Fourth LACCEI International Latin American and Caribbean Conference for Engineering and Technology (LACCET'2006)
"Breaking Frontiers and Barriers in Engineering: Education, Research and Practice"
21-23 June 2006, Mayagüez, Puerto Rico.

Manufacturing Technologies in the Trinidad and Tobago Firms: A Survey

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Abstract
There remains an urgent need in Trinidad and Tobago (TT) to research and assess opportunities to strengthen the manufacturing sector that is expected to provide a stable economy posture through reduced lead times and improved quality and productivity of manufacturing operations while ensuring flexibility. This paper presents the current status of manufacturing technologies in the TT manufacturing firms through an industrial survey. From the responses of the survey, it was observed that considerable scope exists for the introduction of advanced manufacturing technologies such as computer aided design (CAD), computer aided manufacturing (CAM), and computerized numerical control (CNC) facilities in the small and medium enterprises (SME) of the region. Only 36% of manufacturing industries in TT employ CAD, and a smaller proportion (23%) still use CAM. Not many companies are of the view that manufacturing resources planning (MRP-II) (20% using) and just-in-time (JIT) manufacturing (30% using) are applicable to TT. There seems to be inadequate awareness of the flexible manufacturing system (FMS) and their potential applications (10% using) to TT. There is, however, enthusiasm to acquire the knowledge and skills of advanced manufacturing technologies through seminars and workshops. Also, the study shows that there is a tremendous potential in TT manufacturing firms for manpower training especially in the area of information technology (IT).

Keywords
Industrial survey, Manufacturing technologies, SME, CAD, CAM, FMS, JIT

1. Introduction

Manufacturing enterprises worldwide have been utilizing computers in a number of ways to speedup the process of bringing their products to market as fast as possible. Developing a product by conventional manufacturing methods involves a fairly complex process and as such is time consuming. Computers on the other hand have significantly contributed for the design and development of products by using

computer-aided design (CAD), computer-aided manufacturing (CAM), flexible manufacturing systems (FMS), and numerical control (NC) machines that have attracted organizations to undertake significant investments in these systems.

By implementing computer-integrated manufacturing (CIM), manufacturing enterprises have achieved significant performance enhancements in several areas, e.g. improved quality, responsiveness, effective sales and marketing information, increased operational productivity, lower overhead costs, reduced inventory levels, reduced lead time, less floor space, and reduced setups (Rehg and Kraebber, 2001). Reduction in WIP and lead times is a result of lean manufacturing, which includes JIT. Improvement in shop floor operation is a hindrance in some of the small and medium enterprises (SME) (Marri et al., 2000).

In this study a construct 'Integrated Manufacturing Technologies (IMT)' is used to study the status of the manufacturing technologies in TT manufacturing firms (Chowdary and Rao, 2004). IMT is defined as the integration of the total manufacturing enterprise through the use of several hard and soft systems that include CAD, CAM, FMS, flow line automation (FLA) and data communication networks coupled with new managerial philosophies that include JIT manufacturing, which improve organizational and personnel efficiency. IMT is expected to show a new way to do business that includes use of a single computer database for all product design and development information that is the basis for manufacturing and production decisions in every department, and the integration of various enterprise resources (Ulrich and Eppinger, 2003).

2. Objectives and Scope of Work

The Caribbean is mostly known for its large Tourism and Agriculture industry. The income from these sectors contributes considerably to the development of the various islands in the Caribbean (The Industrialist, 1998). Only few islands have strong manufacturing bases, such as Barbados, Jamaica, Trinidad and Tobago (TT), which are major contenders in the plastic, metal and food products (Harris, 2000). In TT alone, there are over 350 registered manufacturing companies.

The main contributor to the gross domestic product (GDP) in TT is the energy/ oil and gas sector. Others include the agriculture, services and manufacturing industries. The energy sector contributed approximately 31.4% of the GDP in 2003 while the manufacturing sector provided only 6.8% (Trinidad and Tobago At A Glance, 2003). Hence, an urgent need exists in TT to research and assess opportunities for development in the manufacturing sector that is expected to provide a more stable economy and offer sustainable development in the absence of the energy sector. Presently, the manufacturing sector in TT caters primarily to the regional markets as well exporting to the North and South Americas and European markets. The steel industry is also quite prominent in TT, but it is still small in comparison to other industries. Also, there are plans to build an aluminum smelter in the country. It can be seen that the manufacturing sector in TT is also a major contributor to employment opportunities while petroleum and gas is the smallest contributor (Trinidad and Tobago At A Glance, 2003). So, development of such a sector is of great importance.

There are initiatives to develop the manufacturing sector in TT but on a small scale. The manufacturing sector mainly supports the petroleum sector since the latter relies on the former to provide maintenance items for example. The extent to which manufacturing industry is being developed is limited at present. Metal Industries Company (MIC) for example is performing some mould design work and making a limited number of plastic products, which is an indication of the diversification of the sector. The objective of this paper is to study the current status of IMT in TT using a questionnaire based survey and onsite interviews. Further, this study provides some guidelines for implementation of IMT with a view to improve the manufacturing operations and be competitive by producing better quality products.

3. Methodology

To conduct the survey in TT manufacturing firms, two types of questionnaires were developed.

3.1 Preliminary Questionnaire

The questionnaire labeled as the *Preliminary Questionnaire* gathered general information from the companies, pertaining to their current usage of IMT and the level of assistance they expected from the outside agencies in terms of introduction of IMT within their firms. Further, this questionnaire was designed to be as short as possible in order to obtain immediate responses from the participants, i.e. the estimated completion time for the preliminary questionnaire is in the range of 5-10 minutes. The questionnaire contained two sections: Section 1 covered various questions on the usage of IMT and their plans of implementing it or not. Section 2 focused on various questions pertaining to the type of information or training that the firm might need for implementation of some IMT components within their company. The responses from the preliminary questionnaire played a major role in the development of the main questionnaire since, from them we are able to pinpoint those firms that:

- are using some form of IMT
- have plans of using IMT in the future
- have no intentions of using IMT
- the line of study does not fit their company objectives

This study targeted on the manufacturing firms that are currently involved in design, fabricate and manufacture of products for both the local and global markets.

3.2 Grouping Criteria

Based on the outcome of the preliminary questionnaire, we were able to construct and fine-tune the main questionnaire according to the general trends within the manufacturing industry. The information from the preliminary questionnaire allowed us to streamline our onsite interviews. Also, it enabled us to eliminate questions based on technology that is not currently being used by the company or have no plans on using it in the near future. This method was chosen based on its efficiency though it may look a bit redundant at first, since some of the questions from the preliminary questionnaire reoccur in the main questionnaire but at the end it saves both time and resources on both sides of the study. The following criteria are used to group various components of IMT:

a) Technology interaction and similarity
b) Trends in usage amongst the manufacturing industry
c) Uniqueness of technology.

Using the above criteria and based on the information gathered from the preliminary questionnaire, we have divided IMT into four groups. These groups are as follows:

Group-1: CAD and CAM (based on criteria a and b)
Group-2: MRP II and JIT (based on criterion a)
Group-3: FMS and FLA (based on criteria b and c)
Group-4: IT in Manufacture (ITM) (based on criteria b and c)

3.3 Main Questionnaire

The questionnaire labeled as the *Main Questionnaire* gathered technology-specific information from the companies. The questionnaire includes more detailed questions pertaining to IMT and a few questions on

the organizational structure of the company. This questionnaire was sought to gather information regarding the status of IMT especially on:

- how many TT manufacturers know about it?
- how many are currently in use and the degree to which they are employed?
- what plans or expectations they have for their organizations?

The main questionnaire comprised four sections and thirty-two questions. These sections are labeled in the following manner:

A. General questions on IMT: implementation issues and evaluation of currently used technologies
B. Detailed questions on the individual technologies: perceived/expected outcomes of implementing IMT tools and also experiences gained from these technologies
C. Organization related questions: like the product range and company type
D. Feedback: recommendations made and assistance needed by the firms in order to improve or implement IMT.

4. Data Collection

To conduct this survey six distinct firm types as presented in Table 1 were selected. These six categories represent the various types of manufacturing firms one can find in TT. The job titles of the individuals responsible for filling in and returning the questionnaires ranged from CEO, middle level managers and engineers to shop floor technicians. Two methods were used to fill in the questionnaires: e-mail delivery and personal onsite interviews. The majority of the preliminary questionnaires were delivered by e-mail and most of the main questionnaires were performed through onsite interviews.

Table 1: Categorization of the Manufacturing Firms in Trinidad and Tobago

Firm Type	Description (Products Grouped)
Assembly	Seafood containers; die design and mould development; plastic products; circuit breaker panels; lighting fixtures; metal structures; ornamental works; manhole covers; metallic windows and doors
Chemical and non-metallic	Automotive batteries, tyres and glassware
Construction items	Air-conditioners; refrigerator coils and metal structures
Personal care and food products	Tooth brushes; milk and juice products
Energy related	Petroleum products
Engineering services	Metal component design; metal refurbishments; gears and shafts

The questionnaires were targeted at manufacturers who were using or had potential for using IMT. A search at the TT Manufacturers' Association (TTMA)'s website provided the names of such companies. Both questionnaires were sent to 70 different organizations. Fourty two questionnaires were completed and returned. Of those returned, 11 of them were considered not relevant to the study. The criteria used to decide the usable responses are based on 'whether a questionnaire is completely filled in or not' and on 'its content' to meet the objective of the study. This resulted in 31 usable questionnaires. The overall

response rate was therefore (42/70 x 100) = 60%, and the effective response rate was (31/70 x 100) = 44.29%.

5. Results/Findings

For analysis of the data, bar graphs were used to give straightforward views on the status of IMT in TT. Group-wise, analysis of the data for various technologies is presented below:

5.1 Group-1: CAD and CAM

From the analysis it was found that 35.48% of the survey population uses CAD in their day-to-day operations (refer Figure 1). Also, the companies that have used CAD generally have a positive perception of the technology with a majority of participants stating that it has improved the quality of design in terms of accuracy (Figure 2). Largely, the responses show that CAD not only reduces design time but also saves labor costs. Also, when asked on 'how CAD has performed within their firms', they said it has been improved the flow of information.

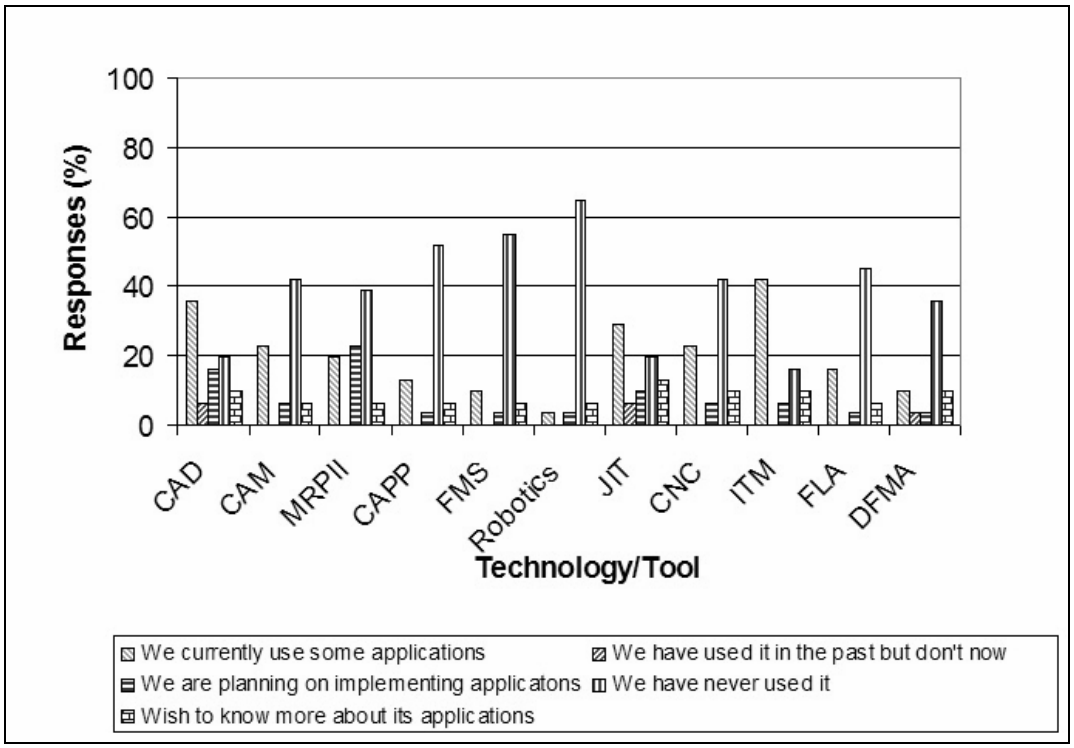

Figure 1: Current situation with respect to various technologies.

CAD and CAM are mutual technologies. Therefore, CAM cannot function without CAD. This statement is true because from our CAD users, we learnt that certain per cent also use CAM. The information from Figure 1 indicates that 22.58% of the survey respondents are currently using CAM. The low number of CAM users in the region is due to several reasons ranging from lack of capital to inadequate skills and training within the firm.

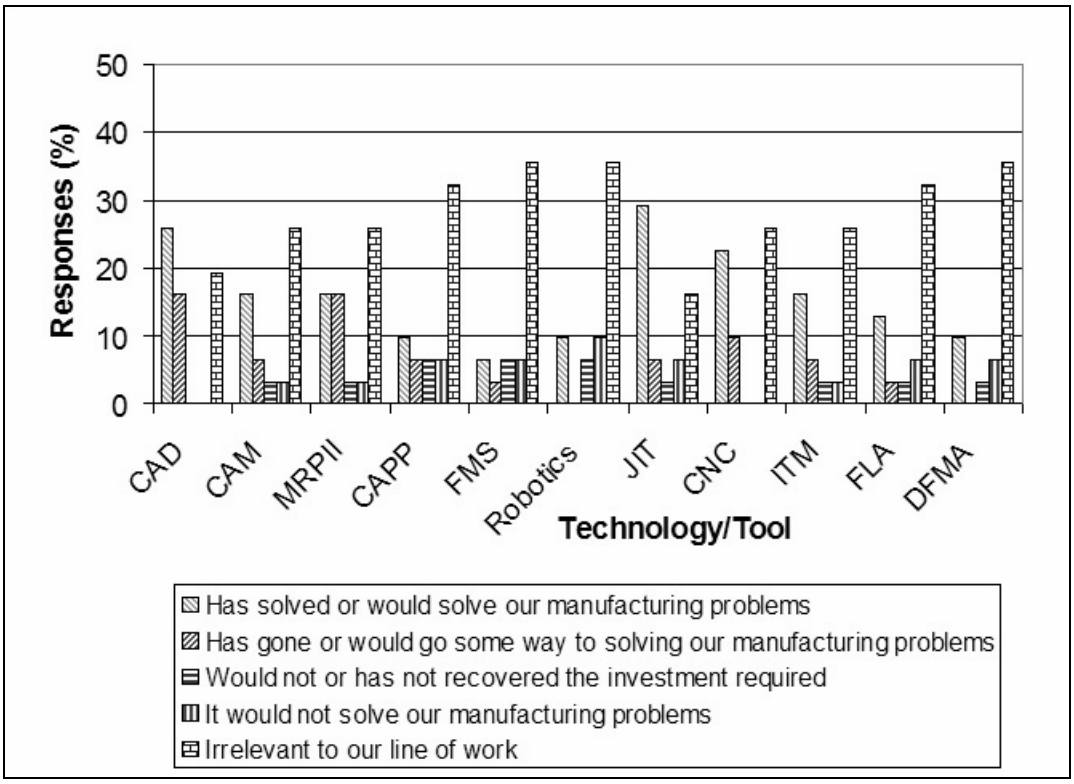

Figure 2: Evaluation of the use of various technologies.

CAPP is also another component of IMT that works closely with CAD and CAM hence we expect that the users of CAPP are also users of CAD and in some cases CAM. The information from Figure 1 indicates that 12.9% of the survey respondents are currently using CAPP. In Figure 2 it can be seen that CAPP expectations in Trinidad is quite low. We also found from our onsite interviews that the CAPP will increase the legibility of a process sheet.

The responses to the questions pertaining to CNC technology based on the firm's expectations were quite mixed; overall, most questions were above neutral, lying between neutral and agree. Based on the onsite interviews, many firms had a hard time in understanding the principles under which CNC can reduce non-productive time even when we demonstrated examples that supported the claim, hence the reason for such a low score.

5.2 Group-2: MRP II and JIT

From Figure 1 it is clear that only 22.58% of the population has plans to put MRP II into practice. Also we found that most firms have benefited from the use of MRP II when it comes to long-term planning tool for manufacture of customized products and to pinpoint progress and inventory within the firms.

From Figure 1 it is clear that only 9.68% of the population has plans to put JIT into practice. Many of the firms have expressed negative views on the performance of JIT within the TT manufacturing organizations. They claim that JIT does not complement the general attitude towards material distribution and procurement methods being displayed in TT. Several firms monitor their inventory by the "buffer" stock method in other words by over stocking which results in waste. This simplistic approach to inventory and material management can be a result of ignorance.

5.3 Group 3: FMS and FLA

Figure 1 illustrates a 9.68% usage of FMS in TT. The most positive response was made with regard to the option that FMS would reduce WIP and lower manufacturing lead times. Where as many firms disagreed that FMS would provide higher machine utilization. The population agreed that FMS would increase flexibility and provide higher labor productivity.

The usage of FLA in Trinidad can be seen in Figure 1, which is 16.13% of the survey population. The opinion that FLA would provide an increase in capacity production was strongly agreed upon by most of the firms. Also we noticed through our onsite interviews that FLA would provide higher machine utilization and help to decrease inventory.

5.4 Group 4: ITM

The role of IT in the TT manufacturing firms can be categorized as: (i) knowledge management, (ii) e-business, (iii) enterprise resource planning, and (iv) enterprise maintenance and asset management. A majority of manufacturing firms in TT employs one or a combination of the IT tools for addressing the areas mentioned above. Some routine IT tools employed are: Electronic mail (e-mail), Internet access, Intranet and collaboration through web-enabled applications.

From the Figure 1, it can be seen that firms constituting 41.94% of the sample use ITM. Also through the onsite interviews conducted, it was observed that many firms who responded in the negative manner, however, are using some of the other individual IT tools. Questions were also asked on areas where help might be required by the respondents in order to facilitate the better use of various IT tools. From the results as presented in Figure 3, we can see that the majority of respondents require assistance in the training of professionals for use of various tools.

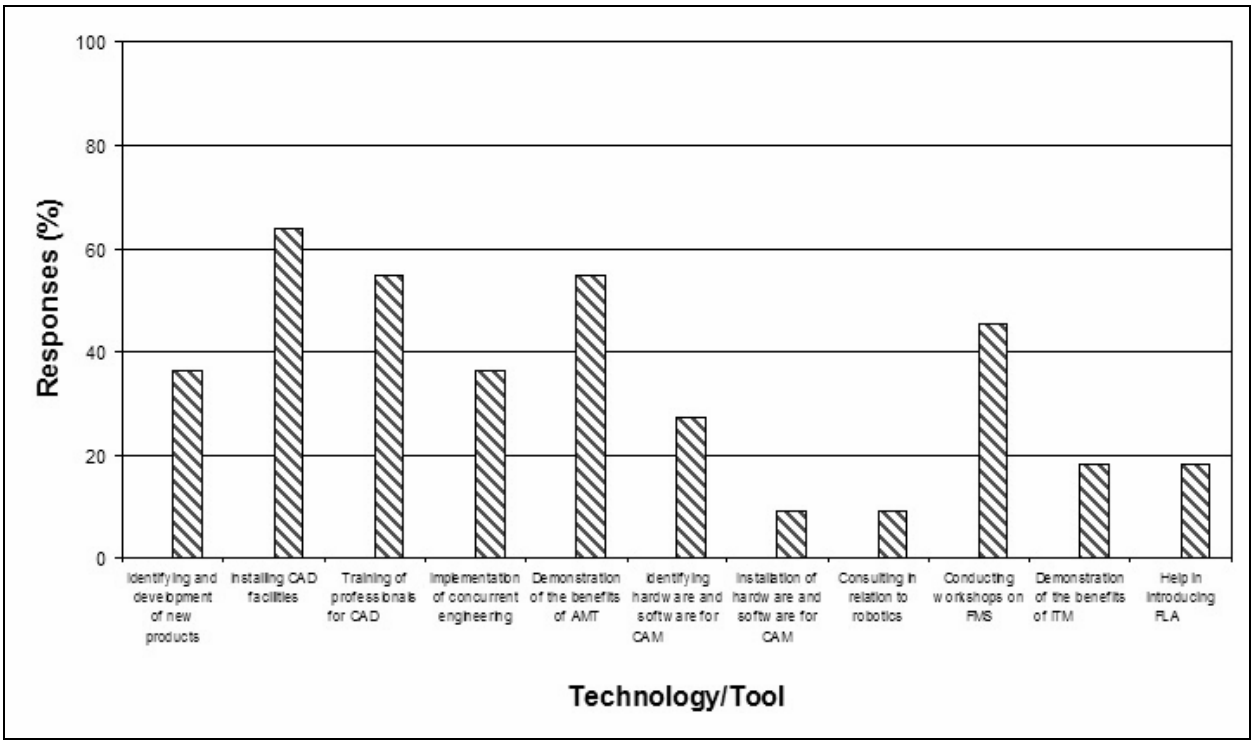

Figure 3: Assistance required in implementation of IT related tools in TT manufacturing firms

The graph as depicted in Figure 4 gives some very interesting statistics. The graph showing the use of IT for distance learning is of particular importance. It appears that 22.22% are currently using and are planing to use distance learning for the training of employees. Some of the respondents suggested the need for a consultant in their field to gain hands on experience.

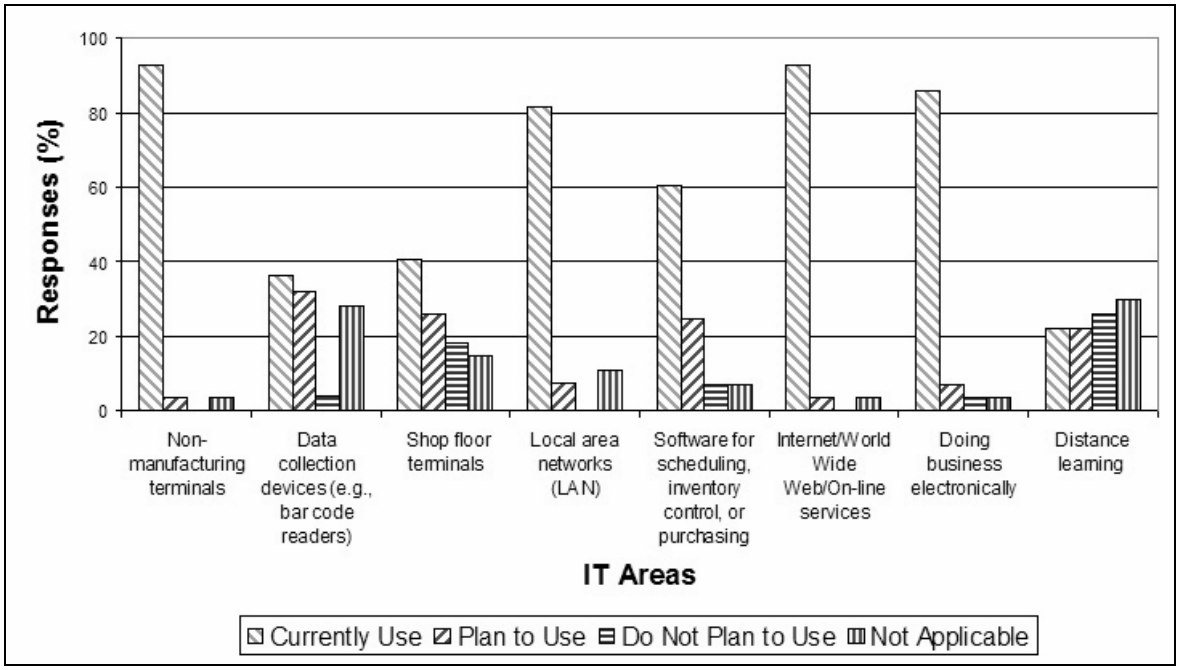

Figure 4: Summary of IT usage in TT manufacturing firms

However there is evidence of strong positive trends in that all respondents use personal computers and the Internet, while over 81.48% use LAN and do business electronically. This is shown in Figure 4. It is also seen that 60.71% the respondents indicated the use of software for scheduling, inventory control and purchasing.

6. Some Insights and Guidelines

Identifying the gaps for introduction of IMT in the local industry could help to minimize product design and manufacturing risks and to promote the success of manufacturing organizations. From the current study, some valuable insights on the status of IMT in TT manufacturing firms are:

- only 36% of manufacturing industries in TT employ CAD, and a smaller proportion still use CAM
- most companies felt strongly that CAD not only reduces design time but also saves labor costs
- Reduction in lead-time and engineering costs are widely agreed by the TT manufacturers as key benefits from the use of CAM
- not many companies are of the view that JIT (30% using) and MRP-II (20% using) are applicable to TT
- there seems to be inadequate awareness of the FMS (10% using) and their potential applications to TT manufacturing sector
- there is a need in TT manufacturing sector that requires manpower training especially in the area of IT

- there is, however, enthusiasm to acquire the knowledge and skills of advanced manufacturing technologies through seminars and workshops.

A need exists to establish a forum to share IMT information for a greater degree of collaboration and co-operation amongst the TT manufacturing organizations. Based on the knowledge gained from the survey we are now able to formulate some guidelines regarding what could be done to encourage the implementation of the IMT in the local firms. Some of the proposed guidelines are as listed below:

1. *Establish a symbiotic mechanism between SMEs and the higher learning institutions where information can be freely shared and a greater degree of collaboration and co-operation is displayed amongst the local manufacturing firms.*
2. *Put mechanisms in place to encourage the importance for development of computer integrated manufacturing.*
3. *Identify new products and to provide support for its design and development.*
4. *Provide a checklist for integration of CAD/CAM with the other business functions of the organization.*
5. *Need for government encouragement especially to promote the development and growth of the manufacturing sector by providing incentives, tax breaks on machinery and other advanced equipment.*

The goal here is to install systems that facilitate a shared network of knowledge among various industries. This coordinated information can be used for the endeavors of the manufacturing industry. Such collective efforts are further useful to monitor the developments within the industry and pose as a forum for troubleshooting and technical support.

7. Conclusions

Serious thought should be given for the implementation of IMT in the TT manufacturing sector. Most importantly, with the free trade area of the Americas (FTAA) negotiations taking place, most of the SMEs in TT are concerned about their survival and ways of competing amongst the global market. This paper comes up with an industrial survey to study the status of IMT in the TT manufacturing firms.

From the survey findings, we have seen little usage of what is perceived to be critical manufacturing technologies and philosophies. Technologies such as CAD and CAM and JIT philosophy are key tools and are quite common amongst leading manufacturers' worldwide. To begin an upgrade in this sector will require manpower training, which will facilitate the industry to grow into a globally competitive sector providing high quality products. The results of this study will serve as the basis for further research into specific IMT needs and applications in the region. The challenge for the future is to identify new products and appropriate hardware/software that help to build reconfigurable and proactive manufacturing systems with capabilities for managing the change and innovation to be able to adapt to market evolution and prosper, in the face of global competition.

Acknowledgement

This research was supported in part by the School of Graduate Studies & Research of the University of the West Indies, St. Augustine Campus under grant CRP.3FJ.

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