To Analyze the Impact of Labor Related Factors on The Performance of Cellular Manufacturing Using AHP Technique

Sanjay Kumar[1], Vasdev Malhotra[2], Vikas Kumar[3]
[1]*Dept. of Mechanical Engineering, YMCAUST, Faridabad*
[2]*Associate Professor,*[3]*Professor, Dept. of Mechanical Engineering, YMCAUST, Faridabad*

Abstract- Cost cutting without negotiating with quality is getting popular and competent to every manufacturing industry. For any organization its feasibility and survival is determined by the quality of products that is being produced in it. The quality of the product and attributes increasingly depend upon the number of factors in the organization. Competencies regarding an effort made for improving productivity in all spheres of activities by utilizing the resources like machinery, men, and material as optimally as possible. The quality requirements is the forcing factor behind the use of tools such as Cellular manufacturing System (CMS) effectively to get higher achievements in business performance. Labor related factors are the main driving factors for quality and productivity of any organization. This study use analytical hierarchy process to evaluate the impact of labor factors in CMS. Safety and wages of the workers got the top ranking and making them as the potential impact in the organization.

Keywords- *Cellular manufacturing system CMS, Analytic hierarchy process AHP.*

I. INTRODUCTION

Organizations are continuously motivating to improve their manufacturing efficiency to compete the current dynamic environment. It is commonly recognized in manufacturing systems that cellular manufacturing system (CMS) is the best manufacturing system that can be utilized to get the required target with customer satisfaction, synthesizing the benefits of similar kind of parts with mass production. Cellular manufacturing system is constructed with arrangement of identical processing part families having of similar operation and collections of committed machines that have similar working (Wemmerlov et, al., 1987). The various merits of CMS over other manufacturing system are to shorten the setup times, material handling, inventory, and lengthen the tool life (Huber &Hyer, 1985; Olorunniwo, 1997; Gunasekaran, McNeil, McGaughey, &Ajasa, 2001). Furthermore, the implementation of CMS has been shown to achieve significant improvements in product quality, space utilization, control of operations, scheduling, and employee morale (Huber et, al., 1991). The evidence of difficulties and threats to implement the CMS are also studied in the past literature. Companies that are in transforming phase in to Cellular Manufacturing system may face the maximum resistance during the implementation of CMS.

Depending on the presence of humans, manufacturing cells are divided into manned and unmanned cells. In manned cells, human operators are doing all the activities including loading, unloading, handling of parts and tools, setup of machines , and inspection of parts for holding the desired dimension and quality control. The number of mentioned tasks assigning to each operator depends on automation level. In unmanned cells these tasks are on robots and computer numerically controlled machines (CNC). Most of the time changing manned cell to unmanned cells results in quality, reliability, and scheduling improvement. But achieving these, installing unmanned cells begs huge investment. Consequently, manned cells are still more common than unmanned cells which paying attention to human aspect in this kind of cells are still attracts many researchers as an interesting subject.

Manned cells depending on automation level and the amount of human's works can be categorized to labor intensive and machine intensive cells. In labor intensive cells, most of works are done with simple tools and manual control machines so it needs permanent presence of operators (Suer et. al. 2005). On the other hand, in machine intensive cells main tasks is done by automatically machine and only loading, unloading, and setup are done by labor. In between, among machining, operator can complete other work on the other machines. So an operator can manage simultaneously more than one machine (Eraty et. al. 2005). Because an operator can work on more than one machine, finding an assignment strategy to maximize the performance of the cell in order to have maximum human recourses efficiency is an important problem. So assignment of operators to cells is an attractive problem to researchers (Eraty et. al. 2005).

Bidanda et al (2005) with a comparative evaluation among published papers with focus on human themes in have shown that there are eight human aspects involved in cellular manufacturing system (CMS). These issues are assignment strategies, finding skills, education, relationships, job independence, intensive plans, team works, and conflict management. Which among them labor assignment of strategies are the most addressed subject (Bidanda et. al. 2005). The labor assignment policies are those methods that permit the engineers and managers to assign workers to particular cell's tasks in order to achieve the maximum cell output and labor efficiencies. These assignment strategies based on man-machine assignments can be grouped to three distinct categories (Cesani et. al. 2000)

1- Dedicated: each worker is operating his particular machine.

2- Mutual: when more than one worker operates one or more than one machines.
3- Collective: in this situation the above two methods are combined for assignment.
It is obvious to having such strategies, flexible or multi skills operators with different skills are necessary. (Bobrowski et. al. 1993) have defined flexibility of workforce as capability to go from one working station to another working station. In CMS, flexibility of workforce depends on the route they can travel in. Based on this, two kind of flexibility of workforce are considered, intra-cell flexibility which focuses on traveling of workers from one cell to another cell and inter-cell flexibility which addresses traveling of labor from one machine to other machine in a cell (Cesani et. al. 2005). Because workforce's flexibility has many strategic benefits it is a useful tool for improving performance of cells. Utilizing multi skills workforces allow the company to response quickly to unbalanced and unpredicted fluctuation in demand. Also exploiting multi skills workforces reduces production times and decreases work in process (WIP) and if it combines with efficient utilizing of machines and workforces, it can improve customers' satisfaction (Johnson et. al. 1996). (Cesani et. al. 2005) had a study on a manufacturing cell with two and three workers. In their study, all three strategies, dedicated, shared, and combined were examined. They considered three parameters, degree of shared job, measure of balance, and cell productivity and found that with increase of shared job between workers, system productivity considerably amplified. But if degree of shared job and cross training goes beyond limitation, improving system productivity eventually would decrease.
Because of significant inter connection of human and technological skills in a CMS, many of researches paid attention to available skills of workforce in labor-task problem. Warner et. al. (1997) introduced a procedure to assign workers according to human and technological skills. Technological skills are defined as capability of calculation and measuring and also mechanical skills and human skills are those which are related to relationship, leadership, team working capability, and decision making. Fitzpatrick and Askin (2005) considered grouping workforce with respect to their technological skills. Bhaskar and Srinivasan (1997) introduced a mathematical model for assigning labor in two dynamic and static cases. The goal was balancing workload and minimizing make span. In static environment, assignments given to workers in such a way that workload is balanced for all products in every cell. But in dynamic assignment, when different products enter the cells, workers are free to move between cells.
Rassellet. al., (1991) carried a research to employ workforce assignments approaches in a tacit group technology workshop which is built up of three cells. Having only one kind of workforce is the result of their study. In other words, each worker must have gained complete cross training and must have had capability that he/she can be assigned to every machine in every cell. Muraliet. al., (2010) derived a worker assignment model that determines the fitness attributes of each worker for each cell in terms of machine coverage ratio, multi-functionality and the total processing time, considering the cell formation solutions available in the literature. They used a new approach based on artificial neural networks (ANNs) which proposed to assign workers into virtual cells. Eratay and Ruan (2005) studied and conducted the research to find the number of workers and proper assignment strategy in cellular manufacturing environment by means of simulation and Data Envelopment Analysis (DEA). They evaluated only some special assignment strategies. They did not consider balancing of the workload. In fact they assumed that the ability of workforces to travel between workstations can resolve the workload balancing.
One of the important factors which affect labor assigning is cell loading. Assigning parts to cells with defining their production sequencing in each cell is cell loading. Dagli and Suer (2005) considered a labor intensive cell and introduced a Fuzzy solution to minimize movement of workers between workstations. In this research we have focused on assignment of labor to the tasks within each cells, which is called as labor assignment strategies. This type of assignment is an important subject in Cellular Manufacturing System. The performance of cells mostly depends on choosing proper strategies to maximize utilization of human working capacity. Up to now there have been a few researches on this subject. Most of these researches only consider labor assignment on special cases. In this research a study is introduced to approach the labor assignment problem with a global view and introduce an analytic hierarchy to find an efficient strategy.
The study is conduced first to recognize the labor related factors that influence the cellular manufacturing system and then secondly by synthesizing the AHP technique on the selected factors to get the optimal results among the various considered factors.

II. LITERATURE REVIEW

Sharma et. al., (2018) carried out research to develop an exemplary for the enablers affecting the application of CMS by using ISM technique. The enablers have been found with literature and questionnaire based survey. The ranking of these enablers have been done using the survey. The MICMAC approach is used to derive the related reliance of "dynamic enablers" (i.e., used to derive other enablers) and "reliant enablers" (i.e., used to derived from other enablers). Enabler improved production process stability and capability, increased automation, and improved worker skill flexibility are the driving enabler or the potential enablers of the system. Thus, these enablers may be called as the 'key enablers'. These key enablers will assist the management in synchronizing the various activities in the production system for healthy cellular manufacturing system.
Kumar et, al. (2017)studied that India is struggling potentially to provide challengeable platform for the manufacturing. Global customer's demands vary with the range of products free from any defect, at lowest possible price. In India industries are showing their interest to transform in cellular manufacturing practices to get the customer satisfaction. Industries are adopting cellular

manufacturing system methodology to enhance respective effectiveness via minimizing scrap within system whereas, in India, cellular manufacturing is still found lot of impediments. Therefore, the barriers have to be identified before implementing the lean manufacturing system in India. This research elaborates the ISM technique for the connection between the several barriers affecting cellular manufacturing in Indian manufacturing. A model is developed for potential barriers affecting cellular manufacturing system. Driving power and dependence power is calculated for the various interrelated barriers. The study provides an organized attitude for abolition of barriers affecting cellular implementation with dynamic power and reliance power. The tenacity of this research is to categorize and ranking of the various barriers of cellular manufacturing.

Nomdenet. al., (2017) carried out a study to find the applicability of Cellular Manufacturing (CMS) systems in different situations. Cellular manufacturing system finds the suitable position from the past years. Case study of CMS implementations provides the advantages of CMS technique, such as reduction in set-up, arrangement, yank production, etc. But still, reviews specify that complete cellular manufacturing systems are exceptional in exercise. In fact, cellular manufacturing systems are only applicable to a restricted amount. From the past literature, barriers affecting implementation of cellular manufacturing system has not been found. The research customs a challenge to plug this information gap through a numerous case study. In starting, they report to what extent the methods of CM are applicable in a number of non-cellular circumstances. Then secondly, they recognize the barriers and enablers responsible for the success or failure of CM system in these circumstances. Thirdly, they designate promising issues for future research. The subjects of study are Dutch manufacturing companies, which do not, or only partially, apply CM techniques. The examination and consequent analysis of these cases results into the documentation of a number of factors affecting the applicability of cellular manufacturing system. Important are an organization's arsenal of manufacturing technologies, as well as product and demand characteristics. Also the organization of manufacturing and the possibility to exert extensive control over jobs and resources seem important. Some benefits from links between different business functions have also been found. By confronting from findings with the current state of CM research they derive a number of promising directions for further study.

Kaur et. al. (2015) stated about the need of quality tool as an important factor in total quality management (TQM) and TPM is synthesized to develop the optimal objectives in business industries. This logical study deals with AHP to get the optimal solution among the various hard alternatives influencing the system. The research involves the various measuring parameters of manufacturing like as productivity, employee competency, quality, cost, flexibility and delivery, employee safety and moral. AHP method is elaborated for the researchers for deep understandings in context of manufacturing in Indian organizations.

Sundharam et al. (2013) have investigated an AHP methodology to get the workable development of production organizations in Indian context. The AHP technique is synthesized with various possible attributes and sub attributes. The method is relied on the decision of the experts. The judgments can be conflicting towards the particular criteria. Kumar and Kumar (2013) has investigated a integrated method of AHP-TOPSIS in the area of telecom service providers (TSPs) to get the benefits of quality performance of relative service in Delhi. The findings of the survey will help the various service providers in context of technical and service performance to the standard and take corrective actions to cultivate the challenges in nature.

III. METHODOLOGY

From the above literature review it has been observed that there is a potential impact on cellular manufacturing system from workers attitudes and quality of concern. There is scarcity of the research in the above concluded area for the effective implementation of CMS. Research or study related with the documentation of such parameters over Indian manufacturing scenario is rarely found (Anderson et. al., 2003).

The Labor related factors are selected as the potential area for the current research the conclusion from the literature also directs for a valid area of research. Some of manpower emphasizes for training, education and awareness. The issue has some criteria and sub-criteria that are directly or indirectly explored by some authors.

A survey is conducted in Indian industries, for taking the response of the experts which are using and facing the practical constraints with cellular manufacturing system. The outcomes of the survey are synthesized to draw the conclusion. The questionnaires were designed on Likert's scale and more than 90 companies are surveyed for the concerned issue. From the findings of the survey are lastly compared in the form of a general matrix to show the final outcome. The matrix obtained with the solution is as shown in Table 1.1

Where,

AW: Administration of Workers
WR: Workers role
TS: Team Spirit
HC: Healthy Communication

Table 1.1 Labor factor matrix

	AW	M	WR	TS	S	T	SL	SF	HC
AW	1	2	2	3	3	1/2	1/3	1/2	3
M	1/2	1	2	2	2	1/3	1/3	1/2	2
WR	1/2	1/2	1	2	3	2	1/3	1/3	½
TS	1/3	1/2	1/2	1	1/2	1/3	1/3	1/3	1/3
S	1/3	1/2	1/3	2	1	1/2	1/3	1/3	2
T	2	3	1/2	3	2	1	1/3	1/2	3
SL	3	3	3	3	3	3	1	1/3	3
SF	2	2	3	3	3	2	3	1	5
HC	1/3	1/2	2	3	1/2	1/3	1/3	1/5	1

Priority vector has been calculated by the GM method. The first step is to prepare pair wise comparison matrix. The priority vector, can be calculated by the total row then is divided by the sum of all the total rows. The priority vector is the normalized vector derived after the process is completed. The steps for this method are as follow:

The matrix obtained is converted into decimals as shown in Table 1.2

Table 1.2 Standard matrix of Labor factors

	AW	M	WR	TS	S	T	SL	SF	HC	PV
AW	1	2	2	3	3	0.5	0.333	0.5	3	0.11841
M	0.5	1	2	2	2	0.333	0.333	0.5	2	0.08562
WR	0.5	0.5	1	2	3	2	0.333	0.333	0.5	0.08561
TS	0.333	0.5	0.5	1	0.5	0.333	0.333	0.333	0.333	0.03993
S	0.333	0.5	0.333	2	1	0.5	0.333	0.333	2	0.05797
T	2	3	0.5	3	2	1	0.333	0.5	3	0.12582
SL	3	3	3	3	3	3	1	0.333	3	0.19213
SF	2	2	3	3	3	2	3	1	5	0.22478
HC	0.333	0.5	2	3	0.5	0.333	0.333	0.5	1	0.06968

Step 1 Weightage of rows

Step 2 Normalizing the each row

The priority vector is P.V.=

$$\begin{Bmatrix} 0.1184 \\ 0.08562 \\ 0.08561 \\ 0.0399 \\ 0.0579 \\ 0.1258 \\ 0.1921 \\ 0.2247 \\ 0.0696 \end{Bmatrix}$$

Sum of the priority vector = 1.000

Sum of all the priority vector results should be unity.

The consistency ratio (CR) should be below or equal to 0.10 (Kardi et al., 1999; Liu et al., 1999; Anderson et al., 2003; Bodin, 2003). The result (ranking of priorities) may be different if the consistency ratio for the pair wise comparison matrix is higher than 0.10, which is not recommended (not accepted) by many of the experts (Liu et al., 1999; Anderson et al., 2003; Bodin, 2003). Therefore the matrix must be adjusted. From the study, it shows that consistency ratio is an important step in determining the priority vector. Hence we will now calculate the consistency ratio (CR), the procedure is as follows:

The consistency ratio (CR) of the pair wise comparison matrix can be obtained by dividing consistency index (CI) by random consistency index (RCI) which is provided below in the Table 1.3

Table 1.3 Value of RCI corresponding to n

N	1	2	3	4	5	6	7	8	9
RCI	0	0	0.58	0.90	1.12	1.25	1.32	1.41	1.45

λ_{max} is obtained to be equal to 10.1970 and by using it the value of CI then it can be calculated using the formula (Kumar and Ganesh, 1996b; Kardi et al., 1999; Liu et al., 1999; Anderson et al., 2003):

$CI = (\lambda_{max} — n)/(n—1)$

Where n is the number of the matrix dimension which results in,

$CI = (10.1970— 9)/(9—1)$

$=0.14$

Lastly the CR can be computed by using the formula (Kumar and Ganesh, 1996b; Kardi et al., 1999; Liu et al., 1999; Anderson et al., 2003):

$CR = CI / RCI$

This result in

$CR = 0.14 / 1.45$

$= 0.096$

We can see from the above calculation that the value of CR < 0.10, hence the value obtained by us is correct.

IV. CONCLUSION

Finally the results from the AHP method rank the various considered factor of labor. We can give a ranking order to all the factors considered in our study on the basis of our calculations, as shown in the Table: 1.4

Table : 1.4 Ranking of labor related factors

S.No.	Factors considered	Values	Rank
1	Administration of Workers	0.11841	4
2	Motivation	0.08562	5
3	Worker's Role	0.08561	6
4	Team Spirit	0.03993	9
5	Supervision	0.05797	7
6	Training	0.12582	3
7	Salary	0.19213	2
8	Safety	0.22478	1
9	Healthy communication	0.06968	8

Any manufacturing firm having these issues satisfied well in manner will definitely yield a better result in terms of producing good outcomes, if the labor of any firm will be well satisfied with the services being provided to them than they

will definitely provide the firm their best which in turn again affects the firms' progress. Safety and the salary got the first and second rank respectively giving that for workers the most influencing factor is the safety and wages provided to them in the organization. Team Spirit and healthy communication comes last in the ranking shows that these factors have very low impact on the manufacturing system so that manufacturing organizations have to pay attention towards the potential labor related factors for getting higher productivity and quality and competency in the global dynamic environment.

V. FUTURE WORK

There are opportunities for further research utilizing larger sample size, more socio technical variables and possibly, an improved instrument. A final area of great interest relates to performance measurement and achievements. The further research can be identified as for more factors and by using some other MCDM approaches to optimize the results.

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Author's Profile

Sanjay Kumar
is Research Scholar in YMCAUST, Faridabad. His interest area is AMS, Cellular Manufacturing System

Dr. Vikas Kumar
is Professor in YMCAUST, Faridabad. His area of Interest lies in JIT, Cellular Manufacturing System.

Dr. Vasdev Malhotra
is Associate Professor in YMCAUST, Faridabad. His interest lies in Reconfigurable Manufacturing System, Agile Manufacturing System