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Decision Analysis of labour issues in Cellular Manufacturing System through Analytical Hierarchy Process

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Abstract— Cellular manufacturing has received strong endorsement as an innovation that enhances quality, throughput time, inventory turnover, workflow, space utilization and flexibility. Even, the motivation for process improvements often arises naturally in manufacturing cells. The research work summarized in this paper will try to find out whether the labour issue is directly imposing any impact over cellular implementation success or not with the help of analytic hierarchy process (AHP). The work also supports the notion that implementing cellular manufacturing is not merely an issue of rearranging the factory layout, but more importantly an issue that involves and affects the organizational and human aspects of the manufacturing firm.

Index Terms— Analysis, Analytic hierarchy process, Cellular manufacturing system, Decision making, Implementation, labour issue, Pair wise comparison.

1 Introduction

The emergence of cellular manufacturing (CM) has dramatically changed batch type manufacturing. CM is an approach that helps build a variety of products with as little waste as possible. A cell is a group of work stations, machine tools arranged for a smooth flow, so a product can be processed progressively from one work station to another, without having to wait for a batch to be completed or requiring additional handling between operations (Olexa 2002). The processing of part-families in cellular manufacturing provides the advantages of the economy of scale in production without the formation of lots of large sizes (Burbidge 1992)[1]. For this reason, the full/ partial conversion from job shop to cellular manufacturing is a common practice in many discrete productions systems (Wemmerlov and Hyer 1989).
Cellular Manufacturing offers an opportunity to combine the efficiency of product flow layouts with the flexibility of functional layouts. In cellular manufacturing, products with similar process requirements are placed into families and manufactured in a cell consisting of functionally dissimilar machines dedicated to the production of one or more part families. By grouping similar products into families, the volume increases justifying the dedication of equipment. But since this volume is justified by process and product similarity, cellular manufacturing warrants much more flexibility than a pure product-flow layout. In terms of the Product-Process matrix, cellular manufacturing allows movement down the vertical i.e. it allows increasing the continuity of the manufacturing process flow without demanding that the products be made in large volumes.

The benefits of cellular manufacturing include faster throughput times, improved product quality, lower work-in-process (WIP) levels and reduced set-up times. These gains are achieved because the batch sizes can be significantly reduced. As set-up times decrease through the use common tools or the collaboration of cell workers during set-up times, batch size can be reduced. The shorter the set-up time the smaller the batch size, and as a goal a batch size of one is feasible when Set-up time is zero. Within a cell, small batch sizes do not travel very far as machines are collocated, resulting in less work-in-progress, shorter lead times and much less complexity in production scheduling and shop floor control.

2 Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is a basic approach to decision making and has been acknowledged as an important multi-criteria decision model (Sajjad, 1999). The AHP was introduced by Saaty in 1970's (Saaty, 1977; Saaty et al., 1994; Cook, 1988; Mikhailov, 2003). The AHP is used to solve complex multi-criteria decision problems (Cook, 1988; Kumar and Ganesh, 1996a; Sajjad, 1999; Saaty, 2003; Anderson et al., 2003). It allows the problem to be modelled in a hierarchical structure by the decision makers. Decision makers must first understand and determine the goal, criteria and alternatives of the problem before a hierarchic structure can be developed.
The AHP then requires the decision makers to carry out simple pair wise comparison judgements (Saaty et al., 1994). The judgements of the decision makers are generally based on the state of mind, situations, learning and the personal experience.

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There are two ways of generating the comparisons, which are by experience and feeling (Saaty, 2003; Takeda et al., 1987). The output of the AHP is the composite priority that based on the overall judgements articulated by the decision makers (Kumar and Ganesh, 1996b; Anderson et al., 2003). The composite priority is developed to rank the decision alternatives, as decision makers have to make their choice based on the ranked priorities. The major advantage of AHP is that it allows inconsistency in the judgements and provides a measure of inconsistency in each set of judgements (Saaty et al., 1994; Saaty 2001).

2.1 THE BASIC PRINCIPLES OF THE AHP

The essence of AHP is to construct a matrix expressing the relative values of a set of attributes. For example, what is the relative importance to the management of this firm of the cost of equipment as opposed to its ease of operation? They are asked to choose whether cost is very much more important, rather more important, as important, and soon down to very much less important, than operability. Each of these judgments is assigned a number on a scale. One common scale (adapted from Saaty) is as shown in the Table 1:

Table 1: Saaty Scale

Intensity of importance	Explanation	Definition
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more Important	Experience and judgment slightly favour one overthe other.
5	Much more Important	Experience and judgement strongly favour one over the other.
7	Very much more important	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice.
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity.
2,4,6,8	Intermediate values	When compromise is needed.

The overall summary of implementing the AHP can be classified to three basic principles; i) decomposition of the problem ii) pair wise comparisons and iii) composition of the resulting priorities or synthesis of priorities (Kumar and Ganesh, 1996b; Liu et al., 1999)[2]. Next the three basic principles for AHP are explained further:

a. Decompose of the problem

The problem is decomposed by structuring it in a hierarchical form. Figure 1 shows the example of a three level hierarchy structure. Level 1 signifies the overall objective or the focus of the problem, which should always be on the top. Level 2 characterize the criteria of the problem and Level 3 represents the alternatives that need to be evaluated by the criteria. However, Liu (1999) denoted that the level of hierarchy should divided into a four level-hierarchy which contains the goal level, criterion level, sub criterion level and scheme (alternatives) level (Liu et al., 1999).

b. Pair wise comparisons

The pair wise comparisons are constructed by comparing pairs of elements in each level of hierarchy with respect to every element in the higher level. These pair wise is used to establish priorities for each set of elements in each level of hierarchy. Comparing the pairs of elements is generated by giving a comparative judgments of preferences for each pair of elements in every level using the Saaty's nine-point scale (Mikhailov, 2003) (see Appendix B). This comparison process is carried out to determine which of the element in a pair is more desirable or preferred compared to the others. These comparisons are positioned into a positive reciprocal or pair wise comparison matrix. The derivation of the priorities from pair wise comparisons matrix is the main concept of the AHP (Mikhailov and Singh, 1999; Srdjevic, 2003). The AHP allows decision makers to derive ratio scale priority or weights from the pair wise comparisons matrices (Anderson et al., 2003). The priorities or the priority vector for every set in a level is estimated by using the prioritization method (i.e. eigenvector method, additive normalization method, geometric mean method).

c. **Composition of the resulting priorities or synthesis of priorities**.

This principle is applied to attain the composite priority for the lowest level elements, which are the alternatives based on the overall preferences expressed by the decision makers. Every priority vector (priorities) in the lowest level is weighted by the higher level priorities. The purpose is to attain the composite priority (the overall relative weights of the alternatives) that reflects the overall importance of each alternative (Mikhailov, 2003; Indrani, 2002; Saaty, 2003; Srdjevic, 2003). The prioritized ranking of the decision alternatives can be derived from the composite priority. Different methods of prioritization may lead to different final values (Saaty, 2003).

3 METHODOLOGY

Several empirical studies have dealt with the impact of cellular manufacturing (CM) on employee's attitudes and quality of work life. A lack in research does exist to get those sociotechnical characteristics which have significant impacts on the success of CM implementation. Any work regarding the identification of such characteristics over Indian manufacturing scenario can be rarely found [3]. The methodology consists of the survey instrument and all its inclusion and later discussions related to the models using analytic hierarchy process.

The human infrastructure is the key issue for our study and the conceived notion through the literature study also suggests it as valid selection. Other suggestible human resource practices are training, selection and communication. Management role is also considered. Each of the main factors and practices has some sub-factors that are directly or indirectly explored by some authors. It has been also postulated by those authors that a complimentary match between technical and social systems is needed to ensure optimization of CM.

This research study involves a survey of Indian organizations, which implemented cellular manufacturing. It also includes responses of experts with knowledge and experiences in successful CM implementation. The ideas and results expressed here were deductive outcomes of this response dependent exploration, from more than 25 companies. Using a standard set of questions we asked operations managers to relate stories about the changes due to CM implementation and to highlight the outcomes and improvements resulted from the changes they made. From this very rich set of responses, we discovered consistent patterns that ultimately led us to reformulate our thinking about cells and even industries. 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 2:

Where,

SM: Self Management
EI: Employee Input
GC: Group Cohesiveness
EOC: Ease of Communication

Table 2: Result Obtained For Comparison

	SM	Motivation	EI	GC	Supervisi-	Training	Wages	Safety	EOC
SM	1	2	2	3	3	1/2	1/3	1/2	3
Motivation	½	1	2	2	2	1/3	1/3	1/2	2
EI	1/2	1/2	1	2	3	2	1/3	1/3	½
GC	1/3	1/2	1/2	1	1/2	1/3	1/3	1/3	1/3
Supervision	1/3	1/2	1/3	2	1	1/2	1/3	1/3	2
Training	2	3	1/2	3	2	1	1/3	1/2	3
Wages	3	3	3	3	3	3	1	1/3	3
Safety	2	2	3	3	3	2	3	1	5
EOC	1/3	1/2	2	3	1/2	1/3	1/3	1/5	1

There are three steps to be followed in deriving priority vector by using the GM method. The first step is to multiply every value in each row of the pair wise comparison matrix and power the values by 1⁄n (number of dimension) to obtain the total row. In deriving the priority vector, 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 first converted into decimals so that the standard algebra can be used, as shown in Table 3:

Table 3: Standard matrix

	SM	Motivation	EI	GC	Supervision	Training	Wages	Safety	EOC
SM	1	2	2	3	3	0.5	o.33333	0.5	3
Motivation	0.5	1	2	2	2	0.33333	0.33333	0.5	2
EI	0.5	0.5	1	2	3	2	0.33333	0.33333	0.5
GC	0.33333	0.5	0.5	1	0.5	0.33333	0.33333	0.33333	0.33333
Supervision	0.33333	0.5	0.33333	2	1	0.5	0.33333	0.33333	2
Training	2	3	0.5	3	2	1	0.33333	0.5	3
Wages	3	3	3	3	3	3	1	0.33333	3
Safety	2	2	3	3	3	2	3	1	5
EOC	0.33333	0.5	2	3	0.5	0.33333	0.33333	0.2	1

Multiply each element in every row and then power of 1/n

$(1 \times 2 \times 2 \times 3 \times 3 \times 0.5 \times 0.33333 \times 0.5 \times 3)^{1/9} = 1.276518$

$(0.5 \times 1 \times 2 \times 2 \times 2 \times o.33333 \times 0.33333 \times 0.5 \times 2)^{1/9} = 0.913836$

$(0.5 \times 0.5 \times 1 \times 2 \times 3 \times 2 \times 0.33333 \times 0.33333 \times 0.5)^{1/9} = 0.819480$

$(0.33333 \times 0.5 \times 0.5 \times 1 \times 0.5 \times 0.33333 \times 0.33333 \times 0.33333 \times 0.33333)^{1/9} = 0.431110$

$(0.33333 \times 0.5 \times 0.33333 \times 2 \times 1 \times 0.5 \times 0.33333 \times 0.33333 \times 2)^{1/9} = 0.613685$

$(2 \times 3 \times 0.5 \times 3 \times 2 \times 1 \times 0.33333 \times 0.5 \times 3)^{1/9} = 1.276517$

$(3 \times 3 \times 3 \times 3 \times 3 \times 3 \times 1 \times 0.33333 \times 3)^{1/9} = 2.080083$

$(0.33333 \times 0.5 \times 2 \times 3 \times 0.5 \times 0.33333 \times 0.33333 \times 0.2 \times 1)^{1/9} = 0.606543$

Step 1 Sum all the total rows,

Total sum of the rows = 1.276518 + 0.913836 + 0.819480 + 0.431110 +0.613685 + 1.276517 + 2.080083 + 2.172936+ 0.606543 = 10.1907

Step 2 Normalize each total of the row by dividing the total row by the total sum of the rows.

1.276518/10.1970 = 0.1251
0.913836/10.1970 = 0.0896
0.819480/10.1970 = 0.0804
0.431110/10.1970 = 0.0423
0.613685/10.1970 = 0.0602
1.276517/10.1970 = 0.1252
2.080083/10.1970 = 0.2041
2.172936/10.1970 = 0.2136
0.606543/10.1970 = 0.0595

The priority vector is

$$\begin{pmatrix} 0.1251 \\ 0.0896 \\ 0.0804 \\ 0.0423 \\ 0.0602 \\ 0.1252 \\ 0.2041 \\ 0.2136 \\ 0.0595 \end{pmatrix}$$

Total sum of the priority vector = 1.000

Priorityvector

$W=(0.1251,0.0896,0.0804,0.0423,0.0602,0.1252,0.2041,0.2136,0.0595)^T$

According to Golany and Kress (1993), the total for each priority vector in every method should be equal to 1.We can see the values obtained by us are also correct as the sum of all the priority vector results in 1.

The matrix is acceptable if the consistency ratio (CR) is below or equal to 0.10 (Kardi et al., 1999; Liu et al., 1999; Anderson et

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al., 2003; Bodin, 2003). Nevertheless, 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) [5]. 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 4:

Table 4: Values of RCI corresponding to n

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

λmax is obtained to be equal to 10.1970 and by using it the value of CI then 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 resuls 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.

4 CONCLUSION

At last 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 5:

Table 5: Final result obtained

Factors considered	Values	Rank
Self management	0.1251	4
Motivation	0.0896	5
Employee input	0.0804	6
Group cohesiveness	0.0423	9
Supervision	0.0602	7
Training	0.1252	3
Wages	0.2041	2
Safety	0.2136	1
Ease of communication	0.0595	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 labour 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.

5 FUTURE WORK

There are opportunities for further research utilizing larger sample size, more sociotechnical variables and possibly, an improved instrument. A final area of great interest relates to performance measurement and achievements. Why do some companies achieve spectacular results while others do not?

6 REFERENCES

[1] Burbidge, J., and Change of group technology: process organization is obsolete. Int. J. Prod. Res., 1992, 30, 1209–1220.

[2] Aryati Bakri, Mahadi Bahari, Azizah Abdul Rahman, Mohd Yazid Pathani (2004). Review Prioritization Methods in Analytic Hierarchy Process (AHP), Jurnal Teknologi Maklumat (in press).

[3] Anderson, D. R., Sweeney, D. J., and Williams, T. A. (2003). An Introduction to Management Science, Quantitative Approaches to Decision making. 10th ed. Mason, Ohio: South Western.

[4] Aryati Bakri, Mahadi Bahari, Azizah Abdul Rahman, Mohd Yazid Pathani (2004). Review Prioritization Methods in AHP, Jurnal Teknologi Maklumat.

[5] Barzilai, J. (1997). Deriving weights from pair wise comparison matrices. Journal of Operational Research and Society 48: 1226-1232.

- Huq, F., (1992), "Labour issues in the implementation of group technology cellular manufacturing", Production and inventory Management Journal.
- Huber, V.L., Brown, K.A., (1991), "Human resource issues in cellular manufacturing: A sociotechnical analysis", Journal of Operations Management, 10 (1).