

# Reviewing the Role of Technology Change Management in Implementing Advance Manufacturing Technology: Automating the Shop Floor

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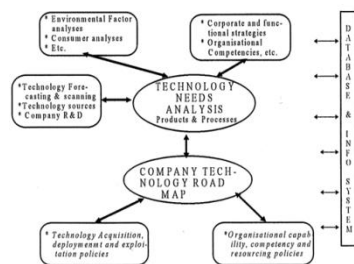
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## Graphical abstract



## Abstract

The industrial manufacturing revolution has shown a rapid growth in past two decades and the future is expected to be characterized by more innovative and advanced manufacturing technology (AMT) growth. The advanced manufacturing technology did not only change manufacturing process techniques but also changed the role of engineers and management in an automated shop floor. The automation has improved the quality and productivity by reducing man power intervention. This paper will discuss some important trends in industrial manufacturing and the role of AMT. Furthermore, this paper will present a conceptual framework to link shop floor automation directly to the different operational departments of the firm. The concept is helpful to take immediate action for occurring of any criticality or error in the advance manufacturing technology. To achieve high manufacturing prosperity, active and proper intervention of management is quite important and if the management is linked well to the shop floor, it makes the shop floor fully automated.

**Keywords:** Advance Manufacturing Technology (AMT); automation; Computer Integrated Manufacturing (CIM); manufacturing

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## 1.0 INTRODUCTION

Change is unavoidable. Organizations that don't change or cannot keep pace with the changing environment will soon get outdated and cannot compete well in the current and future markets. To be successful, organizations need to balance the internal environment in terms of technology, structure and employees. But at the same time external relationship of an organization are quite important to know the market demand for being competitive [1]. Actually both external and internal factors are reasons for the organizational technology development [2]. The change in technology is quite important and effects the organization when it is implemented. Thus organizations need to change as per the market demand and incorporate the latest innovations available to become more competitive. Technology is getting advanced day by day because of technology innovation, so the organizations are being compelled to upgrade the technology to the advance one. As per the technology change of an organization is concerned, the change takes place prior to the people who are ready to deal with the new technology [1].

The process of introducing a new innovative technology in an organization makes different changes in the organizational structure.

This paper explores the introduction of 'Advanced Manufacturing Technologies' (AMT) and automation which will be the subject of technology changes and provides an overview of an AMT shop floor. These advances can be viewed as assets utilized by organizations to create higher levels of performance and competitiveness [3].

Around the year 1900, industrial facility automation encouraged large scale manufacturers to meet the customer's requests for enhanced items. In the year 1930 fixed automation were made to encourage large scale manufacturing. This brought about the improvement of programmable automation. By the year 1950, numerical control (NC) was created as an advance methodology to programmable computerization and automation. With the improvements in financially accessible PC technology, the application of computers in manufacturing started to emerge by supporting the automation in different ways.

By the year 1955, the introduction of computer aided design (CAD) was implemented and by the year 1970, improvements in CAD and advancement in computer aided manufacturing based systems gave birth to a new technology called as computer integrated manufacturing, which are collectively now called as AMTs [4].

Organizations are rebuilding themselves according to the demand and requests from 21st century market. Today's

organizations need to overcome the challenges of different customer expectations with high quality, low cost and rapidly challenging needs. This all is not possible until a company implements the latest technology like AMT [5].

A computerization system plays a vital role in the manufacturing automation systems. Only PCs provide an open platform and no other system exists with little hardware and huge software option for the purpose of automation like technology interface, operations and control, data processing and storing and input-output distribution [4].

## ■2.0 RESEARCH METHODOLOGY

The role of computer in AMT has shown a subsequent quality and product improvement by information processing and transferring. The paper discusses the rapid change of manufacturing technology towards shop floor automation. The primary objective of this paper is to draw the attention of researchers as well as the practitioners towards the link between the shop floor automation to different operational departments of the firm. Mostly it is the computer integrated manufacturing which facilitates the shop floor automation and keeps away the decision making management on different shop floor situations. But it is important to have involvement of decision making management in critical situations of the shop floor. The gap can be filled by making a strong link by using CIM techniques between the shop floor and the operational departments of the firm.

A conceptual framework is being proposed here to understand the need of the communication between the shop floor and the different operational concern departments. This framework gives an overall view of shop floor automation.

## ■3.0 MANUFACTURING SYSTEM & TECHNOLOGIES

There are actually three sorts of different manufacturing systems. Craft shops, dedicated manufacturing system (DMS) and advance manufacturing technology.

There are many distinctions between craft shops and DMS. It needs skilled and experts to run craft shops by using different hand tools and devices, while as DMS introduced a special sort of machineries which can be easily operated by unskilled labors. In craft shops the workers are involved in different tasks and different groups but in DMS, the work is specific and is allocated to someone particular [6].

The global market had shown a drastic change in terms of competitiveness and now DMS is not able to support the new market of innovation and latest technologies because of not being well competitive. So it is AMT which allows many strategic options such as rapid market response, quality product and greater process control [6].

AMTs are developed after the integration of conventional manufacturing and computer based technology. AMTs include all such technologies as discussed in the introduction like CAD, computer aided manufacturing (CAM), flexible manufacturing system (FMS), computer integrated manufacturing (CIM), different automation systems and other computer support systems [7]. The technology decision, which is evolutionary in nature, depends upon the latest available technology in the market and its adaptation by different leading firms to achieve competitive capabilities like the innovative technology in manufacturing process and control [1].

## ■4.0 ROLE OF AMT IN MANUFACTURING

Advanced manufacturing technology (AMT) represents a variety of modern innovation and technology especially computer based systems for the enhancement and the improvement of the production [1].

AMT is developed well to be flexible in process technology and has replaced microprocessor automation which is quite inflexible. Wide research has been done to take best from the AMT environment to be well competitive in the global market [7].

AMT, for example, automation and robotics technology, CAD etc. apply high technology innovation and use of PC to improve manufacturing. The main advantages of AMT are reduction of labor cost, product quality, less floor space required to implement AMT, improved productivity, shorter manufacturing time, reduction of waste and fast response to the market [8].

AMT received a great response to enter the market for the new level of customer demands and needs. AMT has been well supportive to produce quality items with improved reliability and consistency. The research in manufacturing is highlighting the need to invest in both structures and technologies like IT and process and infrastructure like management etc. to be competitive in the global market. However, it has been found that structural investments such as AMT adoption are more successful if implemented well along with the strong organizational structure. [9]. Manufacturing organizations invest in bulk to implement AMT each year as the organizations enjoy many benefits by using AMT. The main 5 benefits are as follows [1, 10]:

- Reduces cycle time
- Market share growth
- Progress towards zero defect
- Return on investment
- Focused production

The conventional design of combined AMT system is a sequential batch processing arrangement which is tightly coupled. The more worldwide AMT systems (CAD/CAM, CIM) exceed the production limit and are helpful in the integration of design, planning and production of the firm [11].

### 4.1 Technology Strategy

Technology strategy development is a consistent methodology and process in view of the expanding rate of outdated the technology and advancing the innovation. It became difficult to define an advance technology because of the fast change in the technology competitive environment. A formal technology strategy development structure is well defined in the Figure 1 below. It incorporates different elements and their inter relationship [2].

The implementation of more appropriate techniques gives a future picture of the market place demands. Technology forecasting is not always defined by advance technology innovation but usually it is decided by the market needs [12].

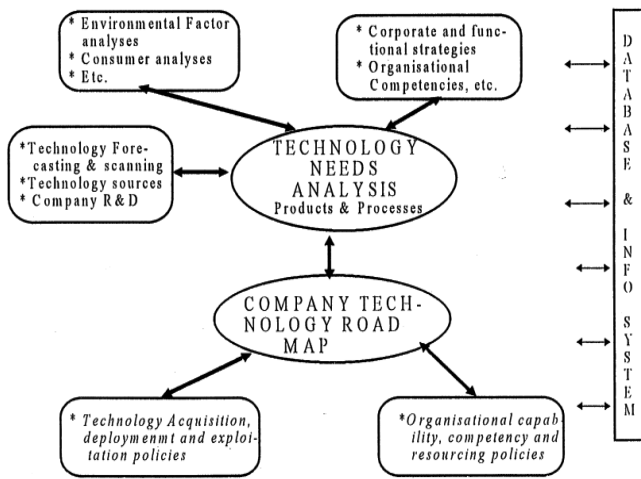


Figure 1 Technology strategy development structure [2]

But companies need to consider many elements in their strategy formation processes to meet the market needs and it is not important to follow any defined technology strategy development process. As there is usually lack of clear view point on technology development in different organizations as in reality R&Ds are active in most companies but no efforts are being put forward to implement the research. A different approach should be taken by the managers to develop future technology road map by considering both external and internal factors [2].

4.2 Implementation Issues and Chances of Failure

4.2.1 Implementation Issues

There are many issues in implementing the AMT and these issues have a long term effects for the organizations as a whole. Some of the main issues are highlighted in Figure 2.

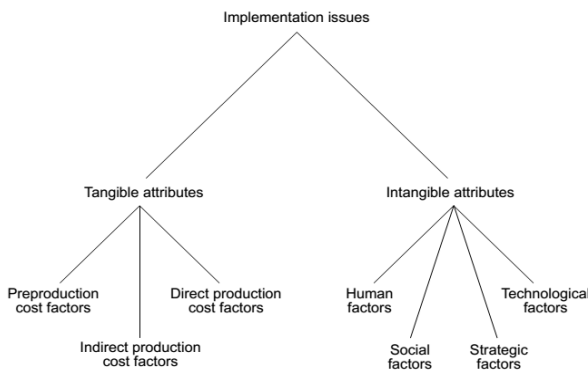


Figure 2 Issues in implementing AMT [13]

As per the technical issues are concerned, the manufacturing technology should be user friendly and flexible for further modification, the maintenance should be easy, and importantly the technology should be the latest and compatible as per the market needs. In general all these issues are inter-related with hardware and software of the technology [13].

4.2.2 Chances of Failures

Research has suggested that new technology can benefit to a great extent when they are coupled well with changes to the organizational system. It is quite important in an organization to integrate the technology, employs and organizational culture. The failure rate of technological change (new technology) becomes high if the organization cannot change the human resource and other organizational structure as per the technology change. In simple words, the technology change demands the organizational structure change and development with new strategies [1].

Technology is the key to the development of many organizational systems and therefore technology play a main role in the decision making and manufacturing processes [2].

New technology needs a well compatibility with the organizational structure. It is very important to have strong advance planning to implement new technologies. So consequent training of workers in relation with the technology change and its need is quite important [1].

5.0 SCOPE OF AUTOMATION

Automation actually supports in atomizing the process by providing feedback which keeps different controls in the loop for the control of production rate, product quality etc. It also supports in integrating the operation with the transfer of material from one station to another and makes the production process smooth and continuous [14].

Automation is having a great scope in the AMT and it will influence the future structure of the organization like, the size, growth, investment, working conditions, managerial functions and cost of the firm. Now importantly the relative strength of competitive and monopolistic elements in industry has changed by implementing latest automations [15].

6.0 INTEGRATED MANUFACTURING

By the advancement of PC and network technology, hundreds of computers can be linked together, as the new client/server technology makes the processing power of PC so compatible. Client/server architecture facilitates the application of PC-based systems to all the “islands of automation” in the typical shop-floor. It is the open system architecture which provides enterprise resource planning and customer oriented manufacturing system capabilities. It is the innovation of low cost communication technology which provide a flexible CIM to make it work as per the requirement to work in a competitive market [4].

To satisfy the competitive demands of today’s market, the research in the manufacturing automation and control suggests effective integration of a number of available AMTs (particularly with different type of advance machines). Actually the technology integration includes, management strategy, firm integration, network communication, implementation of AMT and application of artificial intelligence. The integration of different components and tools makes the communication, programmable controls and operator interfaces quite easy. Communication should be integrated throughout the organization from the control level to the field level and communication should be consistent with integrated automation by using fieldbus and Ethernet [4].

## 7.0 SHOP FLOOR CONTROL SYSTEM

Development of automated manufacturing system is quite complicated task so their development also requires skills from all related fields like communication, man machine interfacing, manufacturing processes and programming [16].

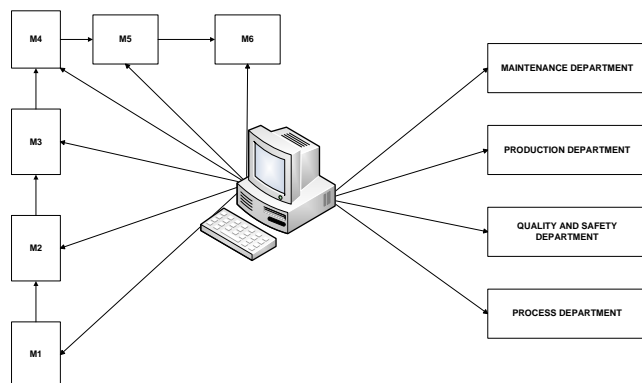
A shop-floor control (SFC) system is one of the most important elements within the whole manufacturing system and as such it influences strongly to the shop floor automation capabilities. So it is important to develop several fields like operations departments, supply and chain system etc. around the SFC system to have maximum benefit from it. So in fact it should be the last part to be designed, tested and implemented because it is necessary to have all other resources in hand first like manpower etc. to run the shop floor [16].

Integrating several automation islands as an integrated manufacturing system attracted attentions from many researchers in recent years. The major objective of CIM is to integrate the material flow with least human intervention as most of the material movement takes place in the shop floor. For example moving raw material from the store to an automatic guided vehicle (AGV) and then transferring it to the robots. When the new material or work in progress (WIP) is loaded it is important to transfer the information between different work stations [17].

## 8.0 CONCEPTUAL FRAME WORK

The framework links automation technology, SFC and different operational departments of the plant. It is important for all related departments in a manufacturing firm to be well aware about every breakdown, machine error and other alarms from the automation. For a quick response from the related and concerned experts, it is important that the alarm from a machine to reach them. This paper focuses on the quick response from the shop floor to the different concerned departments to make the shop floor progress more automotive and quick. It can raise the performance of the firm if shop floor is directly linked to the decision making authorities of the firm.

The frame work in the Figure 3 below suggests a real time communication network between the shop floor and the different operational departments. This type of communication is quite important in AMT manufacturing firms.



**Figure 3** Framework to integrate shop floor automation and operational departments

These firms cannot effort the factors which are affecting the manufacturing performance like quality issue, machine down time, unexpected process variation etc. This is only possible if

shop floor is well linked with the responsible operational departments for fast decision making regarding any serious alarm or issue from the shop floor.

Figure 3 gives a visual overview of the integration of shop floor machineries (manufacturing cells) represented from M1 to M6 with the respective operational departments. In automation manufacturing usually control unit of all the manufacturing cells are connected to a central PC (or many such PC's in large firms) to get the different information. Here the PC plays a central role to link the control units from all the manufacturing cells to the different operational departments for the active involvement of all decision making managers.

Centralization of authority (locus of decision-making), and patterns of communication to the authority is quite important. Among these aspects of organizational structure, locus of decision-making and level of communication is quite important and may directly affect the development of manufacturing practices if not defined well [18].

The requirements of integration in manufacturing applications are decided by increasing productivity, quality product and flexibility. This integration is driven by the industrial needs such as consistency of the data model and continuity of communication through all administration and control levels [19].

To achieve maximum performance from a manufacturing firm, the management should try maximum integration between technology structure and employees [1]. Anticipating changes (changes in advance) in organizational structure, employment outline, communication patterns and inter-organizational relationships minimizes the failure of AMT. Management practices are key to successful AMT execution. Administration's main role is to raise trust and co-operation as AMT places extraordinary pressure on the utilization of innovative enhancement [6].

If in automation, error transparency is not possible, the computer integration should provide the necessary information to the application as well as to the operator about the errors in order to handle this breakdown [19]. If the same error or the incident is being reported in the real time the firm can improve its operational efficiency.

A manufacturing system should be able to assess the overall level of support that each department provides to achieve the competitive priorities. In the system there should be selection of some set of measures capable of assessing and controlling all critical factors on the basis of responsibility given to different manufacturing departments [20].

There are different systems used in manufacturing firms like shop floor integrated system (SFIS) that offers state information of factory activities to the administrator in order to control the factory effectively. SFIS mainly support for relevant control problems and its main functions include operation scheduling and feedback control [21].

Integration in Manufacturing is the first systemic model to organize humans and machines as a whole system. It does not support in the shop floor only but it is supportive in management and corporate level and it is an IT oriented technique. The important purpose here is to integrate the entire manufacturing chain from mind to market over the whole product life cycle. But the major problems arise when it comes to the interfacing between the firm's management level (and corporate level) with the manufacturing shop floor level. If implemented properly, the framework proposed will be able to align the production according to advance technology available and to link the man power involved from bottom to top levels to the shop floor [22].



## 9.0 CONCLUSION

This paper has discussed the manufacturing technology change from conventional to the advance manufacturing technology. The paper illustrates how the shop floor planning and control can be linked directly with the different operational departments. In this way decision making will be fast and easy in critical situations of the shop floor. It is not only the information and data for which the managements from different departments are concerned, but it is important to have their active and proper intervention during the production phase. An automation firm cannot afford errors often, like machine downtime, safety issues and quality issues etc. To overcome the issues a framework has been proposed in this paper which suggests control unit of an automation machine to be linked directly to the decision making authorities. Therefore they can take proper note of every event in the shop floor automation. This concept integrates machines directly to the highly concern people and makes it a fully automated shop floor.

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