Ranking Job Shop and Group Technology Layout with the Analyzing Approach

Sohrab Rajabi and Hamed Maleki

***Abstract*—Production layout systems consist of job shop or process layout, product layout, fixed position layout and group technology layout. In job shop or process layout, departments consist of the machines with the same capabilities that have the same functions. In group technology systems, the same parts are constructed in a group and by the same set of machines. Analytic hierarchy process is one of the most efficient decision making techniques, which was discussed for the first time by Thomas L. Saaty in 1980. That was based on the pairwise comparisons and enables the managers to study different scenarios. In this paper, for the ranking of job shop or process layout, and group technology, we use Analytic hierarchy process method. For examination the suggested method and of its usage in Iran Tractor Manufacturing Company is shown.**

***Index Terms*—Analytic hierarchy process, group technology, job shop.**

I. Introduction

In job shop production system, the same machines next to each other are established in a way that we can make different models and parts with different combination of the machines in an easy way. May be a part during production, needs some machines in several job shops, and in this situation, moving the machines through the job shops make different complications in controlling of in process materials. We called this layout, process – oriented design. In a condition that the variety at production is high and the rate of demanding each part is low, there is no except to use this system [1].

Group technology (GT) is a manufacturing philosophy that seeks to improve productivity by grouping parts and products with similar characteristics into families and forming production cells with a group of dissimilar machines and processes. In conditions that the variety at production and the rate of demanding each part are moderate, it is better to apply this system. Also this system can be named as cellular manufacturing [2].

The Analytic Hierarchy Process (AHP) is a structured technique for dealing with complex decisions. Rather than prescribing a ‘‘correct’’ decision, the AHP helps decision makers find one that best suits their objective and their understanding of the problem [3]. Users of the AHP first decompose their decision problem into a hierarchy of more easily comprehended subproblems, each of which can be analyzed independently. The elements of the hierarchy can be related to any aspect of the decision problem. Once the hierarchy is built, the decision makers systematically evaluate its various elements by comparing them to one another two at a time, with respect to their impact on an element above them in the hierarchy. In making the comparisons, the decision makers can use concrete data about the elements, or they can use their judgments about the elements’ relative meaning and importance. It is the essence of the AHP that human judgment, and not just the underlying information, can be used in performing the evaluations. The AHP converts these evaluations to numerical values that can be processed and compared over the entire range of the problem. A numerical weight or priority is derived for each element of the hierarchy, allowing diverse and often incommensurable elements to be compared to one another in a rational and consistent way. This capability distinguishes the AHP from other decision making techniques. In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives’ relative ability to achieve the decision objective, so they allow a straightforward consideration of the various courses of action [4].

In this paper our alternatives are job shop and group technology layout systems. As you know either one has some advantages and disadvantages, we consider these advantages and disadvantages as criteria for reaching the maximum productivity.

II. The Method of Using Ahp in Modeling Layout of Production Systems

For helping the modeling of layout of production process, we provide a method that we use AHP technique in it. The main causes of using AHP in ranking the priorities of layout of production process are:

1) Combining different criteria of efficiency such as: lead time of production, mass of work during operation, using tools, reworking and scrap material, setup time, delivery time, human relationship and bureaucracy, which are considered together, not along each other that is possible by using AHP.
2) Quantifying efficiency criteria that are existed in this analysis. Even by using values based on quality judgment, does not have a powerful and strong theory foundation [5].

Analytic hierarchy process with analyzing complicate and difficult cases changes them into a simple form and then solves them. Steps at modeling production systems layout by AHP are mentioned below:

Manuscript received June 21, 2012; revised July 14, 2012.

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A. Structuring of the Decision Problem into a Hierarchical Model

The first step in analytic hierarchy process is creating a graphical picture at the problem that has objective, criterions and alternatives. In this paper, considered different criterions decision making model, has three levels. Our purpose is productivity; these criterions are those 8 criterions at lead time, mass of work during the operation, using tools, reworking and scrap material, setup time, delivery time, Human relationship and bureaucracy, and the alternatives are the methods of production process layout [6]. The structure of model is presented in the Fig. 1.

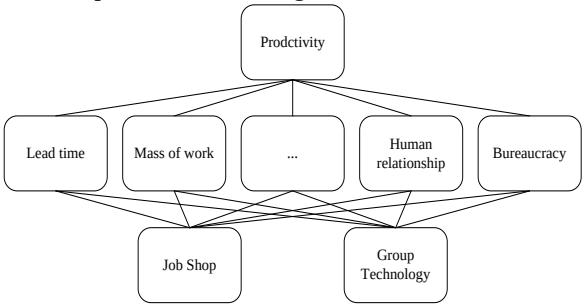

Fig. 1. Structure of model.

B. Making Pairwise Comparisons, Obtaining the Judgment Matrix and Local Weights of Comparisons, and Aggregation of these Weights

In analytic hierarchy process, these elements of each level compare to the respective element in the higher level, and their weights were calculated, that we call it local weights. Then with combining these weights, we present the total weights, that we call it overall weight. The analytic hierarchy process includes pairwise comparisons. These judgments change into quantities amounts from 1 to 9 which exist in Table I.

TABLE I: JUDGMENT VALUE

Verbal judgment	Value
Very strongly preference	9
Strongly preference	7
Definite	5
Weak preference	3
Equal preference	1

For calculating local weight of each criterion or alternatives there are different methods of pairwise comparing, which the eigenvector method is the best of them. In this paper, we use eigenvector for calculating local weights. After calculating criteria weights relative to the objective and weights of alternatives relative to criteria, by synthesizing these weights, we can calculate the overall weight of the alternatives. The overall weight of each alternative obtained by multiplying the vector of criterion weights by the matrix formed by the vector of alternative weights.

C. Consistency of Comparisons

The advantage of analytic hierarchy process is controlling the compatibility of decisions. In other word, we can calculate the compatibility of approach and judge about its good, bad, acceptable or rejected features. If A is important twice B, and B is important three times than C, and when A is important 6 times than C, we call it compatible. In practice the human decisions and judgments are not always compatible. For studying the incompatibility at the decision, there is an indicator in AHP, called ''the consistency ratio''. When this indicator is equal or less than 0.1, the compatibility of the system is acceptable. Otherwise we should review our judgments again.

D. Ranking of Methods

After calculating the overall weight of each aspect of efficiency, now by considering these weights, we rank these methods at production process layout, in a way that a method which has the highest weight, is considered as a best method.

III. CASE STUDY

The proposed model in this paper is performed in the forging Tabriz Tractor Factory By studying the methods of production layout, it was specified that, based on advantages and disadvantages the different criteria of efficiency are: lead time of production, mass of work during operation, Using tools, reworking and scrap material, setup time, delivery time, human relationship and bureaucracy. We achieve the evaluation of the score of each 8 criterions for each method of layout by using production experts' point of view and the respective managers (see Table II), now by pairwise comparison; we achieve the weight of criteria relative to objective. As you can see in table III, here is Reworking and scrap material, because of getting to the highest weight, is the best criterion.

TABLE II: PAIRWISE COMPARISONS MATRIX OF CRITERIA WITH RESPECT TO OBJECTIVE

Criteria	L.t.[a]	V.w.	U.t	Re.	S.t.	D.t.	H.r	B.
Lead time	*	1	3	1/3	1	1/2	4	4
Mass of work	1	*	3	1/3	1/2	1/3	5	5
Using tools	1/3	1/3	*	1/6	1/3	1/7	2	2
Reworking & Scrap material	3	3	6	*	3	1	9	9
Setup time	1	2	3	1/3	*	1/3	5	5
Delivery time	2	3	7	1	3	*	7	9
Human relationship	1/4	1/5	1/2	1/9	1/5	1/7	*	1
Bureaucracy	1/4	1/5	1/2	1/9	1/5	1/9	1	*

a. Abbreviation of Lead time.

TABLE III: OVERALL WEIGHTS AND THE RANKING OF TWO METHODS JOB SHOP AND GROUP TECHNOLOGY

Criteria	Weight of criteria	Job Shop	Group Technology
Lead time	0.113	3.08	3.12
Mass of work	0.106	3.20	3.40
Using tools	0.043	3.15	3.25
Reworking & Scrap material	0.287	2.63	3.05
Setup time	0.127	3.15	3
Delivery time	0.271	2.80	2.80
Human relationship	0.027	2.80	3
Bureaucracy	0.026	3.40	3.20
Overall weights	---	3.02	3.10
Priority	---	2	1

Now by making a matrix of pairwise comparisons, for alternatives relative to each criterion, the relative weight of the alternatives relative to criteria are obtained.

For obtaining the relative weight of the alternatives relative to the criteria, we make eight 2×2 matrices. For obtaining the relative weight of the alternatives relative to the criteria, we perform the same things that we do for obtaining the relative weight of the criteria relative to the objective. The obtained local weights for alternatives and at last, the overall weight and their priorities, are existed in table III.

IV. Conclusion

By introducing the AHP method, we see that we can consider the production layout as a multicriteria decision making. As it was said in this paper, each of the layout systems has advantages and disadvantages. By considering that each industry has differences with other industries, in different grounds so each of the advantage may be a disadvantage in another industry, or vice versa. Even the performance time of each system may affect on the efficiency system. By presenting a practical example in forging industry, we get to this conclusion that the group technology for a layout design is more suitable than job shop. We use AHP technique for comparing these two systems. AHP helps the analyzer to perform a systematic and analytic method and studying the aspects of the problem in a hierarchy manner. In fact, AHP by using pairwise judgments can control the difficult condition arose from the quantitative and direct assessment. Another advantage of using AHP is that this technique is performable by software. In this paper we use Expert Choice 11 for performing analytic hierarchy process.

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