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Highlights

Multi-Product Environment

Engineering Asset Performance

Discovering Thoughts, Inventing Future

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FMEA based Quantification Analysis of Outbound Supplier Risk and its Resilience

By Karthick. M & Manikandan. V
Thiagarajar College of Engineering, India

Abstract- Supply chain is the linkage of series of organizations with facilities, functions, and logistic activities that are involved in producing and also delivering a product or service. In the past, when firms manufactured in-house, they sourced locally and sold directly to customer. During that period, supply chain risk was less diffused and easier to manage. In recent years global supply chain was hit by increasing globalization, because all organizations had to face vulnerable by different types of risk in their inbound and outbound supply chain network. The various supply chain (SC) vulnerabilities are reputation, unreliability, overstocking, price increases, corruption, natural disasters and financial failure. The implications of supply chain possessing vulnerability costlier and lead to significant customer delivery delays, etc. Though, different types of supply chain vulnerability management methodologies have been proposed for managing supply risk. To the above concern, reinforce outbound supply chain risk management by proposing an integrated methodology to classify, manage and assess outbound supply risks were made. The contributions of the work owing to namely (1) outbound supply risk factors are identified through both supply chain risk literature review and industrial interview; (2) Hierarchical risk factor classification structure is created; (3) reduction of outbound supplier risk by using six sigma methodologies was validated. This project is an attempt to quantify the outbound supplier risk with a suitable case study.

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FMEA based Quantification Analysis of Outbound Supplier Risk and its Resilience

Karthick. M [α] & Manikandan. V [σ]

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I. Introduction

Supply chain resilience is defined as the system ability to approach its equilibrium state, after being disturbed by external or internal factors. This consideration is following aspects: Supply Chain flexibility, agility, velocity, visibility and redundancy (Creating resilient SCs: A Practical guide, 2003). Flexibility helps companies in correctly answering to markets variability, the agility as the company capability to quickly respond to unpredictable demand/supply markets changes, the velocity must be interpreted as time required for moving goods along the supply chain. The velocity is usually measured in terms of lead times; the visibility is the capability of the company to see all the information regarding the flow of products, information and finances both downstream and upstream along the supply chain.

The redundancy is the augmentation of capacity and inventory in each node of the supply chain for facing supply chain disruption events (Christopher and Rutherford, 2004). This paper focused on outbound supplier risk in supply chain. Managing outbound supplier risk can be a challenging task due in part to the complex and dynamic nature of supply chain systems.A typical supply chain system can be large in scale, having many tiers of suppliers, where each supplier tier of the supply chain provides goods or services to the next level supplier tier in the supply chain. They are facing much risk in internal and external to the supply chain.

Supply chains expand globally; their risk of disruption also grows. Supply chain risk is a particular type of hazards or threats affect the supply chain performance. Commonly there are two types of risk in the supply chain. There are internal risk (quality, accident, fire, security, IT, marketing, building, human, etc.,) and external risk (political, economical, social, technological, environmental, terrorist attack, war, etc.). (Understanding Supply Chain Risk: A self assessment workbook, 2003).

II. Literature Review

Christopher S. Tang (2006) reviewed various quantitative models for managing supply chain risks. We found that these quantitative models are designed for managing operational risks primarily, not disruption risks. However, we argue that some of these strategies have been adopted by practitioners because these strategies can make a supply chain become more efficient in terms of handling operational risks and more resilient in terms of managing disruption risks.

David Bogataj (2007) et.al suggested that the costs of risk in a supply chain, which is exposed to internal and external risk, are measured using net present value of activities approach. their consider financial risk (where the financial flow has the opposite direction to the flow of goods) increases with the extension of the network, especially when in globalization processes even the currency exchange rate in this flow is not always stable.

David J.Closs (2011) et.al developed a framework to examine the threat of potential disruptions on supply chain processes and focuses on potential mitigation and supply chain design strategies that can be implemented to mitigate this risk. There are focused with unintentional causes such as accidents or natural disasters, Intentional disruptions may include theft, terrorist attack, and man-made. They are not focused with cost perspective in SC network. Their results

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illustrate that the depth and breadth of security initiatives depends on top management mindfulness, operational complexity, and product risk.

Hansuk Sohn (2011) et.al analyzed distributors' selection is based on the rough set theory approach in both equal and unequal weight features. Through this method, several rules are generated for distributors' evaluation and selection. The result not only shows the effectiveness of unequal weight incorporated rules identification, but also it shows the importance of the relationship intensity, marketing experience, and the management ability in selecting the distributors.

Jukkahalikas (2004) et.al says about complete understanding of risk management in supplier network. There are taken from internal and external to the company SC network risks are demand problem, problems in fulfilling customer deliveries, cost management and pricing, and weaknesses in resources, development and flexibility. Their results indicate that risk management is an important development target in the studied supplier networks.

Kevin McCormack (2009) et.al regarding a new approach to the identification and prediction of supply risk. they are consider to risk ,such as the increased use of out sourcing, globalization, reduction of supplier based; reduced buffers, increased demand for on-time deliveries. The results to prepare proper mitigation and response strategies associated with these suppliers by SCRM approach.

Mark Goh (2007) et.al presents a stochastic model of the multi-stage global supply chain network problem, incorporating a set of related risks, namely, supply, demand, exchange, and disruption. They provide a new solution; design an algorithm for treating the multi-stage global supply chain network problem with profit maximization and risk minimization objectives. Nurmaya musa (2011) et.al investigate the development in supply chain risk management (SCRM) by using Literature survey and citation/co-citation analysis. In Most literature still focuses on material flow issues in risk management, in particular with supplier selection. Some efforts have been made to integrate material and cash flows by adapting financial option theory.

Sameer Kumar (2005) et.al proposed model is flexible and scalable and can be extrapolated for analysis of different nodes and layers in the existing disaster relief supply chains. This frame work was used in the example of the March 2011 disaster in Japan which was the result of a Tsunami, after a strong earth quake, followed by flooding and nuclear reactors' meltdown causing radiation dispersal. The failure mode effects and critical analysis method was used assess the reliability of a relief supply chain system and its critical components.

Sri Krishna Kumar (2013) et.al considered the location, production–distribution and inventory system design model for supply chain for determining facility locations and their capacity. Risk pooling effect, for both safety stock and running inventory (RI), have been incorporated in the system to minimize the supply chain cost along with determining facility location and capacity.

Stephen M.Wagner (2010) et.al developed an approach based on graph theory to quantify and hence mitigate supply chain vulnerability. their consider natural disasters such as droughts, floods, windstorms, hurry-canes, earth quakes or tsunamis strike more often and have a greater economic impact. At the same time, the number of man-made disasters such as accidents, wars, terrorist attacks, strikes, that affect supply chains.

Teresa Wu (2006) et.al considers the inbound supply chain risk management by proposing an integrated methodology to classify, manage and assess inbound supply risks. The contributions of this paper are four-fold: (1) inbound supply risk factors are identified through both an extensive academic literature review on supply risk literature review as well as a series of industry interviews; (2) from these factors, a hierarchical risk factor classification structure is created; (3) an analytical hierarchy processing (AHP) method with enhanced consistency to rank risk factor for suppliers is created; and (4) a prototype computer implementation system is developed and tested on an industry.

Timothy J. Pettit (2008) consider the current thought on supply chain resilience and Develop the construct into a managerial process for implementation. Academics and industry leaders have seen the need to supplement traditional risk management techniques with the concept of resilience that is better designed to cope with extreme complexities, unpredictable events and adaptive threats.

J.Vander Vorst (2002) et.al considers the factors are Changes in markets, products, technology, competitors and Governmental regulations.

Walter Zinn (2009) et.al proposed process builds upon an existing risk analysis framework by incorporating an innovative methodology used by the insurance industry to quantify the risk of multiple types of catastrophic events on key supply chain locations. Supply chains are increasingly vulnerable to catastrophic events such as hurricanes or terrorist attacks

III. Resilience Framework

Supply chain resilience is defined as the system ability to approach its equilibrium state, after being disturbed by external or internal factors. The main objective of the supply chain management is minimizing the cost and maximizing the customer satisfaction. However, improving supply chain resilience requires an appreciation that supply chain vulnerabilities may come in many guises, and the drivers of risk operate at several different levels.

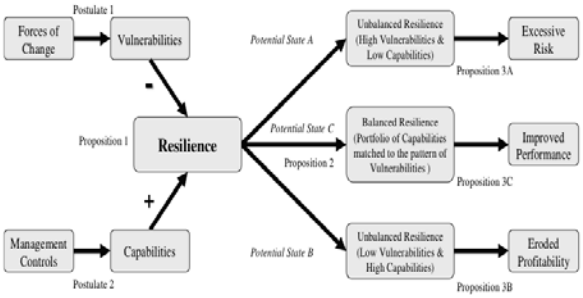

Figure 3.1

Flexibility helps companies in correctly answering to markets variability, the agility as the company capability to quickly respond to unpredictable demand/supply markets changes, the velocity must be interpreted as time required for moving goods along the supply chain.

The velocity is usually measured in terms of lead times; the visibility is the capability of the company to see all the information regarding the flow of products, information and finances both downstream and upstream along the supply chain. The redundancy is the augmentation of capacity and inventory in each node of the supply chain for facing supply chain disruption events (Christopher and Rutherford, 2004).

Supply chains expand globally; their risk of disruption also grows. Supply chain risk is a particular type of hazards or threats affect the supply chain performance. Supply chain vulnerability can be defined as an exposure to serious disturbance, arising from risks within the supply chain as well as risk external to the supply chain (Timothy Pettit, 2010).

IV. Levels of Analysis of Resilience

The main objective of the supply chain management is minimizing the cost and maximizing the customer satisfaction. However, improving supply chain resilience requires an appreciation that supply chain vulnerabilities may come in many guises, and the drivers of risk operate at several different levels.

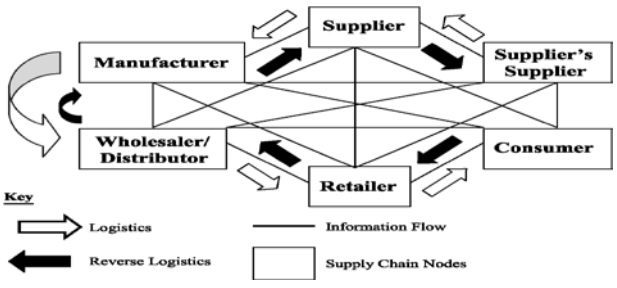

Figure 3.2

a) Events and Network Interaction

The multi-level framework outlined above breaks-down the problem of supply chain vulnerability into its constituent parts, nevertheless it should be born in mind that when an event occurs it may impact at several levels, as the celebrated example of Nokia and Ericsson illustrates (see below).

The Nokia/Ericsson example highlights the vulnerability of industries with capacity constrained production and also raises other important themes, such as the issue of common components and the consequential nature of supply chain risks. The latter is in turn linked to the fact that supply chains are linear processes within complex systems of interacting networks

b) NOKIA and ERICSSON

In March 2000 worldwide demand for mobile telephones was booming. Two of the international market leaders were Finnish electronics company Nokia and its Swedish rival Ericsson. This is the tale of how an 'Act of God' half a world away would set off a train of events that would eventually precipitate a major competitive re-alignment.

The story starts on the evening of March 17th 2000, with a thunderstorm over central New Mexico. A lightning bolt hit a power line, which caused a fluctuation in the power supply, which resulted in a fire in a local semiconductor plant owned by Dutch firm Phillips Electronics NV. The fire was brought under control in minutes, but a batch of trays containing enough silicon wafers for thousands of mobile phones were destroyed in the furnace. The damage to the factory from smoke and water was much more extensive than the fire itself, contaminating the entire stock of millions of chips. The suppliers immediately prioritized customers, according to the value of their business. Between them, Nokia and Ericsson accounted for 40% of the plant's output of the vital radio frequency chips, so these companies were put at the top of the supplier's list.

On 20th March, in Finland Nokia's event management systems indicated that something was amiss. Orders were not coming through as expected, so a components purchasing manager phoned the supplier who informed him that there had been a fire in the plant, which would disrupt production for around a week. Nokia was not unduly alarmed, but dispatched engineers to New Mexico to investigate the situation. Philips were not encouraging visitors, so having been unable to investigate the problem further, Nokia increased monitoring of in-coming supplies from weekly to daily checks. It became clear soon afterwards that the problem was so serious that supplies would be disrupted for months.

Pressure was brought to bear at the highest levels between Nokia and its supplier to ensure that all other Philips plants were commissioned to use any additional capacity to meet Nokia's requirement. In addition, Nokia immediately sent representatives out to its other suppliers in the US and Japan to secure priority

status for all available supplies of chips, and persuaded them to ramp up production as quickly as possible. Because Nokia was such an important customer, they obliged with a lead-time of less than one week.

Nokia also set about reconfiguring its products to take slightly different chips from other sources. Ericsson had also found out about the fire soon after it occurred, but having been assured by the suppliers that the fire was unlikely to cause a major problem, had not acted further until early April.

By then Nokia had already moved to secure its supplies, and unlike the quick acting Finns, Ericsson had no alternative sources of supply. Ericsson lost an estimated $400m in new product sales as a result of the fire. An insurance claim would later offset some of Ericsson's direct losses; nevertheless it was forced to cease manufacturing mobile phones.

V. Details of the Six Sigma DMAIC Tool

The DMAIC toolkit is without question the most effective process improvement framework known in industry today, and teams that learn and apply this methodology will achieve unprecedented success.

The five stages of DMAIC cycle,

Table 5.1

DEFINE	Identify the problem and Collect data from various sources
MEASURE	Measure the capability of the problem by using FMEA
ANALYSE	Classify the problem, use cause and effect analysis and prioritize for action
IMPROVE	Mitigate the problem by using FMEA
CONTROL	Improve visibility of the process. Use statistical process control.

a) Data Collections from small scale industries and literature surveys

Table 5.2

FROM LITERATURE SURVEY	FROM SMALL SCALE INDUSTRIES
Outbound supplier risks	Outbound supplier risks
Demand Security External legal issues Market characteristics Political stability Natural/man-made disaster II tier supplier	Labor strikes Loss of contracts Economical down Delay delivery Uncertainty in power supply Labor absenteeism

b) Failure Mode Effect Analysis

Failure Mode and Effect Analysis (FMEA) is a tool that makes it possible to determine a system's possible modes of risk, and then to establish the effects of those risks on the Overall performance of the system.

FMEA is widely used as a quality improvement tool that can be applied equally to physical systems (vehicles, aircraft, electronic devices and so forth) and non-physical systems such as supply chain processes. The purpose of FMEA is to prevent process and product problems during the design phase. However, conducting an FMEA on existing processes is also hugely beneficial; unlike products, processes can be re-engineered more easily.

c) Using FMEA (or FMECA), businesses can

- Exhaustively identify and catalogue the various ways in which links and nodes in the supply chain may fail.
- Determine the effects of those risks.
- Rank risks according to their likelihood of occurrence, their disruptive effect and the likelihood that imminent risk can be detected in time to put in place remedial action. Combined, this then gives an estimate of criticality, in order to guide preventative action.

d) Steps to creating a FMEA

- Identify the risks.
- List the potential risk mode for each process step.
- List the effects of this risk mode. If the risk mode occurs what does this mean to us and our customer… in short what is the effect?
- Rate how severe this effect is with 1 being not severe at all and 10 being extremely severe. Ensure the team understands and agrees to the scale before you start. Also, make this ranking system "your own" and don't bother trying to copy it out of a book.
- Identify the causes of the failure mode/effect and rank it as you did the effects in the occurrence column. This time, as the name implies, we are scoring how likely this cause will occur. So, 1 means it is highly unlikely to ever occur and 10 means we expect it to happen all the time.
- Identify the controls in place to detect the issue and rank its effectiveness in the detection column. Here a score of 1 would mean we have excellent controls and 10 would mean we have no controls or extremely weak controls.
- Multiply the severity, occurrence, and detection numbers and store this value in the RPN (risk priority number) column.
- Sort by RPN number and identify most critical issues. The team must decide where to focus first.

- Assign specific actions with responsible persons. Also, be sure to include the date for when this action is expected to be complete.
- Once actions have been completed, re-score the occurrence and detection.

i. *Seveority Rating scale*

Table 5.3

Rating	Description	Definition (Severity of Effect)
10	Dangerously high	Risk could highly affect the supplier and customers.
9	Extremely high	Risk would create noncompliance with federal regulations.
8	Very high	Risk renders the unit inoperable or unfit for use.
7	High	Risk causes a high degree of customer dissatisfaction.
6	Moderate	Risk results in partial malfunction of the supply.
5	Low	Risk creates enough of a performance loss to cause the customer to complain.
4	Very Low	Risk can be overcome with modifications to the supplier process, but there is minor performance loss.
3	Minor	Risk would create a minor nuisance to the supplier, but the supplier can overcome it without performance loss.
2	Very Minor	Risk may not be readily apparent to the supplier, but would have minor effects on the supplier process.
1	None	Risk would not be noticeable to the supplier and would not affect the supplier process.

ii. *Occurence rating scale*

Table 5.4

Rating	Description	Potential Failure Rate
10	Very High: Risk is almost inevitable.	More than one occurrence per day or a probability of more than three occurrences in 10 events.
9	High: Risk occurs almost as often as not.	One occurrence every three to four days or a probability of three occurrences in 10 events.
8	High: Repeated risk.	One occurrence per week or a probability of 5 occurrences in 100 events.
7	High: Risk occurs often.	One occurrence every month or one occurrence in 100 events.
6	Moderately High: Frequent risk.	One occurrence every three months or three occurrences in 1,000 events.
5	Moderate: Occasional risk.	One occurrence every six months to one year or five occurrences in 10,000 events.
4	Moderately Low: Infrequent risk.	One occurrence per year or six occurrences in 100,000 events.
3	Low: relatively few risks.	One occurrence every one to three years or six occurrences in ten million events.
2	Low: Risks are few and far between.	One occurrence every three to five years or 2 occurrences in one billion events.
1	Remote: Risk is unlikely.	One occurrence in greater than five years or less than two occurrences in one billion events.

iii. *Detection rating scale*

Table 5.5

Rating	Description	Definition
10	Absolute Uncertainty	Risk is not detectable and uncontrollable.
9	Very Remote	The risk can be detected only with thorough inspection and this is uncontrollable.
8	Remote	Risk is detected based on no effects in a events.
7	Very Low	The risk can be detected with manual inspection but no effects is in place so that detection is left to chance

6	Low	Risk is 100% manually detected using mistake-proofing techniques.
5	Moderate	Risk is partially detected and partially controlled.
4	Moderately High	Risk is partially detected and it is control conditions.
3	High	There is 100% detection or review of the process but it is not automated
2	Very High	All risk is 100% automatically detected.
1	Almost Certain	The risk is obvious or there is 100% automatic detection with regular calibration and easy to take a preventive action.

VI. Results and Discussions

The various inbound and outbound risks are listed

Table 6.1

Risk	Potential Failure mode	Potential Effects of failure	S	Potential Causes of failure	O	Current Process control	D	RPN (S*O*D)
Outbound Supplier risk	Demand	Forecasting Is more complex, Reduce the Performance of the Supply chain, Lack of production and delivery, Erosion of profits, Creating un balanced resilience in the supply chain	6	Sudden Changes	8	Controllable	7	336
	Security		5	Maritime pirate attack, IT/Internet Security	4	Controllable	4	80
	External legal issues		7	Labor strikes, Legal claims By customer	9	Controllable	4	252
	Market characteristics		6	Market size and growth changes, Loss of contract, low Margin	6	Uncontrollable	10	360
	Political stability		5	Economy down, new Government, Rules/ regulation Changes	7	Uncontrollable	10	350
	Natural/man-made disaster		10	Earth quake, Volcano, Flood, Hurricane, Terrorism	1	Uncontrollable	10	100
	II tier supplier		4	Poor communication	8	Controllable	2	64

VII. Prioritization of the Outbound Supplier Risk

Table 7.1

Outbound supplier risk		
Priority number	Potential failure mode	RPN
1	Market characteristics	360
2	Political stability	350
3	Demand	336
4	External legal issues	252
5	Natural/man-made disaster	100
6	Security	80
7	II tier supplier	64

The highest RPN values in outbound supplier risks are market characteristics, political stability and demand flexuation. But the demand risk is already focused in many literatures and mitigated by using suitable forecasting techniques. So first we mainly focused on political and market characteristic risks.

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Overview of a Knit-Dyeing Factory with Necessary Production Formulas

By Md. Tanjin Amin
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Abstract- Different processes associated with complete production of fabrics are discussed briefly in this paper. An effort is made to formulate all the production steps. This paper also gives an idea of different processes and machineries used usually in a fast growing and mass productive knit-dyeing factory. Major processes in all machines are discussed briefly. Different important parameters in different machines are also stated here. This paper tries to gather all the information related to knit-dyeing factory shortly. A helpful estimation of machine capacity for required production amount can be perceived from this paper. Also the existing efficiency of different processes can easily be calculated from different mathematical formulas stated here.

Keywords: *hanks, knit-dyeing, gsm, mercerization, yarn count.*

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I. Introduction

Bangladesh's first growing economy is the blessing of textile & clothing industries. The economy of Bangladesh was dependent on agriculture solely. But after the introduction of textile sector, the scenario has changed dramatically. The economy of Bangladesh is no longer dependent on agriculture. The agriculture based economy has been shifted to textile based rapidly & massively. Now Bangladesh earns near about 80% of its foreign revenue from this sector. Cheap labor has made it easier to spread textiles based industries. More than 5.7 million of people are working in this sector now. Most of them are women. This sector is helping women to be self-reliant. This short brief on the scenario of textile sector shows how much importance it bears for the economy of Bangladesh. Knit-dyeing factory is the second phase of textile factories. Spinning mills are the first phase and garments are the last phase. But very few of Bangladesh population know about the production procedure in a knit-dyeing factory where fabrics are produced actually. Different production formulas are also unknown to most the persons associated to this sector. So, an effort is made here to make all known about the fabric forming process with mathematical models. It will surely help those who experience the processes; but hardly know the calculative approach.

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II. Knitting

In a fabric processing industry, fabric manufacturing starts with knitting process. Knitting is the process by which yarn turns into fabrics. Knitting is of two types- circular knitting and flat knitting process. Knitted fabrics consist of a series/row of loops, popularly known as stiches. These loops are arranged according to predetermined designed pattern according to the type of fabrics. A new loop is pulled through an existing loop during the progression of series. Active loops are held by the needles of knitting machine. When a new loop comes to the needles, previously active loop is released and the new loop becomes the active loop. This loop forming process goes on and thus fabrics are formed continuously. A sinusoidal wave form is observed in needle movement during fabric formation in circular knitting process. Needles move in circular knitting process while needles remain in fixed position in flat knitting process. Carriages with yarn move in flat knitting process. Yarn may be grey colored or other colored. Grey color is the basic color which comes from spinning mills. But different yarn colors can be achieved by yarn dyeing process. Fiber dyeing is also applied to achieve colored yarn. Single jersey, double jersey/rib and interlock structures are the main three types of circular knitted fabrics. Plane single jersey, lycra single jersey, single lacost, double lacost, honeycomb pique, designed interlock, single jersey fleece, rib, lycra rib, waffle, pin rib etc. are the main derivatives of these three types structure. Flat knitting is done to produce collars and cuffs which are mainly rib or interlock structures. Birdseye, Solid, Tipping, Two Part, Two Part Stripe, Welted etc. are the main derivatives of rib and interlock designs in the flat knitting.

a) Production Calculation Approach in Circular Knitting

No of Needles = (π * Machine Diameter in Inch * Machine Gauge)

Weight of Produced Fabrics = [(No of Needles * Machine RPM * Stitch Length in Meter * No of Feeders * Machine Running Time in Minute * Machine Efficiency * n) / (1.094 * 2.2 * 840 * No of Counts)] kg

n= 1 for Single Jersey Fabrics

n=2 for Rib / Interlock Fabrics

- *Sample Calculation*

Given Data:

Machine Diameter = 26 Inches

Machine Gauge = 24 Needles per Inch

Machine RPM = 26

Stitch Length = 2.65 mm

No of Feeders = 84

No of Counts = 30

Machine Running Time = 8 Hours

Machine Efficiency = 85%

n = 1

No of Needles = (π * 26 * 24)

= 1960

Weight of Produced Fabrics = [(1960 * 26 * 0.00265 * 84 * 480 * 0.85) / (1.094 * 2.2 * 840 * 30*1) Kg = 76.31 Kg

Machine diameter means the diameter of the cylinder used in the machines. Needles are attached in this cylinder. Machine gauge means the number of needles in an inch of cylinder. 840 yards of yarn constitute 1 hank. The number of hanks required to make 1 pound weight of yarn is called the yarn count.

b) Production Calculation Approach in Flat Knitting

Weight of Produced Fabrics = [(No of Needles * Maximum Carriage Speed (m/s) * Stitch Length in Meter * No of Feeders * Machine Running Time in Seconds * Machine Efficiency) / (1.094 * 2* 840 * No of Counts * 2.2 * n)] kg

n = 1 for Single Jersey Fabrics

n = 2 for Rib or Interlock Fabrics

- *Sample Calculation*

Given Data:

Maximum Carriage Speed = 1.2 m/s

Stitch Length = 4.0 mm

No of Feeders = 12

No of Counts = 30

Machine Running Time = 8 Hours

No of Needles = 1120 * 2

Machine Efficiency = 85%

n = 2

Weight of Produced Fabrics = [(1120 * 2 * 1.20 * 0.004 * 12 * 8 * 3600 * 0.85) / (1.094 * 840 * 30 * 2.2 * 2)] kg = 26.04 kg

III. Yarn Dyeing

Yarn dyeing is the process by which colored yarn is obtained. Yarn can be dyed in two processes mainly- hanks dyeing and package dyeing.

a) Hanks Dyeing

Hank dyeing is a simple but time-consuming process. First, the skein of yarn is looped over a hook and washed in water, opening the fibers to receive the dye. It is then dipped into the dye for up to forty-eight hours, washed, and re-dipped. This procedure is repeated several times. Once the desired color is achieved, the yarn is steamed to fix the dye to the fibers. Because it does not use as many chemicals as other forms of dyeing, hank dyeing is less damaging to the material. The final dye colors are also usually richer than those achieved by other dyeing methods.

In hanks dyeing, a batch usually requires 14 hours. So, the capacity of a hanks dyeing machine can be estimated in below formula.

Average Production Capacity = (Batch Loading Capacity * Machine Efficiency * 24 / 14) kg/day.

If a 90% efficient machine has capability of dyeing 245 kg yarn in each batch, average production will be 378 kg/day. However this formula gives idea about average production estimation only. In some cases, nearly 20% more or less production can be got depending on the colors of the yarn.

b) Package Dyeing

Package dyeing usually denotes for dyeing of any type yarn wound on the compressible dye springs/perforated solid dyeing tubes or cones. Yarn dyeing in package form is done at high temperature and under high pressure, with the packages mounted on hollow spindles .These spindles are fixed on the dyeing carriers, which is inserted into the dyeing vessel after closing the lid of the machine, the dyeing liquor is forced through the packages in two way pattern (inside to out and outside to in) and goes on circulating throughout the vessel and yarn. Heat is applied to the dye liquor to achieve the dyeing temperature, time –temperature and flow reversal are controlled automatically. Once full exhaustion is brought about, the carrier of colored yarn is consequently removed from the vessel. Considerable reduction in yarn handling, automatic & accurate dyeing possibilities, reduction in liquor ratio, uniform circulation of liquor, faster dyeing process etc. have given advantage to package dyeing process over hanks dyeing process. Fig. 1 shows package dyeing process.

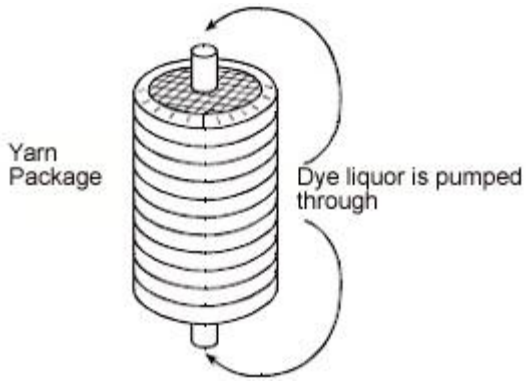

Figure 1 : Package Dyeing Process

In package dyeing, a batch usually requires 10 hours. So, the capacity of a package dyeing machine can be estimated in below formula.

Average Production Capacity = (Batch Loading Capacity * Machine Efficiency * 24 / 10) kg/day.

If an 85% efficient machine has capability of dyeing 500 kg yarn in each batch, average production will be 1020 kg/day. However this formula also gives idea about average production estimation only. In many cases, nearly 10% more or less production has been experienced.

IV. Fabric Dyeing

Fabric dyeing, also known as piece dyeing, is dyeing fabric after it has been constructed. It is economical and the most common method of dyeing solid colored fabrics. The decision regarding color can be made after the fabric has been manufactured. Thus, it is suitable for quick response orders. Dye penetration may not be good in thicker fabrics, so yarn dyeing is sometimes used to dye thick fabrics in solid colors. Various types of dyeing machines are used for piece dyeing. The selection of the equipment is based on factors such as dye and fabric characteristics, cost, and the intended end use.

Most difficult portion of wet processing is to estimate fabric dyeing capacity of a machine per day. This is difficult as different shades require wide range of times to complete dyeing process. For example, white shade requires nearly 4-5 hours whereas navy shade requires 19 hours approximately. Moreover single jersey fabrics can never be loaded in full load batch capacity. If different shades and dyeing operations on different fabrics are done in same machine following empirical relation gives an approximate idea about the capacity of machines per day.

Maximum Fabric Dyeing Capacity = (Maximum Loading Capacity per Batch * Machine Efficiency * 2.5) kg/day.

Some practical observation is compared to this empirical relation in table I considering machine efficiency 90%.

Table 1

Obs. No	Maximum Capacity per Batch (kg)	Maximum Capacity According to Emp. Rel. (kg/day)	Actual Production (kg/day)	Deviation from Emp. Rel.(%)
1	750	1688	1450	14.10
2	500	1125	834	25.86
3	500	1125	2163	92.26
4	250	563	479	14.92
5	60	135	122	9.63
6	360	810	801	1.11
7	1000	2250	1622	27.91

Observation 2 & 3 give some interesting evident. For same batch loading capacity it is seen one machine gives almost 26% less production while another one gives almost double production. In observation 2, machine performed dyeing of different shade on different fabric structures. But in observation 3, machine performed white shade on rib structures mainly. In observation 7, machine did dyeing on rib fabrics of critical shades which caused significant deviation. So, it is clearly understood that dyeing capacity of a machine depends on shade & fabric structure mainly.

V. Mercerizing

Mercerizing is done to both fabrics and threads. Mercerization is a treatment for cotton fabric and thread that gives fabric or yarns a lustrous appearance and strengthens them. The process is applied to cellulosic materials like cotton or hemp. A further possibility is mercerizing during which the fabric is treated with sodium hydroxide solution to cause swelling of the fibers. This results in improved luster, strength and dye affinity. Cotton is mercerized under tension, and all alkali must be washed out before the tension is released or shrinkage will take place. Mercerizing can take place directly on grey cloth, or after bleaching. The factors that affect mercerizing process are-

- Twaddle (Concentration of NaOH)
- Temperature
- Tension
- Time

VI. Singeing

Singeing means burning something. In textile industry, singeing is done to both fabrics and yarn. It is done to make the surface clean & healthy. In yarn singeing, yarn passes through the burner in a very rapid speed and unwanted raised fiber ends are burnt. In fabric singeing, at first fabric surface is brushed slightly to raise the loose fibers. Then fabrics pass through the copper plates or burning flames in such a speed that loose fibers are burnt without damaging the fabrics. After this fabrics enter into a desizer or water bath to prevent any afterglow as a result of singeing.

VII. Reeling, Hanks to Coning, Soft & Hard Winding

Reeling is done to make suitable hanks for hanks dyeing process.

Hanks to coning are done after hanks dyeing process. It is a process by which hanks are winded around required cones.

Soft winding is done before package dyeing. In this process, yarn is rolled against tubular cones in such a way that liquor can pass through the packages uniformly.

Hard winding is done after package dyeing. In this process, yarn is rolled against tubular cones very tightly.

Yarn weight can be related using following formula.

Winding Rate of Yarn = [Winding Speed in m/min. * 60 * No of Cones * No of Plies / (No of Count * 1.094 * 840*2.2)] Kg/hr

- *Sample Calculation*

Given Data:

Winding Speed = 600 m/min

No of Cones = 230

No of Counts = 30/2

Winding Rate of Yarn = [600 * 60 * 230*2 / (30 * 1.094 * 840 * 2.2)] kg/hr = 273 kg/hr

Yarn singeing production process can be calculated using above procedure also.

VIII. Slitting

Slitting is a process that is applied for cutting the tubular fabric through the intended break Wales line on lengthwise direction prior to stenter processing. During slitting, it is required to be aware about the cutting line otherwise, fabric faults can be occurred there. Slitter machine is used for tubular knit fabric to make it in open form. In open form fabric finishing line; slitter machine is used after hydro-extractor, de-watering and drying machine. So, the main objectives of slitting are-

- To open tube fabric according to specific needle mark.
- To prepare the fabric for next stentering process.

IX. Drying

Drying is done after de-watering of fabric. In textile finishing unit, dryer uses for dry the knit, woven fabrics and dyed yarn. But the drying process and drying mechanism of yarn and fabrics is different from one to another. The main functions of a textile dryer is to dry the textile fabrics. Drying is defined as a process where the liquid portion of the solution is evaporated from the fabric.

X. Stentering

Stenter is used for open form fabrics. Cotton fabric shrinks widthwise and weft distorted due to bleaching and dyeing process. The main functions of the stenter are-

- Heat setting is done by the stenter for lycra fabric, synthetic and blended fabric.
- Width of the fabric is controlled by the stenter.
- Finishing chemical apply on fabric by the stenter.
- Loop of the knit fabric is controlled.
- Moisture of the fabric is controlled by the stenter.
- Spirility controlled by the stenter.
- GSM of the fabric is controlled by stenter.
- Fabric is dried by the stentering process.
- Shrinkage property of the fabric is controlled.
- Curing treatment for resin, water repellent fabric is done by the stenter.

Amount of stentered fabrics can be calculated using the following formula.

Stentering rate = (Average Width of Fabric in meter * Average GSM of Fabric in kg per sq. meter * Fabric Finishing Speed in meter per minute * 60) kg/hr

a) Sample Calculation

Given,

Before Width of Fabric = 143 cm

After Width of Fabric = 155 cm

Average Width of Fabric = 149 cm = 1.49 m

Before GSM of Fabric = 194 gm/m2

After GSM of Fabric = 184 gm/m2

Average GSM of Fabric = 189 gm/m2 = 0.189 kg/m2

Fabric Finishing Speed = 20 m/min

Production rate = (1.49 * 0.189 * 20 * 60) kg/hr

= 337.932 kg/hr

XI. Compacting

Compactor is a textile finishing machine which is designed especially for compacting 100% cotton knitted fabric like jersey, pique, interlock, plush, rib and sinker etc. as well as cotton blended fabric in rope form, changing the loft and dimensional stability of the fabric and presenting it to plaited form. By the compactor machine, compacting is done for control the shrinkage of the fabric. Fitted with two felt/rubber/metal compacting units, make it easier to obtain top quality fabrics with minimized shrinking nature and a soft fluffy hand. Compactor machines are of two types-

- Tubular compactor
- Open compactor

Main functions of compactors are-

- GSM control of the knitted fabric. For high GSM, overfeed is increased and fabric width is decreased. For low GSM, overfeed is decreased and fabric width is increased.
- Control shrinkage
- Twisting control
- Increase smoothness of fabric.
- Heat setting is done of fabric etc.
- Fabric width is controlled by the compactor.

The main processes in compacting process are-

- The fabric is fed through the guiding system and stretcher which then takes the fabric through the steam box onto the felt of the twin compacting units.
- Width control through a stepless, adjustable fabric spreader driven by variable speed motor for distortion-free fabric guidance.
- Over feed roller controls overfeed.
- Brush pinning arrangement for controlling pinning.
- Steaming with a condensate-free steam box which is easily operated and completely made from stainless steel. The Steaming Device has sliding shutters that allow steam to flow only as per the width of the fabric.
- Compacting through two Nomex felt belts.
- Calendaring while passing between the felt belt and the heated shrinking rollers.
- At the fabric delivery, the machine is equipped with a precision plaiting device with its platform. The height of the platform is controlled automatically and is adjustable according to the plaited fabric height.

Amount of compacted fabrics can be calculated using the same formula that is used to calculate stentered fabrics amount.

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An Approach to Manage and Evaluate Engineering Asset Performance

By Mohammed Saif AL Saidi & John P. T Mo
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Abstract- Modern engineering assets are complex and very high in value. They are expected to function for years to come, with ability to handle the change in technology and ageing modification. The aging of an engineering asset and continues increase of vendors and contractors numbers forces the asset operation management (or Owner) to design an asset management system which can capture these changes. Furthermore, an accurate performance measurement and risk evaluation processes are highly needed. Therefore, this paper propose an asset management system performance evaluation for an engineering asset based on the System Support Engineering (SSE) principles. The research work explores the asset management system from a range of perspectives, interviewing managers from across an industrial organization. The factors contributing to complexity of an asset management system are described in context which clusters them into several key areas. It is proposed that SSE framework may then be used as a tool for analysis and management of asset with given an industrial example. The paper will conclude with discussion of potential application of theframework and opportunities for future research.

Keywords: *engineering asset management, performance, evaluation.*

GJRE-G Classification : *FOR Code: 091599, 090505*

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An Approach to Manage and Evaluate Engineering Asset Performance

Mohammed Saif AL Saidi [α] & John P. T Mo [σ]

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I. Introduction

Classical techniques in asset management involve performance monitoring, process control and fault diagnosis techniques that aim to determine the limit of the asset's service life. Theoretically, replacement should be made at the time when a component of an asset is about to fail so that the full service value of the asset can be utilized. However, this is not possible as modern assets are increasing in complexity and sophistication. Moreover, many additional factors are always governing the management of the asset.

Modern engineering assets are complex and very high in value. They are expected to serve for years to come with ability to handle the change in technology and customers' demands. Literatures are showing that the consideration for the sustainment of an asset should be engaged at the very early stages of asset management system development. Asset stakeholders are demanding more value out of their asset by ensuring sustainability in operation. These include availability, readiness, extended operation and other value schemes. Literatures show that asset management industry is proposing a holistic asset management system approach (Herder & Wijnia, 2012; W. Lee, Moh, & Choi, 2012). However, the challenge is how to holistically evaluate the performance of the asset management, whether if it is in-house management or contracted management.

As the asset stakeholders intend (in some cases have) to outsource the support and asset management activities, the service provider will take significant part of the risk of sustaining capabilities of the asset for the duration of the service (Bustinza, Arias-Aranda, & Gutierrez-Gutierrez, 2010; Cai, Ci, & Zou, 2011; Feng, Fan, & Li, 2011; GÖRg & Hanley, 2011; H.-H. Lee, Pinker, & Shumsky, 2012; Li, Wang, & Adams, 2009; Lin & Ma, 2012).

In other words, the performance of the asset will relay or directly affected by service and support provider(s). It is to the interest of the asset owners and asset manager that the asset does perform as they wish. Hence, the relationship between the asset management stakeholders should be clearly drawn and understood in regard to the implication and the nature of performing together to get the most out of the system.

Asset performance measurements depend on good data that is analyzed with sound methods (Pecht, 2012) and be translated into information and knowledge allowing decisions to take place. Industry often complain of information overload and difficult to allocate. Asset managers complain that they do not have all the relevant information to make sound and well-informed decisions. To identify what parameters to measure, it is needed to first understand what to change to improve performance and subsequently, identify what are the measuring parameters. This paper is proposing a methodology to evaluate and calculate the performance of an engineering asset management system. This methodology was built on the principles of the system support engineering.

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II. In Hand Research Literature

Researches on methodologies of providing services with a manufactured products has started on the early eighties of the last century (Baines, Lightfoot, Benedettini, & Kay, 2009). Usually figures shows that 70-80% of the western economic activity is built on service (Wild, 2010). This economic figures stimulated researchers to innovate service systems. As a start, the basic principal of designing a compatible service system is a holistic view of the service where the customer's experience, technical and operational aspects of the product (Pang, 2009; Pombinho & Tribolet, 2012) is taking into account. One of the resent strategies in this regard is the servitization of a product. The main feature of servitization that it is bringing the focus of service system to a strong buyer centricity and resulted aim to generate value from both product and services in bundled packages (Ng, Parry, McFarlane, & Tasker, 2010). The combination of marketable product and service where can both satisfy the need of customer called product- service system (PSS) (Mont, 2002) and it can be provided either by single company or by an alliance of companies. There are over 100 existing articles about PSS in general (Sakao, Ölundh Sandström, & Matzen, 2009). In general, the literatures agreed that the focus of the PSS is to design market well-matched service for itemized product. Keeping in mind that the servitization developments were shifted form product oriented service to user process oriented and the nature of the customer interaction was shifted form transaction-based to relationship-based. These changes introduced new challenges for PSS functional design. Even with the PSS systemic approach, it has given diminutive depth consideration of elements of a service system or how the elements might interact. The foundation of Unified Services Theory (UST) has been drew as "With service processes, the customer provides significant inputs into the production process" (Sampson, 2010). The unified services theory delineates service processes from non-service processes (Dandan & Rongqiu, 2010). The UST is a distinctive process but it will introduce issues (i.e. structures, behavior, effectiveness, environment... etc.) and challenges on the service design process as the customers are vary around the world and they are operating in dissimilar environments for unrelated purposes. Literatures agreed in general that performance based contracting is a defined mechanism of rewarding values based on the measured outcomes which are scored and rated according to an agreement between two parties(Eldridge & Palmer, 2009; Hypko, Tilebein, & Gleich, 2010a, 2010b; Sultana, Rahman, & Sanaul Chowdhury, 2013). The concept of PBC is really unique and provides benefits to both parties of the contract. However, it did not give in depth details of systemic evaluation of the elements which constricting the performance body as it concentrated more on the contracting mechanisms understanding.

Performance measurement practices have undergone many innovations (Davila, 2012). Literatures shows that lots of these innovations have changed the relationships between organization and its employees, customers, suppliers and other stakeholders all to ward systemic approach.

System performance measurement did see a lot of these changes (Tonchia & Quagini, 2010b). Performance system requires specific measurements techniques using accurate performance indicators from the Performance Measurement System (Tonchia & Quagini, 2010a). Measuring performance has different perspectives include but not limited to accounting, marketing and operations. Finding performance is even being a new discipline in management (Neely, 2002). There are models for measuring performances. However, models developed in the last 20 years are more horizontal and process-oriented (Biazzo & Garengo, 2012).

This will lead to the following research question "Can industrial practitioners have a generic architecture to simplify the evaluation and sustainable evaluation of engineering asset performance?" If yes; how does it look like? This architecture can aligned all elements in unified performance scoring process. Which have the ability indicate the rule of element with indication of collaborative performance. So it will make it easier for the practitioners to score and to troubleshoot the performance. In addition have the ability to forecast the performance aptitude.

III. System Support Engineering (SSE)

Decisions such as asset replacement, upgrade or system overhaul are in many respects equivalent to a major investment, which is risk sensitive. Therefore, solution centered proposition is needed. This proposition is form of system support engineering (SSE) (Mo, 2009). Figure 1 maps-out the nature of system support engineering in the development process of an asset.

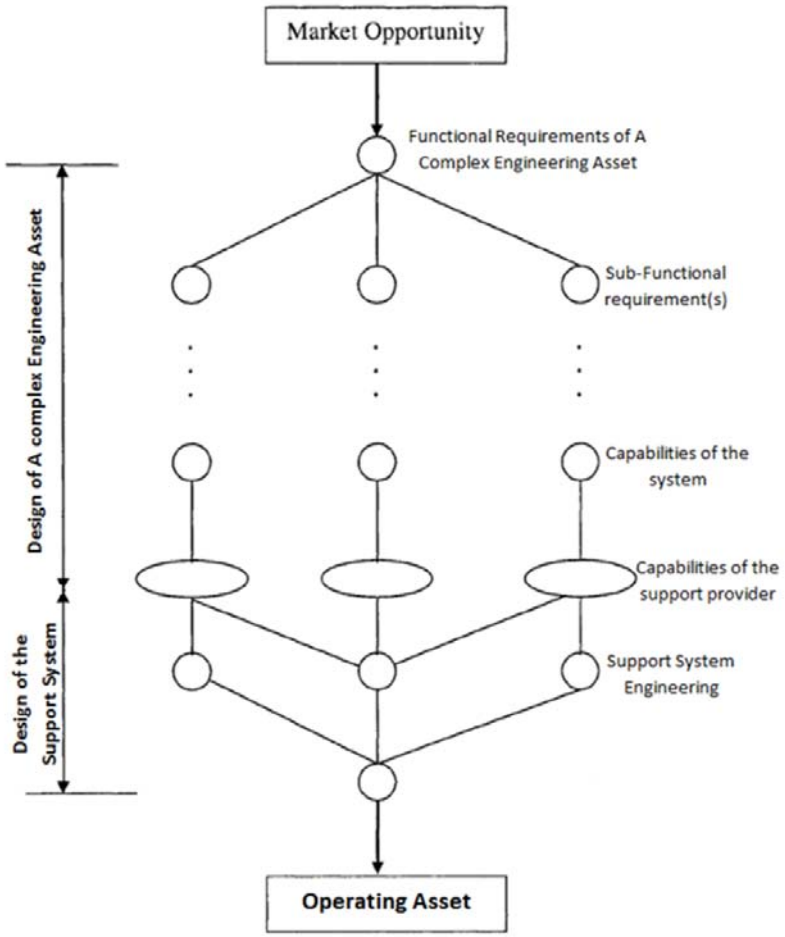


Figure 1 : An Overview of SSE Approach of Designing Support System

SSE concept involves the integration of service and system engineering to design support solutions. It incorporates a core knowledge base, drawing upon principles derived from a wide range of business and engineering disciplines. SSE is "solution centered", delivering output solutions which are a mix of service and product. Service is a dynamic and complex activity. In all services, irrespective of industry sectors or types of customers, services are co-produced with and truly involving consumers. In support solutions, service engineering and system engineering are used together as critical knowledge agents to guide the solution design. Service engineering emphasizes customization of solution designs to meet service needs, while system engineering emphasizes technical performance of the solution. "Service and Support" is a strategic business model. The customer/supplier relationship is different from those of transactional service offerings where interactions are limited mainly to episodic experiences. In this model, the interactions with the customer are enduring, like the systems they support, and a support solution seeks to cement a constructive long term customer relationship. To simplify these process a generic architecture of SSE was drawn by employing a empirical research (ALSaidi & Mo, 2013).

SSE framework is consists of 3 elements (People, Process and Product) in an operation environment. Also, it contains three levels structure (Execution, Management and Enterprise). The SSE framework model called 3PE model as shown in figure 2. This model was verified through multiple industrial visits and professionals contribution during data collection process. The SSE framework was able to outline the relation between the elements of system support. However, the details interaction is still yet to be investigated further. The investigation aims to explore the nature of these interactions and how they get affected by the environment. Nevertheless, the environment concepts themselves need to be clearly defined. In order to do so, the performance concepts of the SSE need to be demarcated in understandable relationship which is the target of this paper.

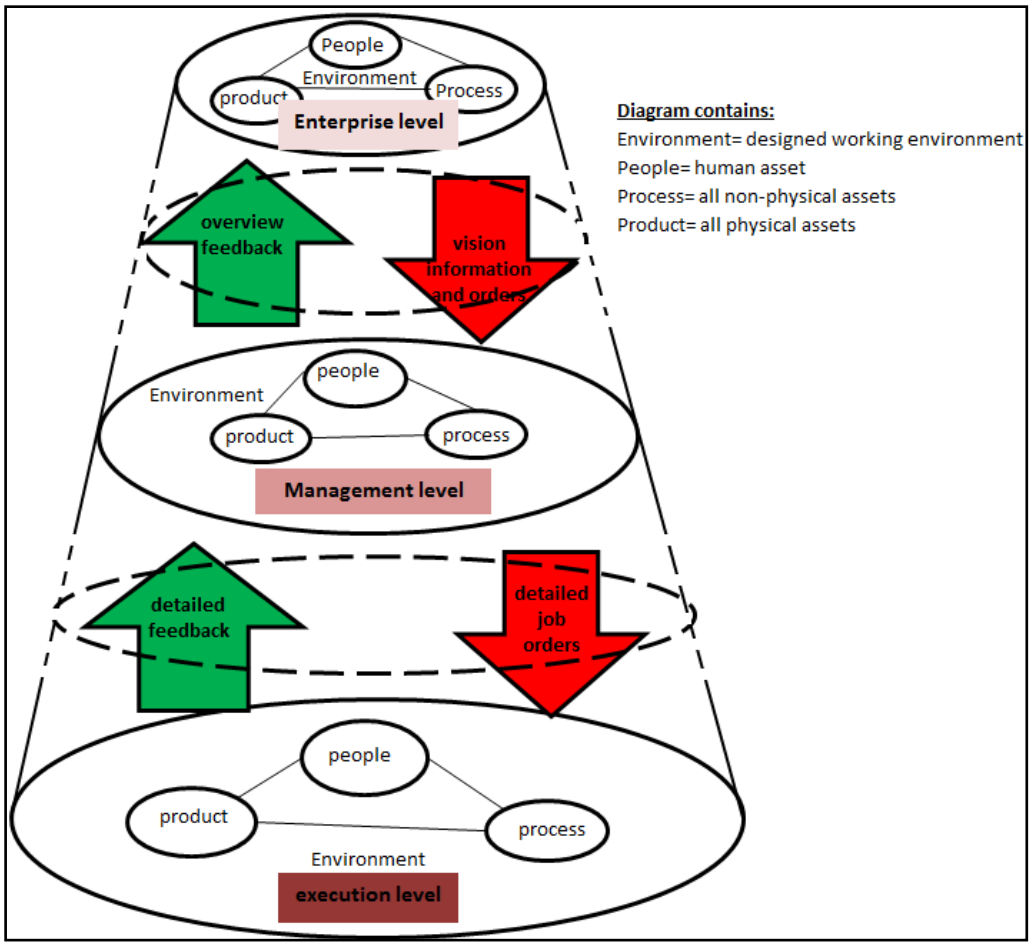


Figure 2 : General Vision of system support engineering generic architecture (multi-levels 3PE)

3PE model is used to structure and calculate performance, as the whole idea of the support system engineering is to sustain the performance of the operating asset. The main challenge at the start is to select a methodology to build and present the structure performance calculation. Talking to a range of professionals in the field, nearly all of them recommended a hierarchy build up format. They did not know the details but they thought it is the best if it can be achieved and easier for them to use and understand. Moreover, the input could be straightforwardly distributed to multi management levels. In addition, literatures overview showed that the advantage of build-up methodology is reducing the amount of error or the error contribution to the final score in calculation. Therefore, the structure of performance calculation was drawn as hierarchy structure so it will be easier to follow and include additions.

IV. Performance Scoring Structure

Many approaches have been published in regard to technology management (Drejer, 1997; Liao, 2005; R. Phaal, Paterson, & Probert, 1998; Robert Phaal, Farrukh, & Probert, 2006), carrying a lot of suggestions for management approach and structure with raising challenges and opportunities new product, service, process and organizational development (Cetindamar, Phaal, & Probert, 2009). Additionally, they provide an academic evaluation of the management tools (Brady et al., 1997; Maine, Probert, & Ashby, 2005). There are many performance metrics and assessment methods, techniques and packages are available (Harris, Boudreau, & Macgregor, 1996; Harris, Seppala, & Desborough, 1999; Jelali, 2006; Joe Qin, 1998; Julien, Foley, & Cluett, 2004). Though, effective multivariable identification methods need to be further developed. Literature shows that, the advantage of hierarchical build-up structure methodology is easier to handover information and knowledge (Csaszar, 2012; Mihm, Loch, Wilkinson, & Huberman, 2010; Mullins & Schoar, 2013; Ogiela & Ogiela, 2014; Spencer, Buhalis, & Moital, 2012; Walczak, 2005; Wang, Ma, Lao, & Wang, 2014; Wright & Pandey, 2010; Yuan & Hipel, 2012) with improving the ability to examine problems (Kang, 2006; Tseng, Lin, Lin, Chen, & Tan, 2014). Subsequently, it is reducing the amount of error or the error contribution to the final score in calculation. Still no sign of using hierarchical build-up structure methodology as performance scoring

and evaluation structure. Therefore, the structure of performance calculation was proposed and drawn as hierarchy structure so it will be easier to follow and include additions. Moreover, it is more popular structure with most professional practitioners in the industries which were visited and reviewed by the authors. The challenge was to formulate an equation to accommodate the elements in a simple format, keeping in mind the interaction and interface between the elements evaluated in the 3PE. Moreover, this formula should be generalized to all support systems which is a huge difficulty by itself. After long surveying and reviewing performance measurement systems available in the literature, equation [1] was proposed to be tested and verified. The proposition is not finalized yet but it provides a good start point.

$$P = \alpha X + \beta Y + \gamma Z \quad (1)$$

There is a need to develop performance scoring and calculation generic structure. After an industry based investigation, it has been suggested a build-up methodology for performance calculation as shown in figure 3.

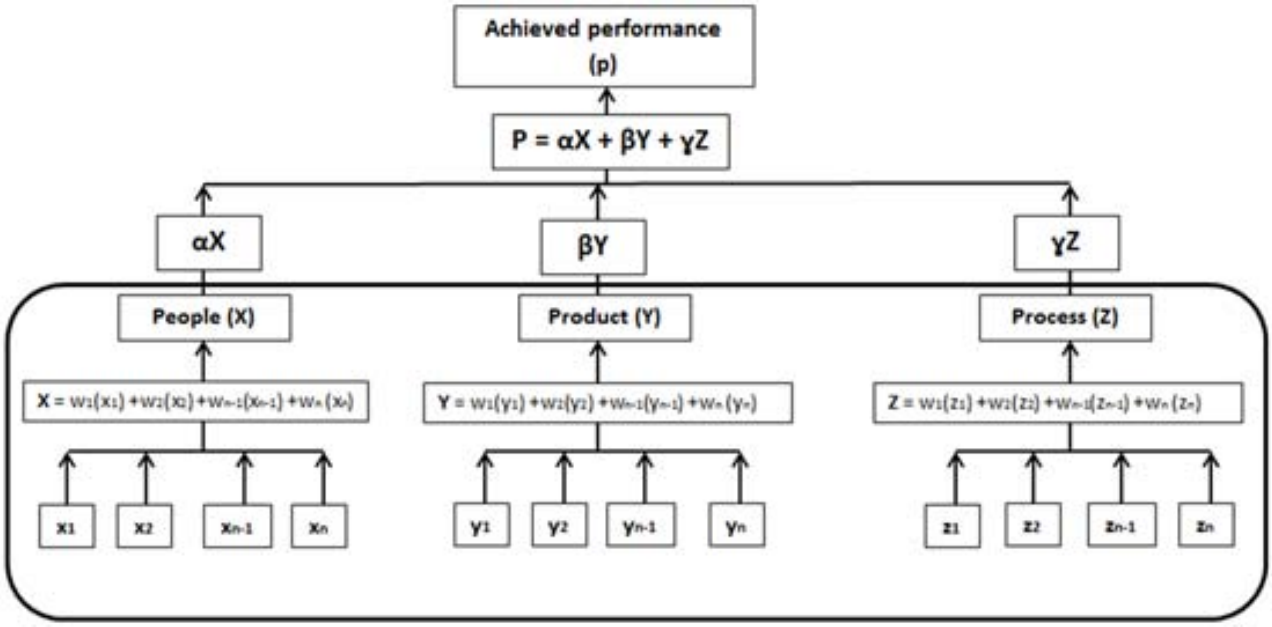
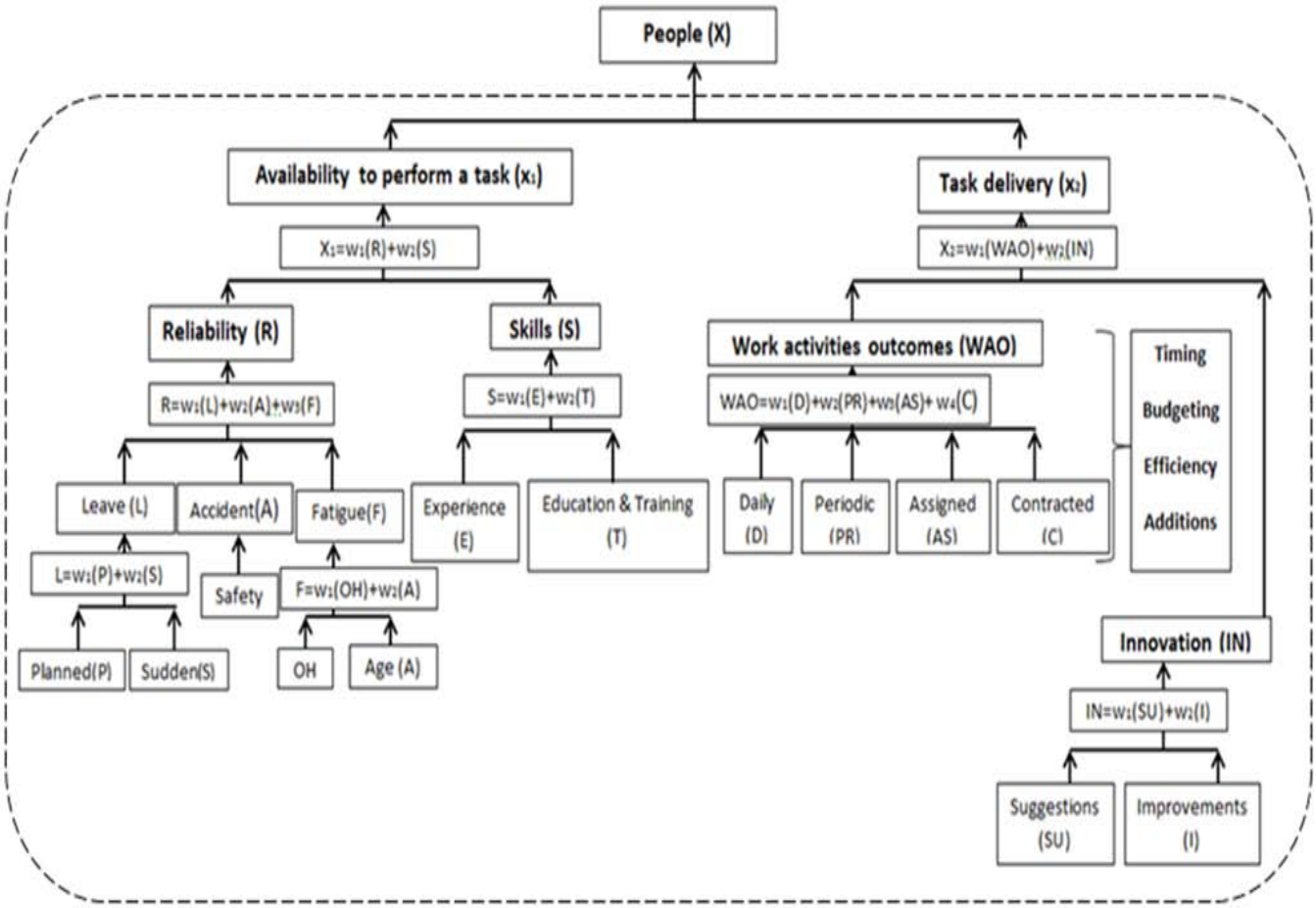


Figure 3 : An overview of SSE approach of designing support system

Where:

- P is the Combined Achieved performance by People (X), Process (Y) and Product (Z).
- α, β and γ are the weights or the factors and in some cases is the value of the element in the system which extracted from the interface and interaction evaluation.
- $1 = \alpha + \beta + \gamma$
- X, Y and Z are the performance scored based on the KPI's calculated.
- x_n, y_n and z_n are the KPI score for that element.
- w_n is the contrition weight of that element or the KPI score.
- 1 = w1 + w2 + wn-1 +wn
- E is the environment where all this elements are performing. Environment will have an effect or an impact on the performance of these elements. The environment factor could be included in KPI score marking.

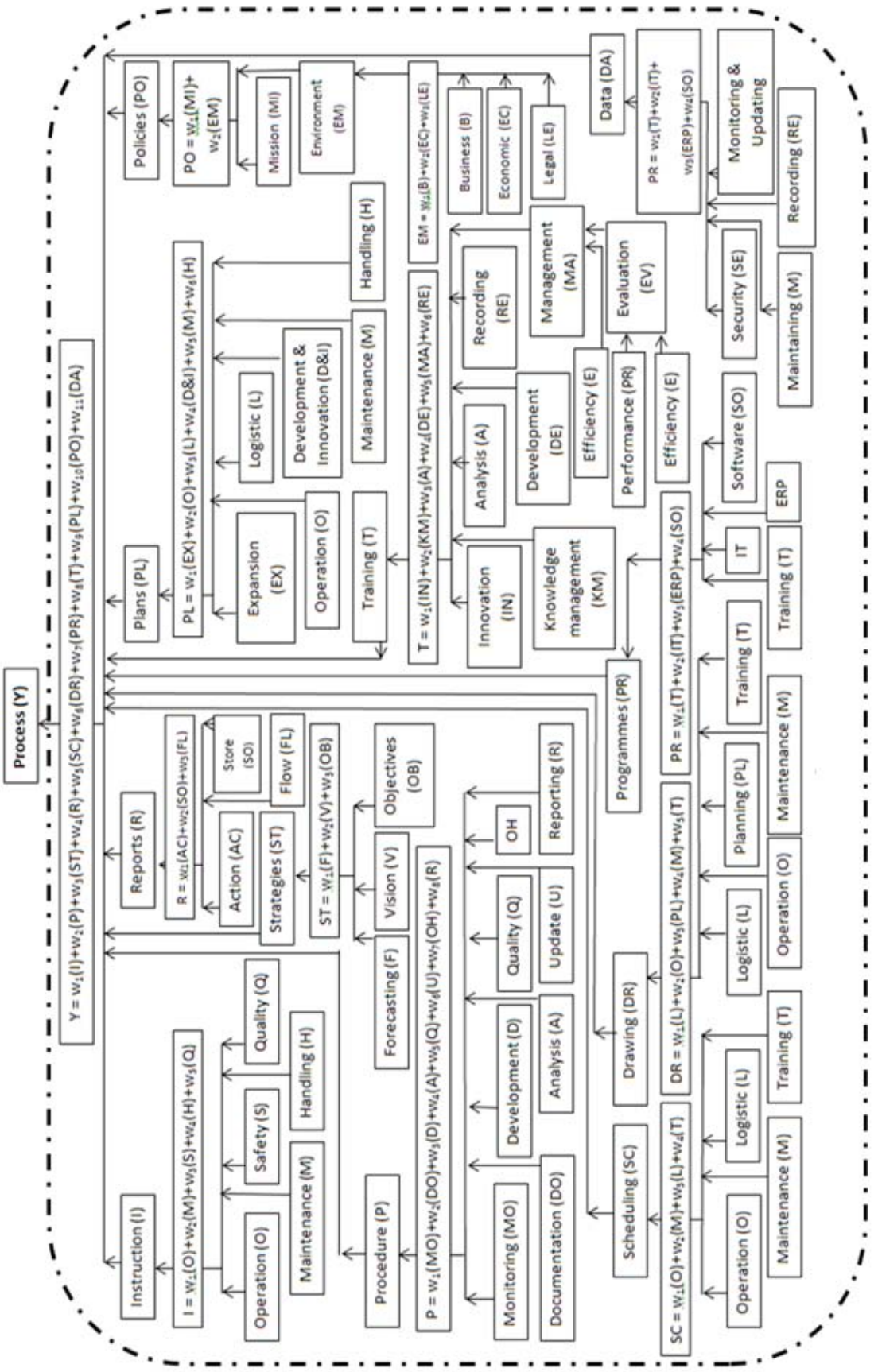
The generic detailed elements in order to calculate the factor "People (X)" is presented in the figure 4.



Where "w_n" is evaluated and distributed in each level separately from other levels but cumulative distribution weight for the calculated element or the interface effect between two elements, as $1 = w_1 + w_2 + w_{n-1} + w_n$

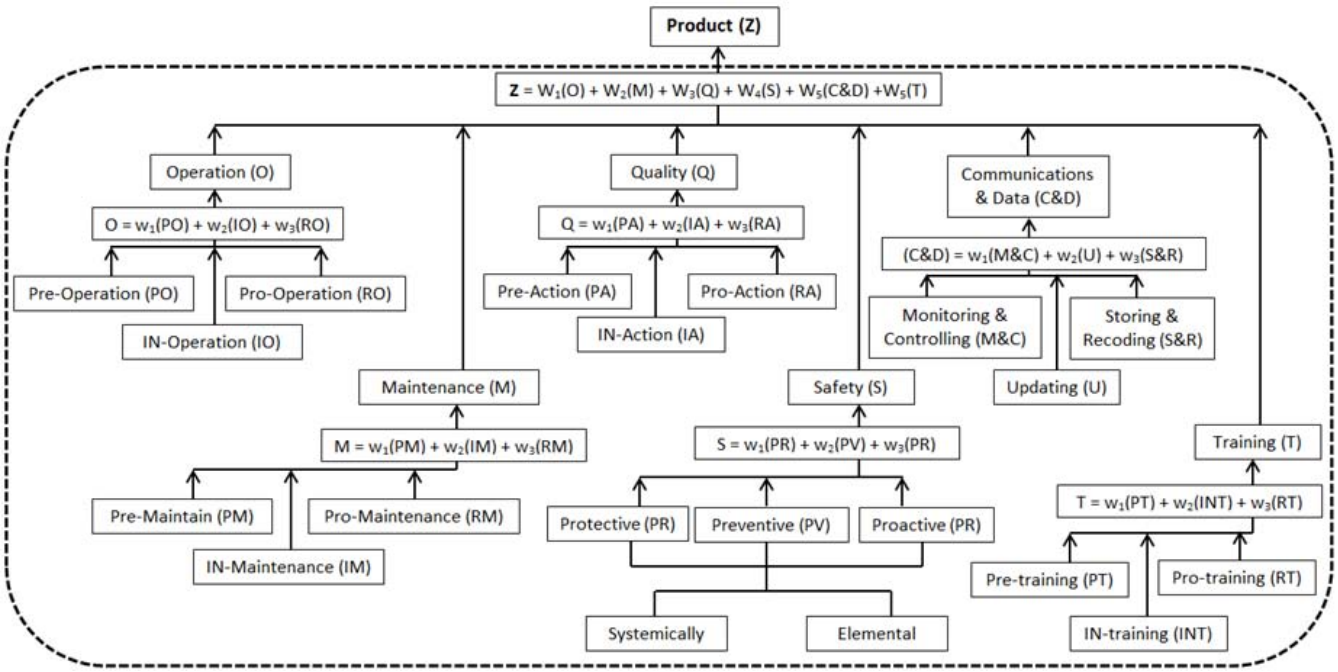
Figure 4 : Performance scoring and calculation outlines for people ("X" factor)

The generic detailed elements in order to calculate the factor "Process (Y)" is presented in the figure 5.



Where "w_n" is evaluated and distributed in each level separately from other levels but cumulative distribution weight for the calculated element or the interface effect between two elements, as $1 = w_1 + w_2 + w_{n-1} + w_n$ Same-wise, the generic detailed elements in order to calculate the factor "Product (Z)" is presented in the figure 6.

Figure 5 : Performance scoring and calculation outlines for process ("Y" factor)



These structures of performance calculation gave the ability to estimate the risks could be associated with each element and the service provided to it. This risk could be identified based on the work environment analysis. Therefore, the first step in the risk identification is to define the work or operation environment and in some cases even the business environment. This analysis is guided by the risk analysis process in SSE model.

Figure 6 : Performance scoring and calculation outlines for product ("Z" factor)

V. Industrial Example

Receiving feedback information about the actual world, and using the fresh information, is essential to review our understanding of the current industrial practice. Learning process always required particular level and depth of understanding of the system. Literature shows that several steps should be taking in order to realize certain depth of understanding (Correa & Keating, 2003). Moreover, Literature shows that because of its unique strengths, case study research is often used for developing new theories. The external validity of multiple cases is not problematical issue or core requirement (Robert K. Yin, 2012) but it will strengthen the validation of the approach. The targeted benefits of industrial example are:

- An extension of the development technique of exiting engineering asset management in the industry by more explicitly treating their sustainability with the performance sustainability.
- Validation of the sufficiency of measurement tools for establishing roles and responsibilities for performance.
- Documentation of the realities of the world of professional practice regarding large and complex engineering systems.
- Determination of the validity of the assumption employed by current systems engineering and performance standards.
- Guidance based on established practices on how to consolidate the engineering asset functions responsible for supporting the performance. All in parallel of our expansion of understanding the roles and responsibilities of the performance charged with overseeing and ensuring the success of support system engineering and integration at the system level.
- Introduce recommendation of further studies and activities.

It has been indicated that the most commonly popular data collection methods are: interviews, questioner and observation (Stanton, Salmon, Walker, Baber, & Jenkins, 2012) depending on the case or the reason for data collection. There are fruitful examples published in the literature on combining more than one method to accomplish better results on data collection (Borrego, Douglas, & Amelink, 2009; Lan & Ramesh, 2008; Runeson & Höst, 2009; Robert K Yin, 2011). To sum up, collecting conscious-based data through self-reporting is not good enough to succeed high accuracy information. Therefore, an interpolation from people involved in the studied system to describe their professional understanding and thinking is included. The targeted information in regard to:

- Classification.
- Authorisation.
- Study, design and planning.

- Implementation planning, management and execution.
- Inspection and evaluation.
- Referencing

Firstly, the critical feedback roots were highlighted and rated in order to capture and evaluate important results. Literature suggested that it could be useful if the research could order them based on the importance which could be difficult in these cases. Instead the number and size of inputs and outputs of each root was considered to be the importance indicator. The second strategy is to analyze outcomes of the complexity. Using cause map as a step toward system dynamic modeling (Woodside, 2010). Such Couse maps will highlights the responds communication roots of real-life complex practice in the studied systems. The data were collected from automotive parts manufacturer. There is variety of processes which manufactures wide range of parts build legitimately complex manufacturing system which need to be supported by reliable and effective asset management system.

With keeping the focus on the engineering asset management, the industrial example:

- ❖ Provides Logical connections among the observed events,
- ❖ Relying on knowledge of how systems preforms.
- ❖ The relation of the Organizations and individuals work.

The Data gathering process was lengthy process due to the complexity of the system. Figure 7 shows layout of the data gathering and structuring process.

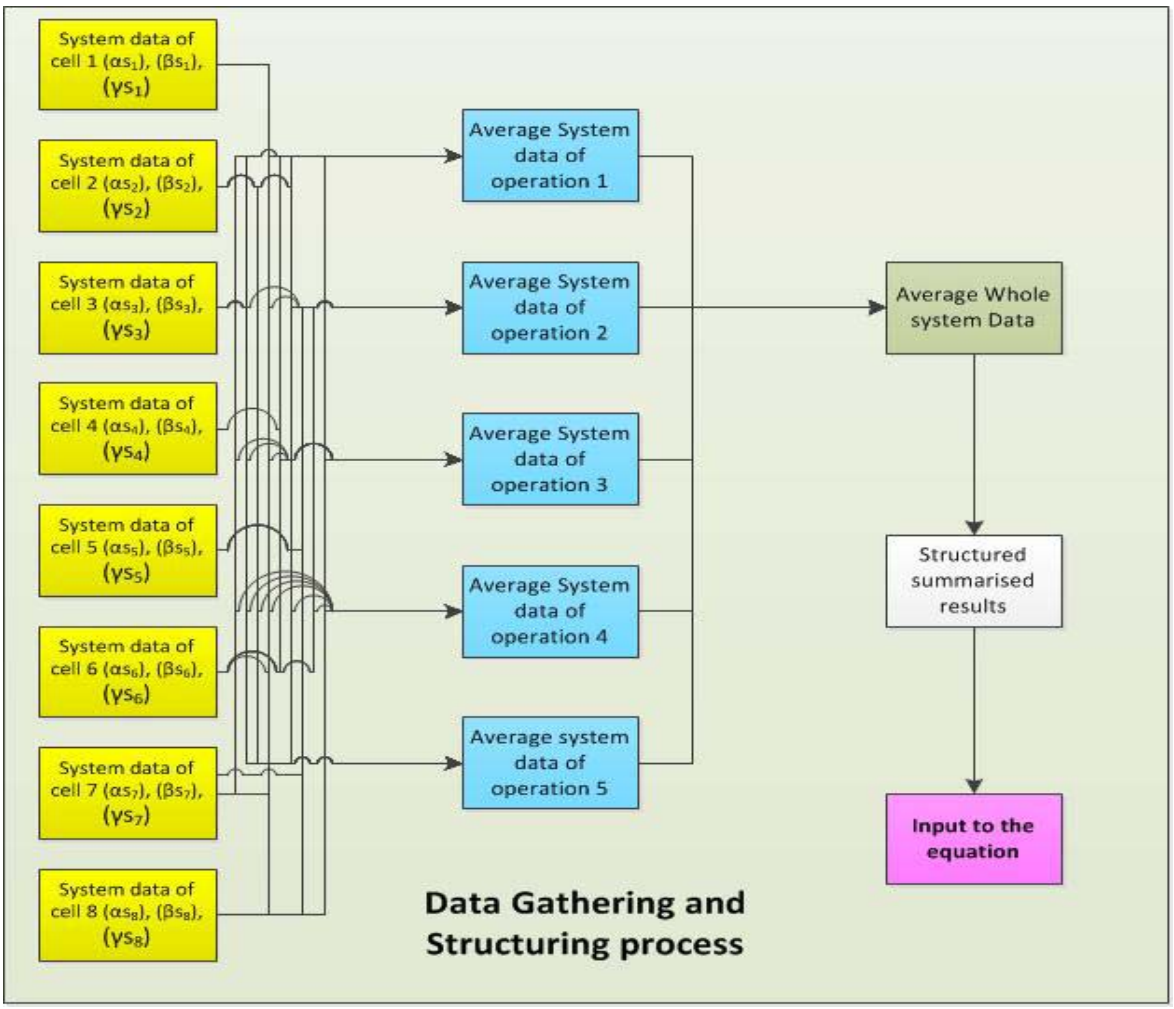


Figure 7 : Data gathering and structuring process

For confidentiality reasons the manufacturing cell was given a number. Then the series of manufacturing cells performing a task called operation and each operation was given a number as well. The data were gathered to indicate how much is the contribution shear of each element of the support

system. Also, it needs to indicate the overall performance value and how much really each element is affecting this score. The data then will be used as a verification inputs in the established equatione.

In the case studied factory, manufacturing cells are performing together forming the operation and operations are performing together forming the production system to give final product which is delivered to a customer. Delivery is considered to be part of the production system in this case. Performance is valued based on established delivery categories. Data of manufacturing cells which are performing an operation is gathered and averaged out to give the system in formation of that operation. Then the total operations are gathered up to give the data information for the whole system.

Average System values of an operation are calculated by inserting the data into the following equations:

- $\alpha O_n = [\sum_k^1(\alpha s_n)] / k$
- $\beta O_n = [\sum_k^1(\beta s_n)] / k$
- $\gamma O_n = [\sum_k^1(\gamma s_n)] / k$

Where "k" is the number cells contributing to that operation

Average Whole system values are calculated by inserting the data into the following equations:

- $\alpha M = [\sum_R^1(\alpha O_n)] / R$
- $\beta M = [\sum_R^1(\beta O_n)] / R$
- $\gamma M = [\sum_R^1(\gamma O_n)] / R$

Where "R" is the number cells contributing to that to whole manufacturing system "M"

Literature says that usability of process models is powerfully associated with its simplicity of understanding (Mendling, Reijers, & van der Aalst, 2010). The framework provided three increasingly detailed views or levels of abstraction from three different perspectives. It allows professionals to look at the same system from different perspectives. This creates a holistic view of engineering asset management. The framework in this regards helped to:

- Guide to set requirements identification procedure for the development process of an operational engineering asset management system in the factory.
- Provide an overview of the behavior vector of an engineering asset management system development process and clearly drawn relations between elements.
- Capture the strategic decisions, inventions and engineering trade-offs.
- Give an appreciation of Technical and commercial issues those are linkable from the maintenance and operation point of view.

Some of the concept implementation results are shown in the examples:

a) Outlining the some of the resulted processes

A standard development procedure was proposed as shown in figure 8. This process schematic is completed by applying the philosophies of the SSE and detailed discussion with the professionals' in the factory.

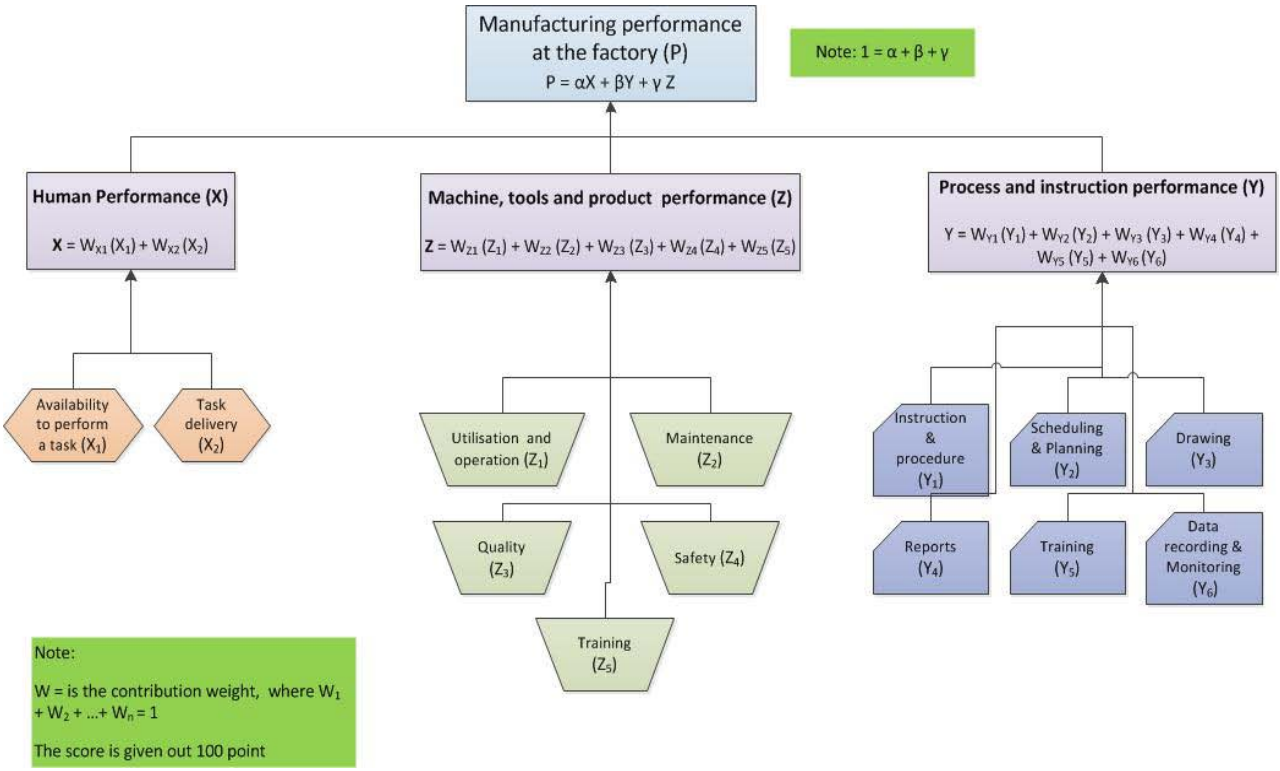


Figure 8 : Example of the proposed a standard performance measurement process to be implemented in the factory

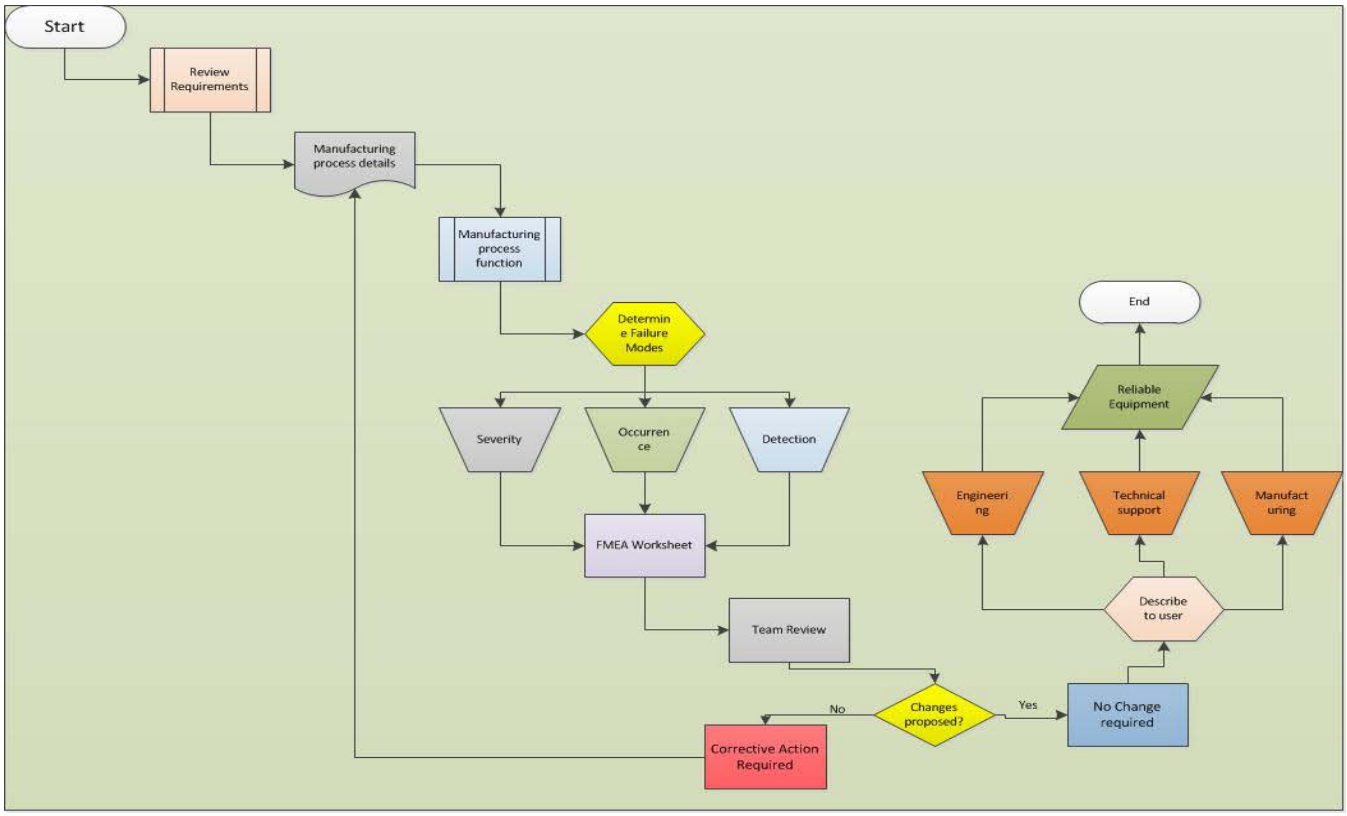


Figure 9 : Example of an improved analytical process to be implemented in the factory

VI. Conclusion

The paper presented an approach to evaluate the performance of an asset management system. This paper briefly discussed the attempt to induct a structure to evaluate the performance of an asset management system. Based on the SSE framework, this paper provides a detail approach to estimate the performance. The research suggested that this could be a useful tool or techniques that practitioners in the industry can apply to help them in service design for operating assets in order to maintain optimized performance. The difference in developing this technique is that it has been inducted from the industry and Allow for interpolation from professionals in the system to describe their practical understanding and thinking. Therefore, it becomes easier to be implemented or used by the practitioners and this could be the main advantage from the preceding research work in this area. The findings suggested that further investigation need to be carried out. The aim of this investigation is to detail the effect(s) of operation environment on the 3P elements in regard to their performance in asset management system. Never the less, the effects of the interface and/or interaction between the 3P elements should be taking into account in this investigation as well.

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A Solution for the Scheduling Problem in a Multi-Plant and Multi-Product Environment

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Abstract- Scheduling is an important tool for manufacturing and engineering, where it can have a major impact on the productivity of a process. In this paper, we use flow shop scheduling in KCCL (Kohinoor Chemical Company Limited) & find out the optimum policy in scheduling operating several machines to produce soap & to reduce idle time of machines. Considering different type of machine that also absorbs different production time. The industry tries to identify their idle time & best presidential relationship between the machines. We use Johnson's scheduling algorithm & a numerical output is achieved.

Keywords: johnson's algorithm, scheduling of chemical industry.

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A Solution for the Scheduling Problem in a Multi-Plant and Multi-Product Environment

Nahid Newaj

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I. Introduction

Production scheduling tools greatly outperform older manual scheduling methods. These provide the production scheduler with powerful graphical interfaces which can be used to visually optimize real-time workloads in various stages of production, and pattern recognition allows the software to automatically create scheduling opportunities which might not be apparent without this view into the data.

In manufacturing, the purpose of scheduling is to minimize the production time and costs, by telling a production facility when to make, with which staff, and on which equipment. Production scheduling aims to maximize the efficiency of the operation and reduce costs.

The Chemicals & Cosmetics Industry is quite large and important sector in Bangladesh in terms of output, export and employment. In the chemical industry, a successful manufacturer must make efficient use of limited resources to meet dynamic customer demand as customer preference change on a seasonal or monthly basis. For this prospect, an ordinary production schedule is not enough. So, we need an advanced scheduling technique.

a) Literature Review

The literature review, focusing entirely on one particular aspect of scheduling theory which is recognized & the review article which are published. in the sector of aspect. For example the literature as hybrid flow shops (Gupta, 1988).Whereas our interest is in the identical job and uniform parallel machine environment, the literature on hybrid flow shops has focused on non-identical jobs and identical parallel machines. The problem of scheduling non-identical jobs on identical parallel machines to minimize the make span is NP-hard even for a single-stage (Garey and Johnson, 1979). For an excellent review of the single stage problem the reader is referred to a paper by Cheng and Sin (1990). With more than a single-stage, the research has focused on developing heuristics (see e.g., Guinet and Solomon, 1996; Gupta Tune, 1994; Lee and Vairaktarakis, 1994; Gupta, 1988). Lawler et al. (1982) show that the I-stage problem to minimize the make span with identical jobs & uniform parallel machines may be solved in polynomial time.

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II. Problem Description

Existing Schedule: In this company the authorities follow any sequence as they like. The two plant named as Frymaco & Jansen which are evolved with the production of multiple product i.e. toothpaste, shaving cream, shaving cream cool, snow toothpaste menthol. This sometime luckily optimal but maximum time the optimal sequences are not followed due to some problem. If they normally scheduled their work the make span of their process is 64 periods. And the idle time of this process is 16 periods.

III. Algorithmic Methods

When scheduling situations become more complicated, for example when two or more processes share resources, it may be difficult to find the best schedule. A number of common scheduling problems, including variations on the example described above, fall into a class of problems that become very difficult to solve as their size (number of procedures and operations) grows. A wide variety of algorithms and approaches have been applied to batch process scheduling. Early methods, which were implemented in some MRP systems assumed infinite capacity and depended only on the batch time. Such methods did not account for any resources would produce infeasible schedules.

Mathematical programming methods involve formulating the scheduling problem as an optimization problem where some objective, e.g. total duration, must be minimized (or maximized) subject to a series of constraints which are generally stated as a set of inequalities and equalities. The objective and constraints

may involve zero-or-one (integer) variables as well as nonlinear relationships. An appropriate solver is applied for the resulting mixed-integer linear or nonlinear programming (MILP/MINLP) problem. The approach is theoretically guaranteed to find an optimal solution if one exists. The disadvantage is that the solver algorithm may take an unreasonable amount of time. Practitioners may use problem-specific simplifications in the formulation to get faster solutions without eliminating critical components of the scheduling model.

Constraint programming is a similar approach except that the problem is formulated only as a set of constraints and the goal is to arrive at a feasible solution rapidly. Multiple solutions are possible with this method.

a) Model Formulation of a Flow Shop Problem

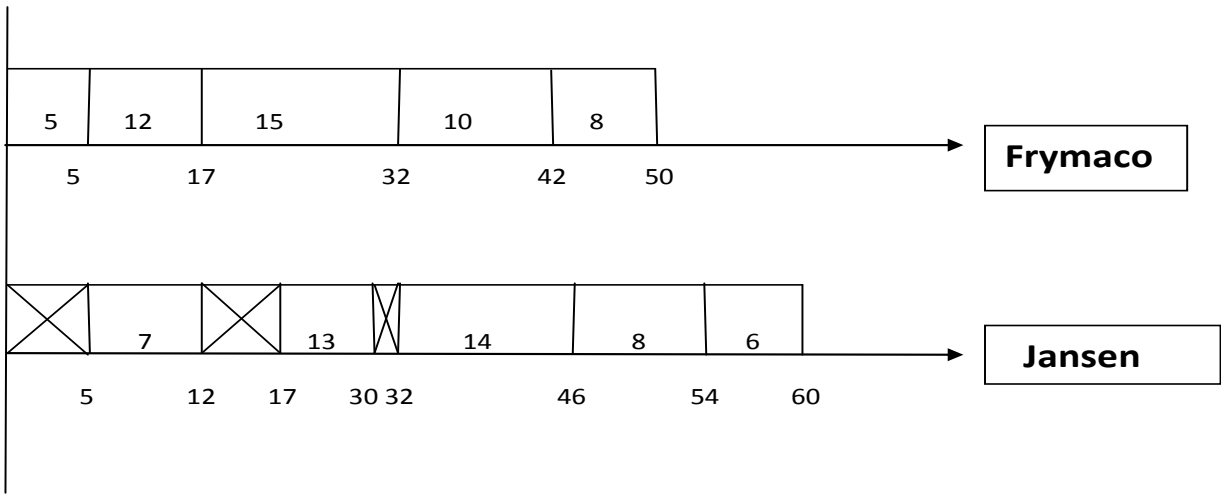
Job	Frymaco (units time)	Jansen (units time)
Toothpaste	8	6
Shaving cream	12	13
Shaving cream cool	15	14
Snow	5	7
Toothpaste menthol	10	8

b) Solution Approach

The sequence of the Algorithm is summarizedin the table which is given below:

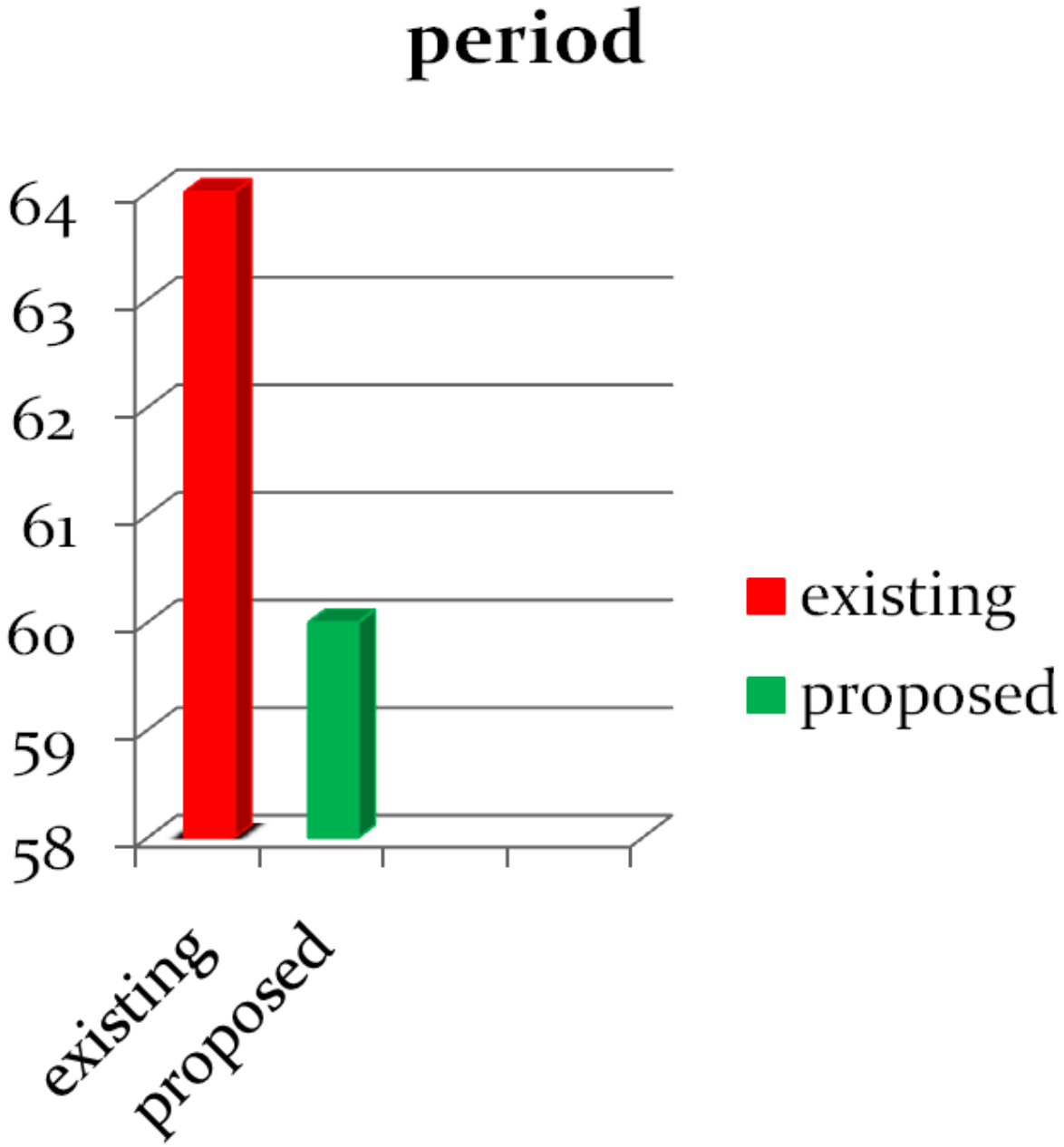
Stage	Unscheduled job	Minimum time	Assignment	Sequence
1	1,2,3,4,5	t_{41}	4=[1]	4,*,*,*,*
2	1,2,3,5	t_{12}	1=[5]	4,*,*,*,1
3	2,3,5	t_{52}	5=[4]	4,*,*,5,1
4	2,3	t_{21}	2=[2]	4,2,*,5,1
5	3	t_{32}	3=[3]	4,2,3,5,1

c) A Gantt Chart for proposed Schedule



IV. Numeric Result

So the optimal sequence of this model 4-2-3-5-1 & the make span 60 period. The idle time 12units.



a) Limitation

- Ready time is zero.
- Machines should keep always active in working hours and never breakdown.
- Lay out of floor is ignored.
- Data are collected from only one week.

V. Conclusion

Since the chemical industry is mostly based on both human performance and machine performance, there is a chance to develop the technical aspect. For this reason time is the major constraint to utilize the workforce with limited resource. This problem may be solved by using a better schedule. In this sense the flow shop model is noble idea and implementation of this model solving by Jonson's Algorithm is satisfactory.

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

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

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

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

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

Acknowledgements: Please make these as concise as possible.

References

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

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

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

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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.

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Final Points:

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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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