to prevent the adhersion between the specimen and the mold, then put the mould at the bottom of compaction in the right position and filter paper was put on the bottom of the mould, then put the mixture of aggregate and asphalt in the mould and put a new filter paper on the top of the mould, then check fastness of mould and rise the hummer to max height. After that release hummer to fall vertically (50) times on the mould for each faces. After a week, weight the specimen in air and dry weight, then immersed the specimen in water for (3-5) min then weight the saturated surface dry (after dying the specimen with clothes).immersed the samples in water for (30)min and weighted it in water.

d) Stability and Flow test

Zero flow water to increase (4 inch) diameter cylinder in the testing head, the specimen is immersed in water path at 60C° for (30 min), then placed the specimen under the test head at constant rate, after that record the load of failure and strain at the point of failure from the results make the calculations.

e) Gmm Test

Specimen resulted from stability test were damaged by separating aggregate from each other

IV. Conclusion and Summary of the Comparative Study

- The review of the literature demonstrates the availability of analytical and experimental methodologies that may be potentially improve the mix design. Such methods rely on the volumetric analysis for establishing the optimum asphalt content.
- The Voids in the mineral aggregate criteria are critical since they initially establish the volume of the effective binder in the mix.
- However, the current VMA criteria used by Marshall and Superpave were derived for mixes with questionable assumptions concerning the type of aggregate.
- (CAA, FAA, Flat and elongated particles, and SE) affect pavement resistance to rutting, fatigue cracking, and low-temperature cracking, and also affect production and laydown.
- There are several Differences between Super pave System v.s Marshall Mix Design for Asphalt Paving Mixtures as shown in table 4.1 below.

Table 4.1 : Mix Design Differences between Super pave System v.s Marshall Mix Design for Asphalt Paving Mixtures

Superpave Mix Design	*Marshall Mix Design*
Tests in Mineral Aggregate like(CAA, FAA, SE, and F&E particles)are considered in the SP	Tests in Mineral Aggregate like(CAA, FAA, SE, and F&E particles)are not considered in the Marshall test
Trial (Intial) binder content is done in the SP to take an idea about binder content before compaction	Trial (Intial) binder content is not done in the Marshall test
Levels of compaction in Super pave System with respect to (N design) which depends on:- 1-Average Design high air Temperture 2- Design ESALs	Levels of compaction in Marshall System depends on Type of traffic as following: 1-Light (ESALs<10000)---Level of compaction= 35. 2-Median (10000<ESALs<1000000)---Level of compaction= 50. 3- Heavy (ESALs>1000000)---Level of compaction= 75.
The Concept of Nmax which is used to compact the test specimen &Nini that is used to estimates Compactibility of mixture.	The Concept of Nmax & N init are not exist in Marshall test.
The Concept (%Gmm-corrected) which is used to collect all the data analysis to select the design binder content.	The Concept (%Gmm-corrected) is not exist in Marshall test.
Nominal Maximum Aggregate size(NMS) (mm)which respected to sieve size larger than the first sieve to retain more than (10%) and it is important to select gradation criteria of mix & make check on VMA% according to (NMS)	The Concept of Nominal Maximum Aggregate size (NMS) is not exist in Marshall test.
The Concept of Dust Ratio which represents ratio between aggregate content passing (0.075) mm sieve to effective binder content.	The Concept of Dust Ratio is not exist in Marshall test.
%G mm @Nmax & % Gmm @ Ninit that are exist in SP	%G mm @Nmax & % Gmm @ Ninit that are exist in SPnot
Evalution of moisture Sensitivity of design mixture and determine tensile strength ratio which should not less than (80%).	Evalution of moisture Sensitivity of design mixture and determine tensile strength ratio are not exist in Marshall test.

Performance Grade binder (PG-binder) which required for any project.	Performance Grade binder (PG-binder) are not exist in Marshall test.
LTPP& Sharp algorithms program are used in the Super ave to calculate T high &T low and to estimate (PG) to the project according to known reliability.	LTPP& Sharp algorithms program are not used in the Marshall test.
Super pave Gyratory Compactor (SGC) which is defined to make compact to mix to select design aggregate structure.	Super pave Gyratory Compactor (SGC) is not used in the Marshall test.
Control point / Restricted zone (FHWA 0.45 power chart) which is used to determine design aggregate structure, determine if the aggregate is Finer or Coarse with respect to max density line and evaluate (NMS).	Control point / Restricted zone (FHWA 0.45 power chart) which are not exist in the Marshall test.
Dimensions of Gyratory are (150)mm diameter which is more than the diameter of Marshall test specimen & number of Gyration per min in Super pave= (30)	The Diameter of specimen in the Marshall test is (102mm) which is less than the diameter of Gyratory in Super pave test.

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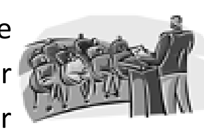

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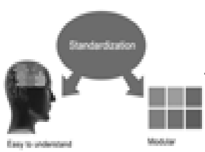

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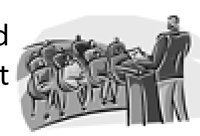

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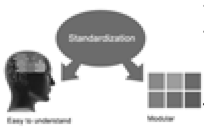

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"

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4. Manuscript’s Category,

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Informal Guidelines of Research Paper Writing

Key points to remember:

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

Final Points:

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

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

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

General style:

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

To make a paper clear

· Adhere to recommended page limits

Mistakes to evade

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

In every sections of your document

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

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

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

· Align the primary line of each section

· Present your points in sound order

· Use present tense to report well accepted

· Use past tense to describe specific results

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

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

Title Page:

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

Abstract:

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

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

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

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

Approach:

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

Introduction:

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

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

Approach:

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

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

Procedures (Methods and Materials):

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

Materials:

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

Methods:

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

Approach:

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

What to keep away from

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

Results:

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

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

Content

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

What to stay away from

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

Approach

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

Figures and tables

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

Discussion:

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

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

Approach:

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

The Administration Rules

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

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

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

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

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

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

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

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