Advanced Manufacturing Technology Utilization: A Review

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ABSTRACT

With the liberalization and globalization of today's economy, a lot of pressure has come on the organizations in developing countries especially in India to perform better in the coming days. This is because that company has improved their technological status by implementing advanced manufacturing technologies (AMTs) through joint ventures or licensing agreements. However, this has brought a lot of difficulties at all levels to improve the utilization level of advanced manufacturing technologies of the organizations. The present work has been taken up to look into the issues concerning technology utilization from existing literature to help the enterprises in this competitive world. Issues have been presented in two parts. In this paper, issues related to hurdles/barriers for advanced manufacturing technologies have been reviewed and synthesized in the second section. In the third section, remedies actions were taken to resolve the issues related to technology utilization have been reviewed and presented. Conclusions from the literature review have been presented in the fourth section.

Keywords: Advanced Manufacturing Technologies (AMTs); Less Developed Countries (LDCs); Human Resources; Technology Utilization; Indian Industry.

1. INTRODUCTION

The word 'Technology' has been derived from the Greek word 'Techno-logia'-Techno means an art or skill and 'Logia' means science or study [5]. Thus technology means systematic treatment of, art or skill. According to Oxford English Dictionary, 'Technology is application of scientific knowledge for practical purposes'. Different people view technology from different angles; it carries different meaning to different people in different situations. Technology is defined as, "the practical knowledge, know–how, skill and artifacts that can be used to develop a new product or service and a new production/delivery system" [38]. Also technology is the knowledge, tools, equipment and work techniques used by an organization in delivering its products or services [42].

In today's highly dynamic and rapidly changing environment, manufacturing scenario has undergone a rapid change in the last two decades, more so in the last few years. The manufacturing units are continuously trying to update themselves by acquiring or developing new technologies. At present, the very survival of Indian industry depends upon effective utilization of new technologies. For gaining competitive advantage and developing firm's internal capabilities, technology utilization is considered to be one of the most critical elements for a firm. As technology is crucial to the development of a country, the management of such an important resource, both at national and enterprise levels, is vital. All this calls for an effective utilization of new technologies for sustained growth of the enterprise and for greater competitiveness [8]. Advanced manufacturing technology (AMT) can have different levels of impact depending upon their pervasiveness and the structure of organization and society. Technology and social change are inter-dependent. Implementation of the newer technologies is a long-term decision. The long-term plans should provide room for technological and possible physical expansion [5].

The purpose of this paper is to look into the issues for improving the utilization level of advanced manufacturing technologies (AMTs) in Indian Manufacturing Industry. In attempting to accomplish this objective, the study is divided into two sections. In the coming section, issues related to hurdles/barriers for advanced manufacturing technologies have been reviewed and synthesized. In the next section, some remedies actions are taken to resolve the issues.

2. ADVANCED MANUFACTURING TECHNOLOGIES (AMTs)

Noori [17] defined advanced manufacturing technologies (AMTs) as new technologies which are used directly by the firm in the production of a product. In the past 20 years, AMT has been widely used by manufacturing companies all over the world. However, world-wide research found that not all AMT perform as expected. Some AMT perform very bad and leads to a total failure. Some AMTs perform "satisfactory", but did not produce the full benefits. It was found that CAD, MRP, LAN, and CNC machines are the most popular AMTs used now as pointed out by Sun [18]. Advanced manufacturing technology (AMT) appeared to represent a perfect marriage between technological potential and the manufacturing challenges [16]. AMT refers to manufacturing process technologies that use computers to store and manipulate data [19]. AMT is an umbrella term used to describe a wide range of automation and related technologies, which have emerged during the past two decades as a consequence of developments in information technology. More specifically, AMT can be described as a group of computer-based technologies, including computer-aided design (CAD), computer numerical control (CNC) machines, direct numerical control (DNC) machines, robotics (RO), flexible manufacturing systems (FMS), automated storage and retrieval system (AS/RS), automated material handling systems (AMHS), automated guided vehicles (AGV), rapid prototyping (RP), material requirement planning (MRP), statistical process control (SPC), manufacturing resource planning (MRP II), enterprise resource planning (ERP), activity-based costing (ABC), and office automation (OA). Past research has described advanced manufacturing technology as a multi-dimensional construct that includes the use of 'hard' machine related aspects: robotics, CNC hardware, CAD/CAM, etc.; and 'soft' reduction techniques, JIT, etc. [43, 24 and 30].

One key aspect of successful AMT systems that researchers have neglected to integrate under the rubric of advanced manufacturing technologies and practices is the human element. It is now widely recognized that the benefits of hard investments in advanced technology are largely moderated by concurrent investments in soft technologies and practices [34, 11and 37].

2.1 Managing Technology

The manufacturing units are continuously trying to update themselves by acquiring or developing new technologies. This need is dictated by economic, social, technical and environmental effect which the new or advanced technologies may have. Generally the new technologies are not utilized to the maximum. The reasons may be; technologies acquired only for the image of the company, choosing wrong area for technology up-gradation and overlooking socio-psychological barriers. To improve utilization, a comprehensive approach involving care and caution should be employed [23]. The acquired technology should be utilized fully to improve the production facilities to meet the growing demand for higher quality, less cost, large variety, customer oriented products and services [15].

Superior utilization of newer technology is the most important ingredient of economic success. To manage technology effectively requires a better understanding not only of technology itself, but of the evolution, maturation, and diffusion of technologies throughout the global economy [36]. The importation of technology does not imply full understanding and mastery of that particular technology. In spite of massive flow of foreign technology, most developing countries have yet to develop a strong indigenous technological capability [31]. One of the major issues raised by several scholars has been the lack of technological capabilities to absorb the imported technology by less developed countries (LDCs), which results in fewer utilization of technology. Utilizing technology and management effectively is important for a firm and is widely accepted as a means for creating a sustainable competitive advantage.

The introduction of AMTs led to an increase in the competitiveness of the Cypriot manufacturing industry in terms of improved product market characteristics, improved plant utilization and flexibility and increased local market share [2]. The reliability, speed of operation, accuracy, compactness, economical and low energy consumption of new technology has greatly extended its range of applications. The present day competition and cost pressures have increased the determination of many employers to overcome inertia and resistance to new patterns of work and organization for which the aid of new technology can be enlisted [10].

In an increasingly globalize and inter-linked world economy, the difficulties of implementing technology acquisition and utilization programs are important forces driving economic growth. Traditional methods of investment evaluation in manufacturing industries have restricted the implementation of advanced manufacturing technology and have contributed to the decline in manufacturing competitiveness. Speeding up the transition process from emerging technologies to new industries is central to successful economic growth, employment, competition, and sustainability in economies [40].

At present, the very survival of Indian industry depends upon effective utilization of new technologies. Many researchers have carried out significant work in the area of newer technology and its utilization by adopting strategic technology management system in the organization on the long-term basis. Advanced technology and its utilization have continuously drawn attention from scholars. This is reflected in a number of survey articles, reviews and case studies. Relevant articles are reviewed as under. The literature related to the present work was reviewed to eliminate waste and achieve manufacturing excellence.

2.2 Hurdles during Advanced Manufacturing Technology Utilization

2.2.1 Resistance from the Employees: Recent years have seen a growing concern of the Indian industrial worker to cope with radical technological changes such as the introduction of Advanced Manufacturing Technologies (AMTs). Adding to the concern is the indispensability of these technologies in meeting global competition. A study of workers in the Indian Automobile Industry shows that while the workers have a significantly positive attitude towards the introduction of new technologies like AMT, they are apprehensive about organizational issues, for example management's objective behind change, skill redundancy [3]. Technology itself increases output and increases demand by increasing productivity. However, the introduction of new technology in the short term will reduce employment as the productivity is increased, leads to resistance from employees [32].

2.2.2 Lack of Training to Employees: As technology changes, so do the skills workers need. In order to compete successfully in the global market, manufacturing organizations must aim at training workers in skills necessary to produce quality goods. Most manufacturing organizations train their employees in various ways, using different means, and achieving different levels of proficiency. Rarely does one find standardized and consistent training programs to develop worker skills; optimal training programs are not generally known. This leads to workers acquiring industry or company-specific skills, often leaving them with only a few transferable skills. It has been shown that variables such as comprehensive training are essential to human resource management practices, particularly in advanced manufacturing environments [35, 28 and 39]. Specifically, many organizations have failed to upgrade worker skills to levels compatible with advanced manufacturing technologies [29].

2.2.3 Long Term Commitment: Commitment from top management is a critical factor in any major organizational change Top management must designate key personnel to oversee the automation project and allocate sufficient financial and other necessary resources to the project [22]. Since factory automation involves strategic and long-term decisions, top management should be more broad-minded, and must be willing to take short-term risks for long-term gains. Many major benefits of factory automation are either long-term or strategic in nature. These benefits are often difficult to quantify, thus only a small part of the benefits can be taken into account by traditional justification methods [9].

2.2.4 Lack of Management Experience and Knowledge: Technology change is a major factor to increase productivity and help organizations to obtain a competitive advantage. In the utilization of new technologies, individual and managerial variables influence directly the use of new technology [27]. Kochen and Chin [26] have investigated that managerial competence is a critical success factor in technology utilization. Utilization of new technology is crucial to the overall management of technology. Successful implementation and utilization of new technology require a commensurate organizational commitment [23]. The various types of AMTs such as computer-aided-design and manufacturing (CAD/CAM), flexible manufacturing systems (FMS), robotics,

material requirements planning systems (MRP), etc. present new strategic opportunities and promise to revolutionize production processes. A good planning system will aid managers to more carefully evaluate the cost effectiveness of the various alternatives, facilitate an appropriate choice of the AMT [25].

2.2.5 Lack of Infrastructure: Industries all over the world are acquiring new technologies. However, it is seen that expensive machinery and equipment is generally not put to use in a manner in which it was planned in the beginning. According to Bhardwaj et al. [1], the most serious problem is the lack of a well-established industrial infrastructure in developing nations. The second most important factor is the need for an adequate number of technical professionals to properly implement new technologies.

2.2.6 Lack of Trained Professionals: It is accepted that technological innovation is a critically important activity that has become the primary driver for competition in the 21st century. Advances in technology have moved manufacturing organizations toward a new competitive landscape. Managers in manufacturing organizations are experiencing the emergence of advanced manufacturing technologies (AMT) such as CAD/CAM, CIM, CAPP, FMS and robotics.

It is well recognized that the failure of many companies to transition to modern competitive manufacturing organizations is primarily due to their mismanagement of human resources [4]. A number of investigators have shown that worker skill levels are a direct determinant of levels of quality performance. It is also suggested that investments in human resources should keep pace with the changing technology particularly if the workers are to take responsibility for quality, productivity, and customers [21].

2.2.7 Uncertainty in Market Conditions: The international globalization of the World markets for manufactured goods has placed an emphasis on nations to improve manufacturing productivity. This need to improve productivity is further prompted by a potential loss of competitive edge in the global marketplace. The market competitiveness and efficiency of any nation is primarily dependent upon the economy, reliability, quality, quickness.

Levitas et al. [14] examined the effects of the value of a firm's technological advancement, the newness of its technology, and industry turbulence on the probability of failure. It was found during periods of low technological turbulence, firms utilizing new technologies to create significant technological advances, face a higher probability of failure. During periods of high technological turbulence, firms using older technology to develop significant technological advancements face lower probabilities of failure.

2.2.8 Disparity in Pay: Traditionally, individual differences in pay (or to some extent, pay structures) have been viewed as most important in influencing the behaviors and attitudes of employees. It may be, for instance, that high performers will be most attracted to organizations that have a strong pay for (individual) performance relationship. For example, evidence indicates that such organizations are more attractive among those that have a high need for achievement.

It was observed that employees were driven, primarily, by high salaries. Pay must be combined with more intrinsically based factors in order for either to be effective [41]. It was suggested that instead of using the traditional macro-economically determined pay plans, more accurate performance-based systems should be devised in order to increase the relevance of rewarding desired efforts and behaviors.

2.3 Research Issues

The literature reflects the following issues connected with hurdles/barriers in the technology utilization process.

- There is always a resistance from the employees to changing conditions.
- Education and training to management and its employees are crucial to utilization of advanced manufacturing technologies.
- Problems encountered during implementation.
- Scarcity of skilled/expert workforce is another hurdle for technology utilization.
- Uncertainty in market conditions need to be investigated for successful utilization.
- Commitment from top management is a critical factor in any major organizational change.
- Disparity in pay scales of employees is another barrier for advanced manufacturing technology utilization.

3. STEPS UNDERTAKEN TO IMPROVE ADVANCED MANUFACTURING TECHNOLOGY (AMT) UTILIZATION

In this fast changing environment, the objective should be to keep people up to speed with change, and find new ways of offering a competitive advantage. Newer technologies arrive frequently and forcing organizations to change their work culture. As the pace of economic and technological change has accelerated in the last half century, employers have tried to ensure the efficiency and quality of learning by formalized learning processes. Employers have managed to maintain the link between learning and real jobs by applying the methods that translate real-world learning needs into structured learning processes.

3.1 Education and Training to Employees:

Technology is advancing so rapidly in the manufacturing field that continuing education and training become necessary. Good education and training programs enable employees to have confidence in performing the new jobs and bring them job satisfaction [9].

Mital et al. [4] has noted that technology is advancing so rapidly in the manufacturing field that continuing education and training has become necessary for its employees, which contributes between 25 and 40 per cent of the total cost of project. The authors claimed that there is a dire need to train workers in manufacturing organizations and thereby improve the overall effectiveness and efficiency of such organizations. A long-term educational and training program should be designed and implemented to train the employees so that reallocation of the human resource for jobs requiring advanced technical expertise can be made possible [40]. Training to employees is an investment for quality improvement, product innovation and client service. From an employee's point of view, tailored training for high-tech jobs is appealing, because it directly supports their career development and their value to the firm. The trend of the corporate training process has gone from informal towards formal learning. For this process, many companies have constructed major training centers. Training to employees is an important investment for quality improvement and competitiveness. Training promotes growth as it generates increasing returns in production through transferring knowledge, skills, and technology. Workers in modern manufacturing environments not only need training in depth (level of proficiency in a skill) but breadth (different skills) as well. Overall, training leads to acquiring new skills and/or improvements in existing skills [20].

3.2 Motivation:

In an age where advanced technology industries are becoming more and more prevalent, employees in these fields also require greater challenge and autonomy. Open communications, integrity, and positive reinforcement of company and professional values are certainly key elements in effective motivation. Utley et al. [13] observed that both Herzberg motivation theory and hygiene factors were required in creating an environment where employees operate more effectively and with greater success. Authors believed that job enrichment is the best way to increase employee motivation and productivity. Job enrichment is a means of complementing pay and providing more rewarding sources such as status, advancement to managerial positions, and authority and influence within the company structure are those most appropriate for engineers. Salary also becomes an important subject. Salary ranges for various engineering classifications should be made clear, with recognition of personal development efforts [12]. In addition to monetary decisions, benefits programs such as pensions and medical insurance need to be designed with this in mind to reduce voluntary quits. More broadly, benefits such as family leave and wellness programs can also be viewed as playing an important role in making sure that human capital is retained or maintained in good condition.

3.3 Interdisciplinary Team Formation:

Ferraro et al. [33] highlighted that mismatches often occur between the various levels of the organization. For example, manufacturing managers with expertise in operations often do not have adequate understanding of strategic issues and conversely, top management does not have a full understanding of operational details. This often results in failure, as operation engineers are expected to meet unrealistic demands of top management. Therefore members of the project team should be selected from engineering, production, purchasing, human resources, marketing, accounting, finance, information systems management, etc. Each member is expected to bring to the table the needs of their own functional areas and be prepared to consider the effects of the proposed ideas on their own organization. In order to encourage integration between separate functional departments, the concept of the multi-functional steering committees should be promoted by the firms. Gain-sharing offers something of a solution, to competition between groups or teams. This can be a particularly important consideration, especially in AMT environments, where coordination and cooperation between groups and individuals in different functions and departments is often critical. This gain-sharing can be evaluated by providing incentives or compensation to better performing teams in the organization. Gerhart and Milkovich [7] have examined the compensation by considering the areas such as: structure, level, and breadth.

3.4 Industry Institute Interaction:

The 21st century is being referred to as the "century of knowledge." The creation and utilization of that knowledge is indispensable to World's future development, for which the cooperation among industry, academia, and government is an important effort. To promote the strengthening of coordination among industry, academia, and government, it is essential to bring about a state of common recognition between industry and public research institutions, including universities. For this reason, public research institutions, including universities, are making research results available to the public and providing information in a number of ways. The Indian manufacturing industry is feeling the scarcity of this concept. By taking the help of technical institutes, the organizations can train their people for advanced manufacturing technology. An attempt has been made by Ojewale et al. [6] to evaluate the awareness and willingness of entrepreneurs to utilize the idle service and manufacturing capacities in selected educational institutions and research organizations in Nigeria by using questionnaire and interview techniques. Entrepreneurs were found to have more consultancy linkages with higher institutions than research linkages, and the majority had no linkage with higher institutions/research institutes. Both entrepreneurs and research institutes agreed to the strategies of publicity, investment through co-operatives, joint ventures and profit-sharing proposed to enhance effective utilization of the idle capacities.

3.5 Rewards and Recognition:

The traditional approach to performance assessment is often described by having first hand information collected from the immediate supervisor. Organizations that do not pay for individual performance face the risk of losing higher performers.

Merit pay ties increases in base pay to individual performance. As indicated by different scholars that merit pay continues to be widely used in companies all over the world. Like merit pay, individual incentives reward individual performance. But, in this case, payments are being paid to the employees depending upon their extraordinary individual efforts [7]. Sometimes individual incentives can be particularly ill-suited to many AMT environments. For instance, individual incentives typically do not fit well with the team approach. The payment system does not encourage cooperation or any sort of organizational citizenship behavior.

Gerhart and Milkovich [7] have argued that compensation decisions are of key strategic importance for organizations' financial performance. The compensation has two important attributes. First, employee pay and second, benefits like job satisfaction, attraction, retention, performance, flexibility, initiative, commitment, cooperation, skill acquisition, individual performance. Putting the cost or investment and behavioral/performance aspects together makes it clear that compensation can have an important influence on productivity and therefore, the ability of an organization to compete in the global marketplace.

With the introduction of AMT, teamwork, open communication and information-sharing, and skill breadth increases, this typically brings higher pay in the labor market. Therefore, a higher pay level policy may be chosen to enhance retention and thus, the probability of realizing an adequate return on the investment in training.

3.6 Research Issues

In the light of the literature review; the following issues emerged.

- Education and training to its employees improve the overall effectiveness and efficiency of organizations.
- Formation of interdisciplinary team leads to more coordination and cooperation between groups and individuals.
- Industry Institute Interaction should be strengthened to have competitive edge in the world market.
- Incentive and compensation schemes should be revised with the passage of time so that human capital is retained or maintained in good condition.

4. CONCLUSIONS

It can be concluded that there is reasonably vast literature available for advanced manufacturing technologies (AMTs) utilization. Still Indian Manufacturing Industry has not been completely utilizing its resources in this competitive world. The following are the barriers that affect the manufacturing system: Scarcity of skilled/expert workforce; resistance from employees to the changing conditions; Disparity in pay scales of

employees; lack of related infrastructure; training to management and its employees. To overcome these problems, some steps have been undertaken by the industry to compete in this modern world to remove the hurdles; dealing with organizational, managerial and employees. In general, the attributes of AMT often call for a significantly different approach for utilization of human resources. This can be done by (i) to upgrade the knowledge by providing on the site training to its employees (ii) Compensation in the form of non monetary or monetary typically has a very important influence on the attitudes and behaviors of employees, whether they are in the executive suite or on the production floor. Thus, in establishing individual differences in pay, some combination of plans (e.g., merit pay, team awards, and profit-sharing) may be chosen to balance multiple. Consequently, it is important to continually evaluate what attitudes and behaviors are being encouraged (or implicitly discouraged) by the compensation system. Teamwork, innovation and proactive involvement that is especially important in an AMT environment. Currently, there are several programs in place to promote exchanges between researchers by Department of Science and Technology in India to promote flexible and creative research activities by researchers at national experimental research institutions by promoting of personnel exchanges.

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