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Evaluation of Competitive Priorities of Manufacturing System

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***Abstract*— Manufacturing System faces changing environment and competition among companies which makes regular improvements making process essential. Ample of criteria and constraints to determine best manufacturing strategy makes changes making complicated. Identifying competitive priorities for plant and industry and focusing on those competitive priorities through manufacturing using improvement programs and investing in people helps in getting competitive advantage over other companies.**

In this paper, a methodology for evaluation of these competitive priorities for manufacturing systems is presented. Analytical Hierarchical Process (AHP) – a Multi Criteria Decision Making (MCDM) tool is used to make a pair wise comparison of competitive priorities in manufacturing system. Ranking of competitive priorities for five companies in automobile sector is evaluated with rating which is recorded as solution for the given questionnaire. A questionnaire for an interviewing company executive is made for data collection in company. A pair wise comparison rating for each criteria and sub-criteria for each plant has evaluated.

This result for each plant is then compared. And order winning and order qualifying criteria are found for the industry. For enhancement of level of manufacturing system practitioners can follow this approach to evaluate its competitive priorities and compare with other companies and industry's best one.

***Index Terms*— Competitive priority objects, manufacturing system, AHP, manufacturing strategy.**

I. INTRODUCTION

Changing environment in manufacturing system, tough competition demands for the best manufacturing strategy for plant which should give competitive advantage over other. For this, evaluation of its competitive priorities for each plant is must. Each plant has its manufacturing capabilities and constraints which create a tread-off condition when selecting best manufacturing strategy for plant. For this a plant should focus on its high ranked competitive priority that is order winning competitive priority. And also try to excel in order qualifying competitive priority by increasing its manufacturing capability [1].

In a manufacturing system an industry needs to be improving itself to survive changing environment, defend and improve its market share. A manufacturing system is a collection of integrated equipment and human resources, whose function is to perform one or more processing and/or assembly operations on a starting raw material, part, or set of parts. In this the integrated equipment includes production machines and tools, material handling and work positioning devices, and computer systems. The manufacturing system is a place where the value-added work is accomplished on the part or product [2]. Changing complex social, political, financial, economic and market conditions affect the manufacturing system. Thus the manufacturing decisions are to be made according to these changes. Today's order winning criteria becomes tomorrow's order qualifying criteria [3]. The technological changes and resource planning allowed the utilization of manufacturing system to optimum. Hence a manufacturing needs to focus on improving productivity in its industry.

Competitive Priorities are defined as dimensions that a firm's production system must possess to support the demands of the markets that the firm wishes to compete in. Competitors identification and their strategy evaluation for determination of their strategies and weakness and relate to it's your own products and services is competitive analysis. This evaluation brings a critical part of company marketing plan. Such evaluation finds product or service uniqueness and therefore what criteria or attributes required for attracting target market can be found [4].

Decision making of modifying or utilization current resources to optimum is to be made in manufacturing system with care. For this choices/alternatives priorities selection and capability judgement has to be made. Manufacturing capacity is the limitation and ability of a business enterprise or a manufacturing plant, to produce a volume of product. This involves use of currently available resources, to produce goods in a given period of time. Choices/alternatives are the tangible or intangible factors affecting manufacturing environment. These choices /alternatives makes to choose one of them to custom the requirements as per the industry. This creates a trade off condition in the manufacturing environment.

In actual manufacturing environment, manufacturing system faces multiple choices/alternative to choose from, which choices/attributes are interdependent on each other so the ranking of priority is to be made to choose the optimum output from given environment of constraints. For this multiple criteria decision making (MCDM) [5] is adopted as a mathematical tool in priority ranking decision. MCDM methods are typically used in evaluation of multiple conflicting criteria in making decisions and calculate an optimum result from complicated data available.

Analytic Hierarchy Process (AHP) is developed by T. L. Saaty in 1980. AHP is a kind of MCDM tool [6, 7]. In AHP pair wise comparison is used to rate each criteria/attribute upon other criteria. This gives more accurate results than most other method in MCDM. AHP has been accepted and widely used in operation strategy and supply chain while in manufacturing strategic decision the application of AHP is found lowest [8].

II. LITERATURE REVIEW

Setting manufacturing strategy is one of the important decisions in a plant made for its smooth operation. Safsten, Winroth [9] concludes that plants should have manufacturing strategies, but it is better for company to focus on a few very important strategies than implementing all strategies in company. For this selection of competitive priorities for that manufacturing system is to be made. A concept of focused manufacturing is discussed by Skinner [10]. Focussing allows preparing competitive strength and offers the opportunity to stop compromising each element of the manufacturing system. Miltenburg [1] shows a framework for factories-within-a-factory (FWF). Dangayach and Deshmukh [11, 12] presented findings of an extensive survey of Indian manufacturing companies. His finding shows most of the Indian companies are still emphasizing on quality; however, automobile sector has set to compete globally with high innovation rate, faster new product development, and continuous improvement.

In industrial engineering applications evaluation of a number of alternatives is a final decision in terms of a number of criteria. Expressing criteria in different units or pertinent data is a difficult problem to evaluate [13]. The AHP is an effective approach developed by Prof. Thomas L. Saaty, is one of the MCDM methods used in dealing with this kind of decision problems. A case study in a China by Jiaqin Yang and Ping Shi [14] found overall performance of firm using AHP. Kamal M. Al-Subhi Al-Harbi [15] made AHP application in project management. In this criteria and priorities determination for contractor prequalification is done according to owner requirements and preferences.

III. RESEARCH METHODOLOGY

Competition and industries acts as a major role in strategic analysis. Competitors offering same or very similar products and competitors producing different products but which meet similar needs should be considered for strategic analysis. Due to complex manufacturing environment decision making requires expert's involvement and different value systems. A precise knowledge gives success rather than imprecise one. AHP application in manufacturing system decision making problem is described in this paper.

3.1 Competitive Priorities Selection

Competitive priority is selected from these priorities and Rank-wise competitive priorities of the company are to be arranged. Among the criteria discussed above, four categories are determined for analysis for the chosen firm. These criteria are categorized under four main-titles such as cost, quality, flexibility, and delivery [3, 16].

Below are the criteria under the classification of these four main-titles.

Sub-criteria	Description
Conformance Quality (CQ)	Improve conformance to design specifications
Product Durability(PD)	Provide durable product
Product Reliability (PR)	Offer consistent, reliable quality
Product Performance (PP)	Provide high performance product
Delivery Speed (DS)	Provide fast deliveries
Dependable Delivery (DD)	Make on time delivery or meet delivery schedules
Product Customization (PC)	Customize products to customer needs
Product Mix Changes (PM)	Make rapid product mix changes
Design Changes (DC)	Make rapid design changes
Volume Changes (VC)	Make rapid volume changes

Table 1: Sub-criteria for case study

3.2 Preparation of questionnaire

From a structured questionnaire followed by a series of interviews, mapping is attempted for manufacturing strategy-related issues in the firms. These issues include:

- Manufacturing mission/vision
- Methodology used for formulation, development, and implementation of manufacturing strategy
- Order qualifiers/order winners
- Structural/infrastructural issues
- Relative position of the firms

The weighted scale of 1 to 9 is adopted for pair wise comparison in the questionnaire.

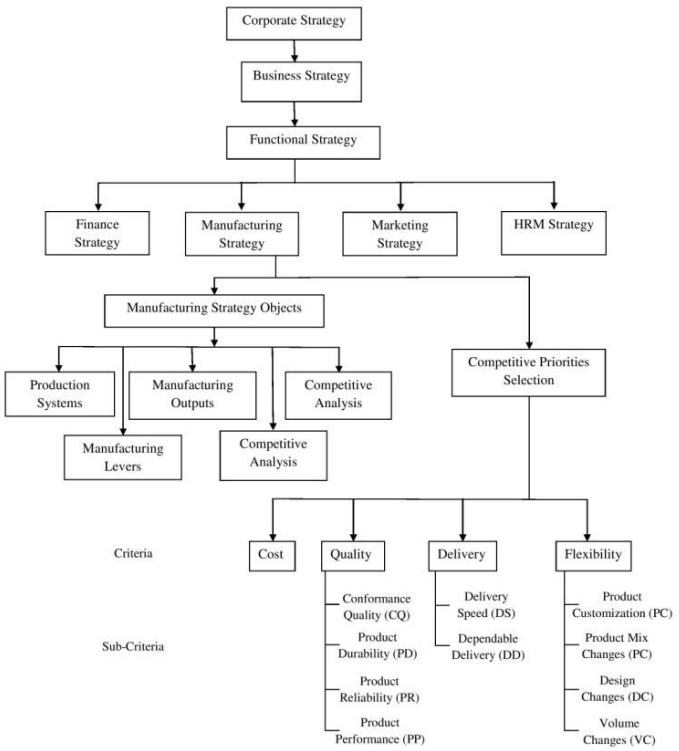

Figure 1: - Hierarchy of selection process

3.3 Selection of industry for case study

a) Automobile manufacturer

The automobile industry is an important component of industrial and economic progress over the world and its development has been characterized global competitiveness of leading industrialized economies. The automobile industry is fairly developed one and involves huge investments in research and development and technology and is seen as an indicator of the economic progress of the country. An understanding of the automobile industry in some of the developed countries enables one to study the emerging trends in developing countries.

b) Automobile parts manufacturer

No automobile company can produce all the components needed in an automobile. These companies have to purchase (even multinationals) various components from local suppliers. This is the boost to the auto component industry.

Survey methodology is used for case study. The objective of study is a collection of information about competitive priorities for decision making in manufacturing strategy for that company. The methodology was based on a questionnaire survey and personal interviews. Final version of the questionnaire was sent to the production manager of these companies. After reminders, phone calls, e-mail responses have been received.

IV. CASE STUDY

A case study in 5 automobile sectors plants (producing four-wheeler vehicles and automotive components) is made. Of these, one (A, B, C) is the major four-wheeler manufacturing company and remaining two companies (D, E) belong to the auto component manufacturers.

4.1 Design of questionnaire and data collection

A structured questionnaire has been developed for pair wise comparisons of competitive priorities. .Four major competitive priorities - Cost, Quality, Delivery and Flexibility are selected with their sub factors. In this case study - applying the AHP model in evaluating the long-term overall performance of this company.

4.2 Profile of respondents

Production manager of that companies having at least 5 years of experience was selected for this.

V. CASE ANALYSIS

Case analysis of all five case studies is explained in this section. The ranking of competitive priorities for all companies obtained by AHP evaluation is presented in this section.

Company A

Company A is a leading manufacturer of all types of four-wheeler vehicles. It produces a wide range of diesel commercial vehicles (heavy, medium and light commercial vehicles) and passenger cars. The company is the largest motor vehicle manufacturer in India and sixth largest commercial vehicle manufacturer in the world. It was established in 1945 and belongs to a giant industrial group of India, which produces diverse range of product in the plants all over the country. The company operates in multi-plant environment. The plant selected for study of this company produces commercial vehicles and passenger vehicles.

Matrix of Pair wise comparison given by company respondents for company A is shown in Table 2. Pair wise for the sub factors for quality, delivery and flexibility is shown in Table 3, 4 and 5. These are the matrix inputs from company A. Composite priority weights for critical success factors calculated using AHP gives the local weights and global weights of each criteria and sub-criteria which is shown in Table 6. This global weight indicates the ranking of each competitive priority. Order qualifying and order winning criteria are so determined by this ranking. A company must meet criteria for a customer even to consider it as a competitor those criteria are order qualifiers. And the criteria those win the order are the order winners. To provide qualifiers companies need not only to be as good as

competitors, but also to provide order winners they need to be better than competitors [3]. A competitive priority having first ranking in priority is its order winning criteria and second ranked priority is its order qualifying criteria. Global weights are the product of local weights of criteria and sub-criteria evaluated. Global weights for company B, C, D and E are calculated similar to company A.

Order winners and qualifiers indentified for company A are as follows:

Order winners: Product Performance, Conformance Quality

Order qualifiers: Low Cost

Table 2: Pair wise comparison matrix for company A

Factor	Cost	Quality	Delivery	Flexibility	Priority
Cost	1	0.2	4	3	0.218
Quality	5	1	6	6	0.611
Delivery	0.25	0.167	1	0.5	0.067
Flexibility	0.33	0.167	2	1	0.102
				Consistency Ratio (CR) =	0.070

Table 3: Pair-wise comparison matrix for quality

Factor	CQ	PD	PR	PP	Priority
CQ	1	3	5	0.333	0.256
PD	0.333	1	4	0.167	0.131
PR	0.2	0.25	1	0.167	0.057
PP	3	6	6	1	0.555
				CR=	0.091

Table 4: Pair-wise comparison matrix for delivery

Factor	DS	DD	Priority
DS	1	6	0.857
DD	0.167	1	0.143
		CR=	0

Table 5: Pair-wise comparison matrix for flexibility

Factor	PC	PM	DC	VC	Priority
PC	1	0.333	0.167	0.125	0.048
PM	3	1	0.25	0.167	0.101
DC	6	4	1	0.2	0.244
VC	8	6	5	1	0.605
				CR=	0.105

Table 6: Composite priority weights for critical success factors

Criteria	Local Weights	Sub-criteria	Local Weights	Global Weights
Cost	0.218	Low Cost (LC)	1	0.218
Quality	0.611	Conformance Quality (CQ)	0.256	0.156
		Product Durability(PD)	0.131	0.079
		Product Reliability (PR)	0.057	0.035
		Product Performance (PP)	0.555	0.339
Delivery	0.067	Delivery Speed (DS)	0.857	0.058
		Dependable Delivery (DD)	0.143	0.009
Flexibility	0.102	Product Customization (PC)	0.048	0.005
		Product Mix Changes (PM)	0.101	0.011
		Design Changes (DC)	0.244	0.024
		Volume Changes (VC)	0.605	0.062

Company B

This company is the largest seller of tractors all over the world and by production one of the largest vehicle manufacturers in India. The Brand Trust Report, India Study 2014 ranked it the 10th most trusted brand in India, also it was ranked 21st in the list of top companies of Fortune India in Fortune India 500 in 2011. This company was set up as a steel treading company in 1945.

Order winners and qualifiers indentified for company B are as follows:
Order winners: Product Performance

Order qualifiers: Low Cost

Table 7: Pair wise comparison matrix for company B

Factor	Cost	Quality	Delivery	Flexibility	Priority
Cost	1	0.33	4	4	0.287
Quality	3	1	5	4	0.517
Delivery	0.25	0.2	1	2	0.111
Flexibility	0.25	0.25	0.5	1	0.083
				CR=	0.079

Table 8: Pair-wise comparison matrix for quality

Factor	CQ	PD	PR	PP	Priority
CQ	1	3	2	0.5	0.259
PD	0.333	1	0.25	0.25	0.082
PR	0.5	4	1	0.25	0.181
PP	2	4	4	1	0.476
				CR=	0.074

Table 9: Pair-wise comparison matrix for delivery

Factor	DS	DD	Priority
DS	1	0.25	0.2
DD	4	1	0.8
		CR=	0

Table 10: Pair-wise comparison matrix for flexibility

Factor	PC	PM	DC	VC	Priority
PC	1	0.5	2	0.333	0.174
PM	2	1	3	1	0.347
DC	0.5	0.333	1	0.5	0.124
VC	3	1	2	1	0.354
				CR=	0.038

Company C

This company was founded in 1948 and manufactures commercial vehicles like trucks, buses including emergency and military vehicles. Total 6 plants operating in different parts of country makes vehicle spare parts and engines for marine and industrial applications. It has annual sales of about 6000 vehicles and 7000 engines. In heavy and medium commercial vehicle segment this company is second largest Indian company. It is a in the bus segment market leader with passenger transportation options, this range from 19 seater to 80 seater vehicles. The plant selected for study of this company produces tractors.

Order winners and qualifiers indentified for company C are as follows:

Order winners: Product Reliability

Order qualifiers: Low Cost

Table 11: Pair wise comparison matrix for company C

Factor	Cost	Quality	Delivery	Flexibility	Priority
Cost	1	0.25	3	4	0.244
Quality	4	1	6	4	0.562
Delivery	0.333	0.167	1	2	0.109
Flexibility	0.25	0.25	0.5	1	0.083
				CR=	0.091

Table 12: Pair-wise comparison matrix for quality

Factor	CQ	PD	PR	PP	Priority
CQ	1	0.25	0.25	0.5	0.085
PD	4	1	0.25	2	0.229
PR	4	4	1	5	0.558
PP	2	0.5	0.2	1	0.126
				CR=	0.072

Table 13: Pair-wise comparison matrix for delivery

Factor	DS	DD	Priority
DS	1	0.25	0.2
DD	4	1	0.8
		CR=	0

Table 14: Pair-wise comparison matrix for flexibility

Factor	PC	PM	DC	VC	Priority
PC	1	4	6	1	0.427
PM	0.25	1	3	0.33	0.141
DC	0.167	0.333	1	0.25	0.069
VC	1	3	4	1	0.362
				CR=	0.033

Company D

Company D has been promoted by the India's largest auto component manufacturers in the world. The promoter company, which was established in 1962, is among the largest steel manufacturers in the world. The company has annual turnover of about USD 375 Million (FY 2012-13) which includes segments like Tractors, Single Piece wheels, Cars/ UVs, Commercial vehicles, and Construction & Earth Movers wheels. The company manufactures also include trucks, buses and air suspension kits. This company is a global player in the auto components industry, its Earth Movers & Construction equipment segment brings turnover of over 15% from exports.

Order winners and qualifiers indentified for company D are as follows:

Order winners: Delivery Speed

Order qualifiers: Product Performance

Table 15: Pair wise comparison matrix for company D

Factor	Cost	Quality	Delivery	Flexibility	Priority
Cost	1	0.2	0.25	2	0.106
Quality	5	1	0.25	4	0.274
Delivery	4	4	1	7	0.556
Flexibility	0.5	0.25	0.142	1	0.062
				CR=	0.102

Table 16: Pair-wise comparison matrix for quality

Factor	CQ	PD	PR	PP	Priority
CQ	1	3	5	0.333	0.306
PD	0.333	1	4	0.167	0.155
PR	0.2	0.25	1	0.167	0.082
PP	3	6	6	0.167	0.455
				CR=	0.101

Table 17: Pair wise comparison matrix for delivery

Factor	DS	DD	Priority
DS	1	6	0.857
DD	0.167	1	0.142
		CR=	0

Table 18: Pair-wise comparison matrix for flexibility

Factor	PC	PM	DC	VC	Priority
PC	1	0.333	0.167	0.125	0.048
PM	3	1	0.25	0.167	0.102
DC	6	4	1	0.2	0.244
VC	8	6	5	1	0.605
				CR=	0.105

Company E

It is an automobile plant manufacturing firm which manufactures speedometers for leading automobile company. It is a group company that entered into a joint venture with a USA based company which is a leading manufacturer of Electronic instruments.

Order winners and qualifiers indentified for company E are as follows:

Order winners: Low Cost

Order qualifiers: Dependable Delivery

Table 19: Pair wise comparison matrix for company E

Factor	Cost	Quality	Delivery	Flexibility	Priority
Cost	1	4	1	5	0.416
Quality	0.25	1	0.333	1	0.107
Delivery	1	3	1	5	0.388
Flexibility	0.2	1	0.2	1	0.088
				CR=	0.009

Table 20: Pair-wise comparison matrix for quality

Factor	CQ	PD	PR	PP	Priority
CQ	1	0.333	1	1	0.172
PD	3	1	4	1	0.427
PR	1	0.25	1	1	0.164
PP	1	1	1	1	0.236
				CR=	0.076

Table 21: Pair-wise comparison matrix for delivery

Factor	DS	DD	Priority
DS	1	0.2	0.167
DD	5	1	0.833
		CR=	0

Table 22: Pair-wise comparison matrix for flexibility

Factor	PC	PM	DC	VC	Priority
PC	1	4	3	4	0.512
PM	0.25	1	0.333	3	0.156
DC	0.333	3	1	2	0.237
VC	0.25	0.333	0.5	1	0.095
				CR=	0.106

VI. CROSS CASE ANALYSIS

Figure 2 show that companies from automobile industries gives flexibility a low priority among all other competitive priorities. Automobile part manufactures gives delivery a decent importance. On an average quality is a highest weighted criterion among case companies followed by cost, delivery and flexibility. Any attempt to improve manufacturing system as per market change will certainly help to achieve high market share and competitive advantage over other manufacturers.

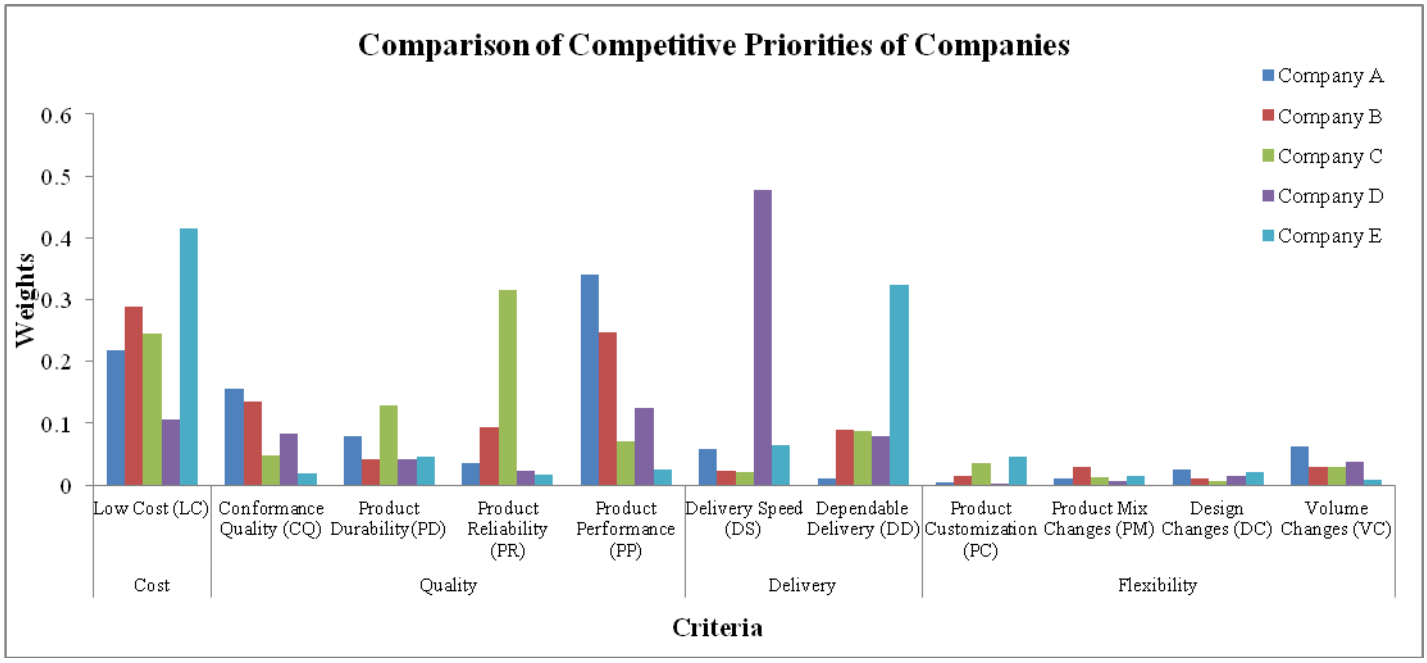

Figure 2: Comparison of Competitive Priorities of Companies

VII. DISCUSSION AND CONCLUSIONS

Paper presents a systematic case based approach to evaluate and rank competitive priorities in manufacturing system of five cases using AHP a MCDM tool. For this study five cases from automobile sector is selected. A conceptual model with four criteria, eleven sub-criteria has been developed. A structured questionnaire for pair wise comparison is used for study. Evaluating this response the following results are observed.

Company A, B and C were automobile manufacturer producing commercial and private vehicles emphasizing quality as there order winning criteria and cost as order qualifying criteria. Company D and E were automobile part manufacturer companies. Company D is an automobile wheels manufacturer has delivery as order winning criteria and as there order qualifying criteria. Company E is a manufacturer of speedometers, fuel level sensors, temperature sensors and dashboard clocks have cost as order winning criteria and delivery as order qualifying criteria.

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