RANKING OF MANUFACTURING SYSTEM CRITERIA

SHARFUDDIN AHMED KHAN

Industrial Engineering & Management Department, University of Sharjah
University City, Sharjah, 27272, United Arab Emirates
skhan@sharjah.ac.ae
www.sharjah.ac.ae

SYED ADEEL HANEEF ZAIDI

Mechanical Engineering Department, King Fahd University of Petroleum & Minerals
Dhahran, 31261 Saudi Arabia
sadeelzaidi@googlemail.com

Abstract:

A high-quality manufacturing system should be capable to meet the company goals. Moreover, it is essential for any organization that its manufacturing system should be aligned with company's strategy. There is always a potential for improvement in components of manufacturing systems but it is also essential to identify the particular areas of the components that need improvement. In this paper, we have discussed the most appropriate criterion for good manufacturing systems with the help of a survey that indentified the importance of seven different criteria according to the experts experience and we ranked them accordingly.

Keywords: Manufacturing System, Manufacturing System Criteria, Ranking of Manufacturing System,

1. Introduction

The manufacturing industries are facing an increase in challenges due to the huge volatile market [Wang and Koren, 2012], recession in global economy, price of raw material, logistics that creates fluctuations in the productivity and product demand. To remain competent in the global or local market the manufacturers have to design manufacturing systems that produce not only high quality products at low cost but also flexible enough to respond the economic changes in an effective way [Raouf and Anjum, 1995; Wang and Koren, 2012].

Manufacturing is the backbone of any company, manufacturing importance is emphasized by the fact that as an economic activity, it comprises approximately 20 to 30 percent of the value of all goods and services produced in industrialized nations [Kalpakjian 2005]. We all know that every company is concerned about their customer service level and they want to meet the promised delivery date.

A manufacturing system is a subset of the production or enterprise system [Black 1991; Cochran 1991]. More specifically, a manufacturing system is the arrangement and operation of elements (machines, tools, material, people, and information) to produce a value-added physical, informational or service product whose success and cost is characterized by measurable parameters of the system design [Cochran 1994; Chryssolouris 1992; Wu 1992].

It means that the company success depends on the factors that are affecting on its manufacturing systems significantly. Moreover, there is a need to identify the major criteria of such system. For instance, for some organizations, over time is the key factor while on the other hand some organizations do not care about it.

In order to identify the importance of each criterion, there is a need to list down all possible criteria of manufacturing system which have a significant impact on overall manufacturing system. After that we will identify the most contributing criteria in descending order. Based on experience and according to experts, we have identified six different criteria which are as follows.

1. Rejection Rate
2. Cycle Time
3. Overtime

4. Unavailability of Raw Material
5. Machine downtime
6. Raw Material Quality
7. Significant difference in forecasting and actual production.

2. Literature Review

There are several definitions by different authors about the flexibility or efficiency of any given manufacturing system. The seven criteria that are mentioned in this research paper should also be flexible or efficient enough to make manufacturing easy at any complex situation. Sometimes modifications are imperative in these seven criteria but it should bring production time down to increase the productivity. Many researchers had worked to make these criteria efficient according to different situations and scenarios faced in the past or present. The flexibility itself is a feature that allows the system to cope-up with immediate manufacturing demands. [Raouf and Anjum, 1995] agreed on a fact that the literature on FMS does not offer integrated methods to measure the level of flexibility exists in the system. The first part of their research describes the definitions for various fragments of flexibility system (e.g. machine flexibility, product flexibility or environment flexibility etc) that are developed by different authors. Following a method was proposed to measure the overall flexibility for any given system. The main reason to carry out this research was to develop a quantitative measure for the mentors of manufacturing sectors that could enable them to determine the level of flexibility in their manufacturing system. A score sheet was developed that awarded a score of 5 for minimum and 25 for maximum flexibility offered by the system. A mentor or manager can evaluate the level of flexibility by deciding the correct score for the given system. In Chincholkar et al.[2004] the novel manufacturing system model was developed that based on queuing network approximations for estimating the manufacturing cycle time and throughput of the system. The research refers to the common problem of parts inspected at downstream inspection station to find out the upstream process out of control. The process may produce rejected parts or increase the cycle time due to the machine error or flawed in-process raw material etc. This affects the production cycle and number of good parts produced in the process. The proposed model details the affects of manufacturing parameters such as cycle time, arrival rate and inspection station placement etc. on manufacturing system.

[Gupta and Buzacott, 1989] proposed a strategy to assess the ‘value of flexibility’, flexibility measures and development of qualitative models in order to evaluate the investments. The work was divided into three parts; the first part was based on the construction of definite basic concepts that brought forward the unclear and indefinite understanding of the flexibility. The second part was comprised on the surrogate flexibility measure that also described as ‘value of flexibility. This part had focused the value of flexibility as an operational measure. The time scale decomposition of changes was proposed to solve the issues related to measuring the flexibility. The last part was focused on the description of procedures that were used in the development of conceptual models based on the information gathered from the first two parts. The research was particularly focused on the better use of FMS that could justify the economics and fulfilling the requirements of an efficient management. The organization of the research paper is excellent because few important concepts were enlisted in the beginning that followed by the significance and the true nature of flexibility. Next the review was provided on the measure of flexibility and the problems that occurred inherently. Then the conceptual model of FMS with the time scale based decomposition of changes for the evaluation of the value of flexibility was defined. In the end, a practical scheme was proposed to measure the value of flexibility.

Freiheit et al. [2003] proposed new configurations that weren’t introduced before and that can be used for loss of buffered system isolation failure, building-up of inventories and for construction to expand production facilities. This paper demonstrates the use of numerical models to forecast the productivity of manufacturing system configurations and explains the equivalency to buffered serial transfer lines. The research was intended to search other feasible methods besides buffering to improve the productivity and to find out other suitable configurations with serial lines alone or combining buffers with non-traditional configurations. The results exhibited that to design productive manufacturing systems without buffers can be done by sensible use of non-traditional configurations for example parallel- serial and reserve capacity types. The results indicated that the efficient material handling system was essential that could also exceed the availability of the machines. If material handling is not effective then buffered system is more suitable. If the repairs of machine failures can be done in low time it means that machine availability is high and stand-by machines are not essential, hence a buffered system is more preferable and justifiable. But if the machines repairs consume long time a reserve capacity system should be incorporated as buffer capacity. Hence to adopt any strategy it is important to model the productivity and compare system and operational costs with the profits and benefits. The mathematical modelling in this work actually makes this research a profitable development as industries can conduct statistical analysis and can judge the current manufacturing systems running in their facilities.

Reconfigurable Manufacturing Systems (RMS) Galan et al. [2007] is another approach uses to produce complex products with high quantity. The products arranged in group of families and the system reconfigures for each group. RMS provides immense support in producing products rapidly and at a low cost with mass production, it also enables manufacturing system to rearrange itself for the following group of families. The most effective use of RMS depends on the formation of groups because the groups of family decide the engagement of resources present in the manufacturing system. The methodology of grouping products into families has a high importance and addresses the requirements of modularity, commonality, compatibility, reusability and product demand. Galan et al. [2007] had proposed an Analytical Hierarchical Process (AHP) methodology for RMS in which the similarities between the products were evaluated and encompassed in the matrix. Then the dendogram was obtained by applying the Average Linkage Clustering algorithm. The main objective was to develop the methodology that increases the production volumes by reducing the time along with required quality.

Scalability is also an important part of RMS that enables the whole system to adjust according to the unexpected changes required to implement in the reconfigured system. In 2012, [Wang and Koren, 2012] suggested that the planning for scalability should be executed with the design of a new system because it provides the cost effective solution by locating the optimal machine positions in advance. This approach is also enables the material handling system to optimise for future scalability activities by reducing the cost of investment. The researchers confirmed their proposed approach by applying it on a case study of CNC-based automotive cylinder head machining system. In this research the most feasible way to configure the existing system was determined by producing a Genetic Algorithm (GA) which is a structured heuristic that uses to generate the optimise solutions. GA can provide solutions for scalability problems because it is effective on complex function mixed integer problems and combinatorial explosions.

The above literature review shows the importance of appropriate manufacturing system and its effect in overall performance. This paper identifies the most important criteria of manufacturing through experts surveys from different companies and ranks the above mentioned seven criterions accordingly. Based on this contemplation, the remainder of this study is organized as follows: Section 3 discusses the methodology, Section 4 analyzes the results. Finally, Section 5 draws conclusion and recommendations for future work.

3. Methodology

Based on above literature review, we found that there is a need to identify the ranking of manufacturing criteria which significantly impinge on the overall manufacturing system. For this purpose, we have developed a survey which consists of all possible criteria of manufacturing systems. The surveys were mailed with cover letter and addressed to the CEO/General Managers of each company. Targeted recipient were instructed to complete the survey themselves or refer it to an appropriate person for the same. Companies were identified from yellow pages and we tried to cover all sectors like automotive, textiles, oil & gas, petroleum, aviation, process industries, plastics, assembly plants etc.

Out of 112 surveys mailed, 29 were completed and returned. A breakdown of the survey responses is shown in Fig.1. Almost all of the responses were received within 6 weeks of mailing. Twenty seven companies returned the survey saying that due to large number of such queries they were unable to respond. Thirty five companies did not respond at all and twenty one companies said that they were unable to reply because their company was not suitable for such kind of survey. The response rate was only 26% and according to Hair et al.[1995], a major step of data collection is to select the sample size. In a very general sense, the best way to ensure predictive power in regression is to use a sufficiently large sample size. However, it is extremely difficult to find a company that undertakes a significant number of samples within a reasonable time. Therefore, in this type of research, since the size of population of interest is small, then the sample size can be relatively small. In this study, the selection of sample size was based on the most widely used rule-of-thumb, described by [Olejnik 1984] ‘‘Use as many samples as you can get and you can afford’’. Therefore, we felt that 26% of response rate is adequate to assist us in developing our framework.

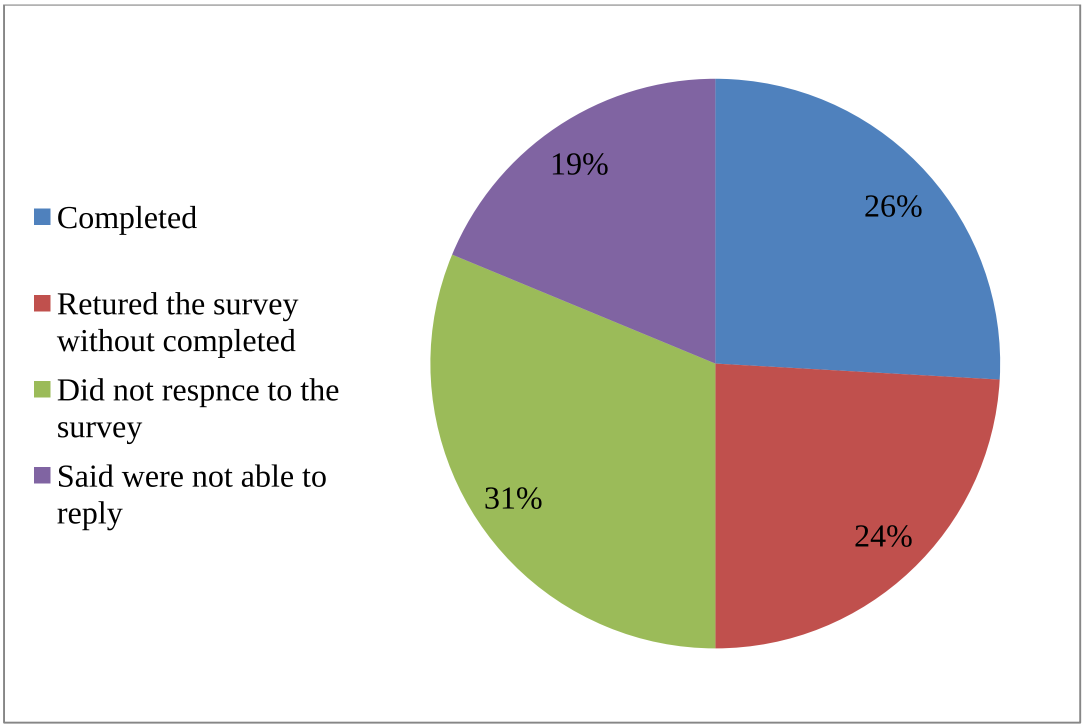

Fig 1: Breakdown of response for the survey

Once we had all 26% completed surveys, we calculated the average of all responses and ranked them accordingly. The ranks were converted to relative percentage by dividing each rank, by the total of all ranks. This approach is similar to Pareto analysis wherein problem frequencies are converted to percentages to show relative importance. The percentage better highlights the differences in the importance of each criterion. Table 1 shows the measures and their relative importance as determined by our analysis of the survey data.

Table 1: Analysis of Survey Result

S. No.	Manufacturing System Criteria	Experts Survey Average	Percentage Importance
1	Rejection Rate	1.60	11%
2	Cycle Time	1.80	13%
3	Overtime	1.90	13%
4	Unavailability of Raw Material	2.80	20%
5	Machine Downtime	1.90	13%
6	Raw Material Quality	2.25	16%
7	Difference in forecasting & production	2.00	14%

The above table results also mentioned graphically in Fig 2 which is as follows.

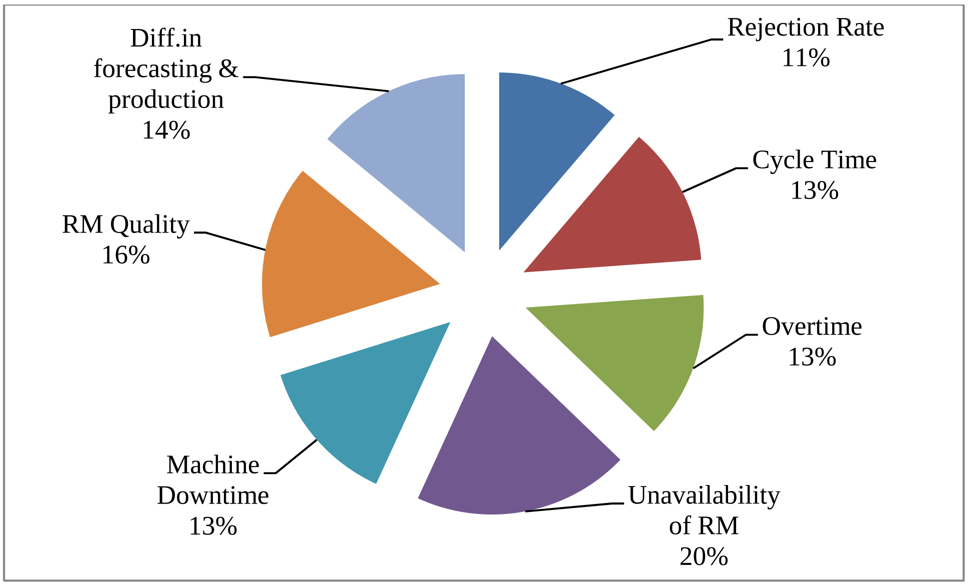

Fig 2: Breakdown of response for the survey

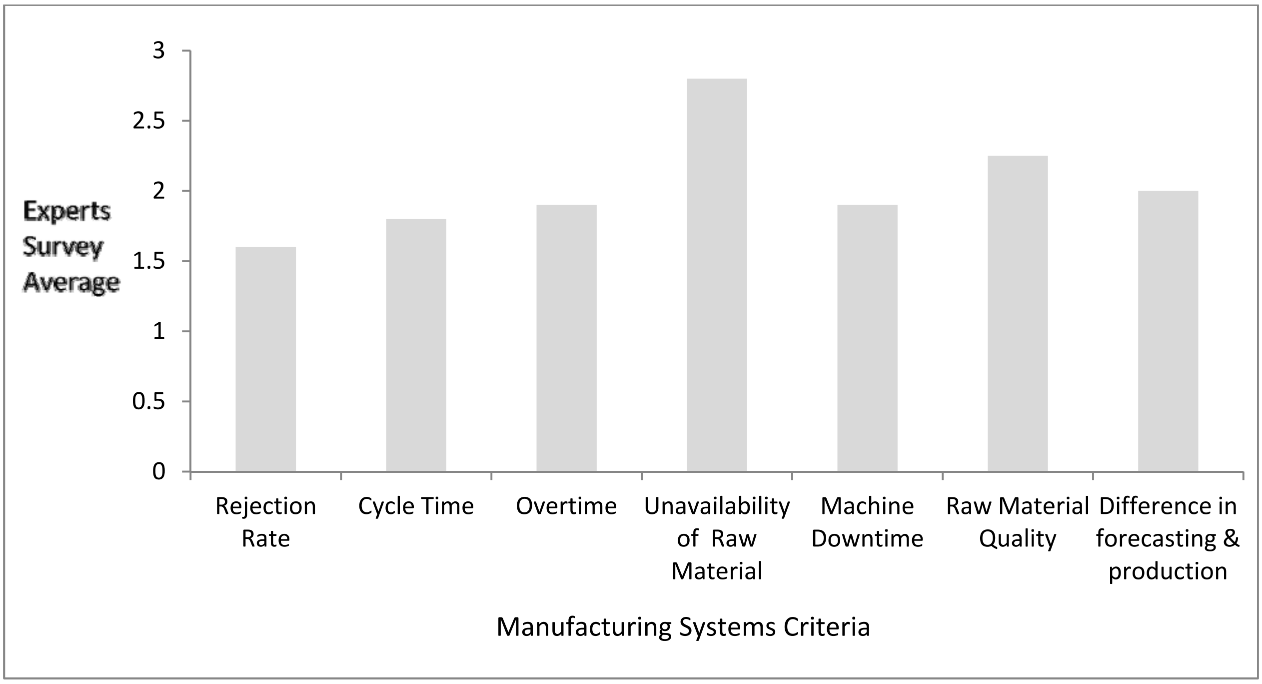

Fig. 3 Experts rating for each criterion

4. Result Analysis

In table 2 and figure 2, the order of priority for the manufacturing system is presented and figure 3 exhibits the ratings given by the experts during the survey for a good manufacturing system. The unavailability of raw material is highly important and ranked as 1st with percentage contribution of 20% and emphasizes the importance of it in manufacturing system. Similarly, the survey shows that the quality of raw material is important with a percentage contribution of 16% in overall manufacturing system criteria. Forecasting is the core of any production system and adequate forecasting is vital to avoid any back lock and increasing customer service. The difference in forecasting and actual production is ranked 3rd with percentage contribution of 14% in overall manufacturing system criteria. For a good manufacturing system, internal factors such as machine downtime, cycle time and overtime is somehow manageable. Expert's survey in this regard shows that all the internal factors (machine downtime, cycle time and overtime) have a contribution of 13% each in manufacturing system criteria. These factors can be reduced by appropriate forecasting and surety of raw material availability on time. Lastly, rejection rate has a contribution of 11% in overall manufacturing system criteria.

5. Limitations of Study

To collect data from company representatives was a tedious process and that made difficult to gather more surveys. . However, authors made enormous efforts to increase the number of survey responses and managed to get completed surveys which is 26% in total. Due to limited resources and time, authors were unable to collect significant number of surveys.

6. Conclusion and Future Recommendations

This paper reports some interesting findings and results associated with manufacturing systems. Seven manufacturing criteria were considered in this paper and based on surveys from different companies related to different sectors; we are able to rank them according to the expert's opinion. The problems related to raw material such as unavailability and quality has been identified as most important and ranked 1st.

There are several multi criteria decision making techniques which are widely used to evaluate the manufacturing system criteria and for future research, Linear weighted Average, AHP, and Fuzzy can be applied to rank the manufacturing system criteria. Moreover, increase in number of data may affect the proposed ranking of manufacturing system.

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Biographical Note:

***Sharfuddin Ahmed Khan** is Lecturer in the Industrial Engineering & Management department at University of Sharjah. Mr. Khan holds masters in Industrial and Systems Engineering from National University of Singapore (NUS) and bachelors in Industrial and Manufacturing Engineering from NED Pakistan. He has 5 years of industrial experience in the field of SCM and automotive manufacturing. His research interest includes Supply Chain Management, Warehouse Management, Manufacturing Systems, Quality Systems and Multicriteria Decision Making.

Syed Adeel Haneef Zaidi is experienced in advanced manufacturing, continuous improvements (CI) and new product development and introduction (NPI). He had earned a bachelor of engineering in Industrial and Manufacturing from NED University Karachi and also holds a Masters degree in Advanced Manufacturing Technology and Systems Management from The University of Manchester. Currently, he is a lecturer in King Fahd University at Mechanical Engineering. His research interests are manufacturing systems and advanced manufacturing processes.