Study the Effect of Advanced Manufacturing Technologies on Manufacturing Industries

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ABSTRACT

This paper revolves around the impact of Advanced Manufacturing Technologies in Indian Manufacturing industries. Statistics inculcates that a number of industries subsists, which are using different forms of Advanced Manufacturing Technologies (AMT). “Advanced Manufacturing Technologies (AMT)” is a generic term, depicting an assembly of manufacturing technologies, which combines both scope and scale capabilities in a manufacturing environment.

Keywords: Advanced Manufacturing Technologies (AMT), CAD, CAM, CNC, JIT, etc.

I. INTRODUCTION

Advanced manufacturing technology (AMT) is broadly defined by distinguished authors in their terminologies; Small and Chen, (1995) say, it is “An automated production system of people, machines and tools for the planning and control of the production process, including the procurement of raw materials, parts and components and the shipment and service of finished products”. In particular, the AMT can be defined as any new manufacturing technique, which is likely to cause constructive changes in a firm’s manufacturing practices, management systems and its approach for the designing and production of various engineering products. Advanced Manufacturing Technologies are classified into two classes: hardware and software by Small and Yasin (1997).

I) Pure Technical tools (hardware)
II) Management tools (manufacturing practice software)

Pure Technical tools or Advanced Technical tools (hardware) can be further classified into the following range of technologies:

(A) Computer aided design (CAD)
(B) Computer numerical control machines (CNC)
(C) Direct numerical control machines (DNC)
(D) Robotics (RO)
(E) Flexible manufacturing system (FMS)
(F) Automated material handling systems (AMHS)
(G) Automated guided vehicles (AGV)
(H) Automated storage and retrieval system (AS/RS)
(I) Rapid prototyping (RP)

The Manufacturing Practice Software or Production Management tools are additionally classified into the following array of technologies:

(A) Material requirement planning (MRP)
(B) Manufacturing resource planning (MRP II)
(C) Enterprise resource planning (ERP)
(D) Activity based accounting systems (ABC)
(E) Total Quality Management (TQM)
(F) Recycling (RC)
(G) Business Process Re-Engineering (BPR)
(H) Statistical Process Control (SPC)
(I) Just-In-Time (JIT)
(J) Benchmarking (BM)
(k) Management Training (MT)

The implementation of AMT affects not only the manufacturing division of a plant, but also the Marketing, Human Resource, Research and Development, and Engineering Design divisions. These technologies transform the design of a plant as well as the relationship between these various interconnected units. The relationship between the firm and its customers also changes; for example, firms can adjust to frequent changes with respect to the demand, more quickly and would be able to offer better quality, shorter lead times, and improved reliability. For organizations that have successfully implemented AMT, the benefits have been outstanding. The liberalization of the economy has opened new windows of opportunities for the Manufacturing sector. Overall the growth of manufacturing industry is sustained on Innovations, Research and Development.

II. LITERATURE REVIEW

Advanced Manufacturing Technology (AMT) express a wide diversity of modern manufacturing systems, mainly computer based which are devoted to the improvement of manufacturing operations. There is a
continuum of possible advanced manufacturing system that can be implemented by an industry. This confines from stand-alone units such as a robot, to more integrated systems such as flexible manufacturing systems and ultimately to fully integrated systems called Computer Integrated Manufacturing (CIM). The implementation of advanced manufacturing technology develops the aspects of any manufacturing plant. The extent to which a plant will modify is reliant on the number of advanced manufacturing technology implemented as well as the level of investment. It has been shown that flexibility often reduces the engineering cost of designs development and the ancillary system conversion. An implementation of advanced manufacturing technology consequence in a decrease in total human resource costs, because advanced manufacturing technology reduces the turnover rates by increasing employee satisfaction (thus decreasing recruiting and training costs). Advanced manufacturing technologies have also been shown to minimize the amount of rework and scrap, which explicate into improved quality and reliability for the customer. In order to express the importance of advanced manufacturing technology for industries, the current literature focuses on the organizational factors, critical for the successful implementation of AMT as well as their impact on the market structure and competitive advantage of the industries. It will also express the impact that advanced manufacturing technology can be in a plant, firm and even industry in order to advancement in the account of the importance of the completion from this study. A careful examination of these conceptualizations reveals it is possible to split AMT investigated into six clear AMT provinces:

1. A design and planning province, i.e. advanced design and engineering technologies (ADET); concerned largely with design and engineering technologies, such as CAD, CAE, GT and CAM;
2. A production planning and logistics-related province i.e. Advanced Planning Technologies (APT); concerned with production and logistic planning, such as MRP, MRP II and ERP;
3. A materials handling province i.e. Advanced Material Handling Technologies (AMHT): which materials handling and transporting of materials, such as ASRS and AGVs;
4. A manufacturing province i.e. Advanced Machining Technologies (AMT) – concerned with repetitive production technologies such as robotics and numerical control machine (NC/CNC/DNC);
5. A manufacturing province i.e. advanced management systems: comprises of as production management tools and can be classified as TQM, BPR, SPC, and JIT.
6. A manufacturing province, i.e. advanced improvement process systems: comprises some advanced process improvement technologies are: bench marking, recycling, kaizen and management training.

III. METHODOLOGY

A structured questionnaire was developed to qualify the presumptions; the questionnaire which is used in this study has been incorporated with inputs from various sources: most of the questions were adapted from formerly published works and henceforth, the preliminary draft of the questionnaire was discussed with the academic scholars and practitioners. The questionnaires were administered by post, accompanying a covering letter and a business reply envelope, to a total of 240 industries, out of which 68 industries reverted back with their data. After the compilation and analysis of the received data, investigation was carried out on the following key points related to the Manufacturing Industries and AMT.

1. Manufacturing strategy of manufacturing industry
2. Different types of advanced manufacturing technologies
3. Level of investment on AMT
4. Effect on manufacturing performance after accomplishment of AMT

IV. DESCRIPTIVE ANALYSIS

The basic survey data was presented for four broad manufacturing sectors on selection of firm and industry characteristics. Indian manufacturers enjoy the advantages of cheaper raw materials and accessibility of educated, qualified and skilled labor as well as engineers and designers at much lower costs. Technological advancements made by some of these domestic conglomerates have allowed them to become incorporated associates rather than outsourcing associates.

The study investigates different types of advanced manufacturing technologies (AMT), which are commonly used by manufacturing industries. These technologies can be grouped based on their functionalities, into six subgroups:

1. Advanced design and engineering technology
2. Advanced machining technology
3. Advanced planning technology
4. Advanced material handling technology
5. Advanced management system
6. Advanced process improvement system

Industries were asked to indicate the amount of investment in the individual technology, on a five point scale of 1 to 5, where 1 indicate no investment and 5 to show heavy investment. Industries were determined to be either users or non users of each technology sub-group. For example, an adopter of the design and engineering technology sub group would be using a combination of either CAD,CAM,CAE,GT or all the above. Analysis of the AMT adoption of the manufacturing industries surveyed is based on the level of investment in the technology.

4.1 ADVANCED DESIGN AND ENGINEERING TECHNOLOGIES

Manufacturing industries invested in various design and engineering technologies such as computer
aided design (CAD), computer aided manufacturing (CAM), computer aided engineering (CAE), and group technology (GT) to assist them in designing and testing a product, from a structural or engineering point, controlling of manufacturing machinery, and also for part classification and coding systems.

Figure 4.1: Advanced design & engineering technologies in different sector

ADT1: Computer Aided Design, (CAD) ADT2: Computer Aided Manufacturing (CAM), ADT3: Computer Aided Engineering (CAE), ADT4: Group Technology (GT),

It is observed by the figure 4.1 that the most common advanced design technology among the industries surveyed is CAD, which encountered above moderate investments, i.e. means score of 3.9; followed by CAM, with mean score of 3.7. The results show that the least investment is in GT with mean score of less than 3.

4.2 ADVANCED MACHINING TECHNOLOGY

The study examines the level of investment and integration of four types of assembly and machining technologies: computer numerical control machines (CNC), numerical control/direct numerical control machines (NC/DNC), flexible manufacturing system (FMS), and robotics (RO). These AMTs are used to perform repetitive functions and work without permanent alteration of the equipments. Computer numerical control machine operates by the computer and control all types of machining operations such as turning, boring, milling, drilling, machining centre etc. numerical control or direct numerical control machines directly control the machining operation such as turning, boring, milling, drilling, machining centre etc. Flexible manufacturing system is used to coordinate the handling and transport through centralized control. Robotics is to carry out various operations like handling, process or assembly tasks.

Fig4.2: Advanced machining technology in different sector

AMT1: Computer numerical control (CNC), AMT2: Numerical control/Direct numerical control (NC/DNC), AMT3 Flexible manufacturing system (FMS), AMT4: Robotics (RO)

As shown in figure 4.2, regardless of the sector of the manufacturing industries, the most important investments are made in CNC technology. All the manufacturing industries are invested less in robotics technology.

4.3 ADVANCED PLANNING TECHNOLOGY

Manufacturing industries invested in various planning technologies such as material requirement planning (MRP), manufacturing resources planning (MRP II), enterprise resources planning (ERP) and activity based counting (ABC) to assist them in planning, scheduling and controlling of material and resources requirements for the production of manufacturing industries.

Figure 4.3: Advanced planning technology in different sector

APT1: Material requirement planning (MRP), APT2: Manufacturing resource planning (MRP II), APT3: Enterprise resource planning (ERP), APT4: Activity based counting (ABC).
The whole manufacturing industries seem to reach an agreement on the investment in advanced planning technologies. As shown in figure 4.3, their investments in MRP, MRPII, ERP and ABC analysis are generally moderate. The manufacturing industries invest more on MRP and MRPII and least on ABC analysis.

**4.4 ADVANCED MATERIAL HANDLING**

Material handling technologies are Advanced Manufacturing Technologies (AMTs) used by manufacturing industries to facilitate the handling of material in manufacturing operations. Automated storage and retrieval systems use computer to direct automatic loaders to pick and place items for production processes or storage by automatic high lift trucks. Industries employ transport automation by using automated guided vehicles (AGVs) to move materials from one place to another.

![Figure 4.4: Advanced material handling in different sector](image)

**AMH1**: AMHS, **AMH2**: AGV, **AMH3**: AS/RH, **AMH4**: RP

The study shows that industries surveyed have little investment in material handling technologies. Generally, industries invested more in automated material handling system as compared to AGV, AS/RS, RP. It is observed from the figure that the investment on material handling system is different in different sector.

**4.5 ADOPTION OF ADVANCED MANUFACTURING TECHNOLOGY**

The adoption of advanced manufacturing technologies (AMT) allows industries to diverge from the traditional manufacturing strategies of striving for low-cost leadership and differentiation. Effective adoption of AMT enables industries to achieve economies of scale and scope simultaneously. That is, implementing AMT reduces the cost of future product innovation, allowing the industries to increase its speed of response to market and competitive changes. Therefore, investment in AMT represents a strategic option, the value of which increases in an environment of competitive and market uncertainties. Respondents were asked to rate the industry efficiency in term of productivity, plant efficiency, product management and market performance on a 1 to 5 point level scale, where 1 indicate lower efficient, 3 indicate average and 5 indicate well above efficient.

![Figure 4.5: Adoption of advanced manufacturing technology in different sector](image)

**AAMT1**: Productivity, **AAMT2**: Plant efficiency, **AAMT3**: Product management, **AAMT4**: Market performance

It is observed from the figure 4.5 that owing to adoption of advanced manufacturing technology productivity, efficiency, product management, market performance are increased. As shown in figure that in different sector due to adoption of advanced manufacturing technology different factors are increased. It is concluded that efficiency enhancement of manufacturing industries through advanced manufacturing technologies.

In terms of AMTs investment, generally surveyed industries invested moderate in AMTs, The most invested technologies are in design and engineering technology, followed by machines and planning technologies. Industries invested least in material handling technologies. There is no apparent indication as to which sectors have more AMTs than other, different sectors invested different level of AMTs, automobile sector invested more in material handling as compared to other sectors.

The manufacturing industries invested more in advanced managements systems as compared to advanced improvement processes. The performance of industries is increased due to adopted or implemented by advanced manufacturing technologies. Automobile industries invested more in advanced manufacturing technologies, owing to that the productivity and performances of automobile industries are increased. It can be conclude that due the adoption of advanced manufacturing technology performance or efficiency of manufacturing industries are increased.

**V. HYPOTHESIS TESTING**

The value cronbach’s $\alpha$ is 0.9629, it is suggested that contingency of advanced design and engineering technology is good in manufacturing industries.

**Null hypothesis ($H_0$):** Advanced design and engineering technology is same for different sector.
Alternative hypothesis: (Hₐ) Advanced design and engineering technology is different for different sector.

According to test, null hypothesis is rejected; it means advanced design and engineering technology different for different sector. Cronbach’s α is 0.8861; which means that all technologies are correlated.

Null hypothesis (H₀): All advanced machining technology are same for all sectors.

Alternative hypothesis (Hₐ): All advanced machining technology are different for all sectors.

According to test null hypothesis is rejected, it means all advanced machining technologies are different for different sectors.

All the advanced planning technologies are positively correlated and the value of cronbach’s α is 0.9259, which indicates strongly reliable variables.

Null hypothesis (H₀): All sectors invest same in advanced planning technologies.

Alternative hypothesis (Hₐ): All sectors invest different in advanced planning technologies.

According to test null hypothesis is rejected, which concluded that the level of investment are different for different sectors.

Null hypothesis (H₀): Level of investment is same by different sector.

Alternative hypothesis (Hₐ): Level of investment is different by different sector.

According to test null hypothesis is rejected which indicate that the level of investment by different sectors are different in advanced material handling systems.

Null hypothesis (H₀): Efficiency enhancement through advanced manufacturing technologies.

Alternative hypothesis (Hₐ): Efficiency decrease through advanced manufacturing technology.

According to test null hypothesis is accepted, which indicate that efficiency enhancement of manufacturing industries through advanced manufacturing technologies.

VI. CONCLUSION

1. CAD is the most popular technology and GT is the least favorable technology for manufacturing industries. Process industries invest relatively less in advanced design and engineering technologies than automobile and electronics industries. Although most industries choose to have investments in advanced design and engineering technologies. All sectors share the almost same point that investment in CAD takes the most important position followed by the CAM and CAE, while GT is worth the least to invest.

2. The most important investments are made in CNC technology. All the manufacturing industries are invested less in robotics technology. In automobile industries the most investment are made in CNC technology followed by NC/DNC and flexible manufacturing system. In electronics industries & machinery industries the most investment in CNC followed by flexible manufacturing system and NC/DNC. In process industries investment in flexible manufacturing and CNC are almost same followed by NC/DNC. Except the automobile industries all other industries invest less on robotics technology.

3. The automobile and electronics industries have moderate investment in material handling technologies. It is concluded that material handling technologies (AMHS, AS/RS, AGV ) gets the least attention in manufacturing industries.

REFERENCES