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EVALUATION OF THE EFFECT OF ADVANCED MACHINING & PROCESS IMPROVEMENT TECHNOLOGIES IN MANUFACTURING INDUSTRIES

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ABSTRACT:

Advanced manufacturing technology (AMT), known to perform repetitive functions and work without permanent alteration of equipment, has been on the increase in most manufacturing industries for their process improvement and overall production. Being a technique which is likely to cause constructive changes in a firm's manufacturing practices, as well as management systems and its approach, this paper evaluates the effect of Advanced Manufacturing Technologies in Nigerian Manufacturing industries. Survey research design was used in this work for data collection. The data were collected from four sectors of manufacturing industries. The majority of respondents are from automobile sectors, followed by process sectors, electrical & electronics sectors and industrial machinery and equipment sectors. Respondents were requested to choose a response on five point likert scale; anchored at one end with 'least important' meriting a score 1 and the other by 'most important' meriting a score of 5. After which the hypotheses testing were performed by testing the level of conformity between the variables. The results showed that the implementation of new technology within an industry for the purpose of improving efficiencies, developing flexibility and enhancing output represents an innovative development. It is concluded that efficiency enhancement of manufacturing industries can be accomplished through advanced manufacturing technologies.

KEYWORDS: Advanced Manufacturing Technology (AMT); CNC/DNC; Kaizen; Benchmarking; Recycling

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INTRODUCTION

Advanced Manufacturing Technology (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)

A structured questionnaire has been 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 have been adapted from formerly published works and henceforth, the preliminary draft of the questionnaire was discussed with the academic scholars and practitioners.

The study investigates different types of advanced manufacturing technology (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 technologies
2. Advanced machining technologies
3. Advanced planning technologies

4. Advanced material handling technologies
5. Advanced management systems
6. Advanced process improvement systems

Industries were asked to indicate the amount of investment in the individual technology, on a five point likert scale of 1 to 5, where 1 indicates no investment and 5 to show heavy investment. Industries were resolute to be either users or non users of each technology subgroup. 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.

2. ADVANCED MACHINING TECHNOLOGIES

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. 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.

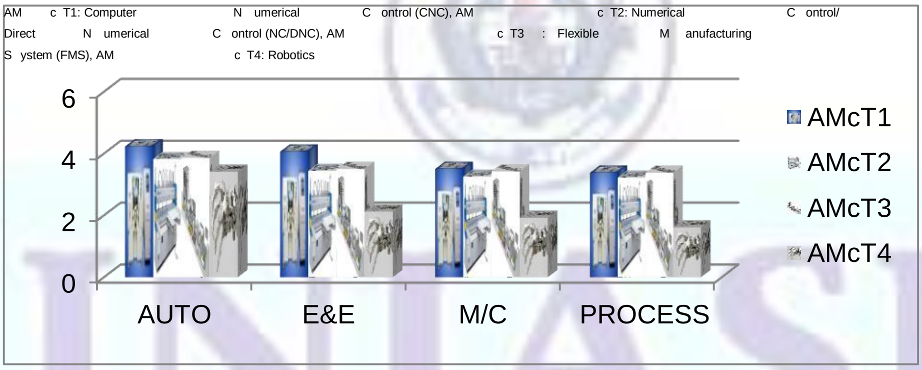

Figure1: Advanced machining technologies in different sector

As shown in figure 1, regardless of the sector of the manufacturing industries, the most important investment is made in CNC technology. All the manufacturing industries have invested less in robotics technology.

Generally, industries have invested the most investment in CNC technologies. It is observed from the figures that all different sectors have invested different level of investment in advanced machining technologies. In automobile industries the maximum investments have been made in CNC technology followed by NC/DNC and flexible manufacturing system. In electronics industries & machinery industries the maximum investments have been made in CNC followed by flexible manufacturing system and NC/DNC. In process industries the maximum investments have been made in flexible manufacturing and CNC are almost same followed by NC/DNC. Except the automobile industries all other industries have invested less on robotics technology.

Null hypothesis (H_{0a}): The levels of investments on advanced machining technologies are same for all sectors.

Alternative hypothesis (H_{1a}): The levels of investments on advanced machining technologies are different for all sectors.
One-way ANOVA: AMcT 1, AMcT 2, AMcT 3, AMcT 4

Source DF SS MS F P

Factor	3	5.527	1.842	7.98	0.003
Error	12	2.771	0.231		
Total	15	8.298			

According to test null hypothesis is rejected, it means that the levels of investments on advanced machining technologies are different for different sectors.

3 ADVANCED PROCESS IMPROVEMENT SYSTEMS

In manufacturing industries advanced technologies are also used to improve the process. Some advanced process improvement technologies are: bench marking, recycling, kaizen and management training. Benchmarking is the process of comparing one's business processes and performance to industry bests or best practices from other industries. Recycling is a process to change waste into new products to prevent waste of potentially useful materials, reduce the consumption of fresh raw materials, and reduce usage. Kaizen is used for improvement for the better or practices that focus upon continuous improvement of processes in manufacturing, engineering, and business management.

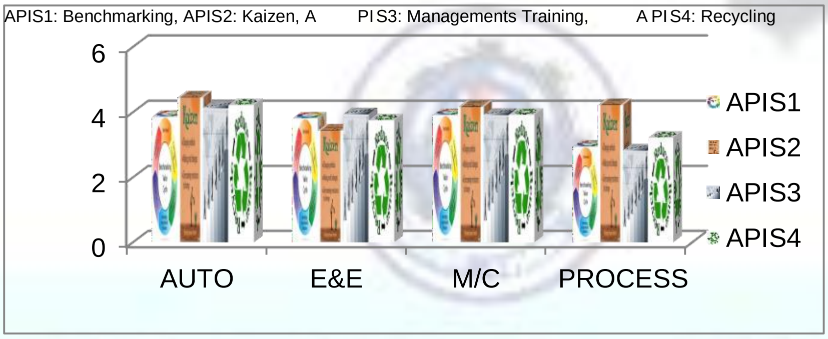

Figure 2: Advanced process improvement systems in different sector

It is observed from the figure 2that the level of investment by different sector in advanced process improvement system is different.

It is observed from the figures that the investment on advanced process improvement systems is different in different sector. Automobile industries have invested the maximum on kaizen followed by management training, recycling and bench marking. Electronics industries have invested the maximum on management training followed by recycling, bench marking and kaizen. Machinery industries have invested the maximum on kaizen followed by management training, recycling and bench marking. Process industries have invested the maximum on kaizen followed by recycling, management training, and bench marking.

Null hypothesis (H_{0b}): All sectors have invested almost same level of investment in advanced process improvement systems.

Alternative hypothesis (H_{1b}): All sectors have invested different level of investment in advanced process improvement systems.

One-way ANOVA: APIS 1, APIS 2, APIS 3, APIS 4

Source	DF	SS	MS	F	P
Factor	3	0.440	0.147	0.63	0.609
Error	12	2.787	0.232		
Total	15	3.227			

According to test null hypothesis is rejected, which indicates that all sectors have invested different level of investment in advanced process improvement systems.

4 ADOPTIONS OF ADVANCED MANUFACTURING TECHNOLOGIES

The adoptions of advanced manufacturing technologies allow 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 likert scale, where 1 indicates lower efficient, 3 indicates average and 5 indicates well above efficient.

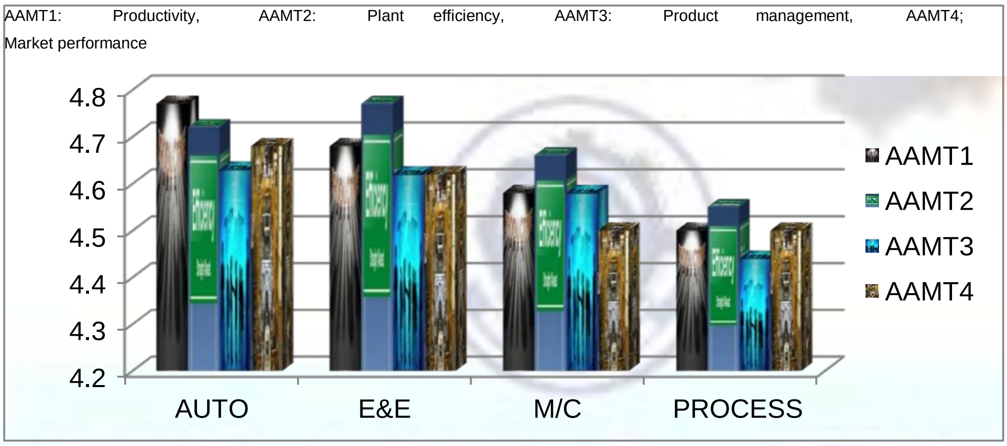

Figure3: Adoption of advanced manufacturing technologies in different sector

It is observed from the figure 3 that owing to adoption of advanced manufacturing technologies productivity, efficiency, product management, and market performance are improved. As shown in figure that in different sector due to adoption of advanced manufacturing technologies different factors are improved. It is concluded that efficiency enhancement of manufacturing industries can be achieved through advanced manufacturing technologies.

It is observed from the figures that in automobile industries overall performance is increased by adoption of advanced manufacturing technologies with mean of above 4. Automobile industries are mostly affected by productivity followed by plant efficiency, market performance and product management. Electronics industries are mostly affected by plant efficiency followed by productivity, market performance and product management with mean of above 4. Machinery industries are mostly affected by plant efficiency followed by productivity, product management and market performance with mean of above 4. Process industries are mostly affected by plant efficiency followed by productivity, market performance and product management with mean of above 4. All sectors indicate the mean above 4, it is concluded that efficiency of all sector are increased due to adoption of advanced manufacturing technologies. The level of efficiency is different for different sector.

Null hypothesis (H_{0c}): Efficiency enhancement through advanced manufacturing technologies.

Alternative hypothesis (H_{1c}): Efficiency decrease through advanced manufacturing technologies.

One-way ANOVA: AAMT 1, AAMT 2, AAMT 3, AAMT 4

Source DF SS MS F P

Factor	3	0.01437	0.00479	0.53	0.671
Error	12	0.10873	0.00906		
Total	15	0.12309			

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

CASE STUDY- A –: (ADVANCED TOOL IN MACHINE SHOP)

The part/job to be machined is "Anchor Bush" on which there are primarily two machining operations to be done that are namely: a) Turning and

b) Drilling (Dia. 19 mm)

(a) The part/job to be machined is "Sleeve" of length 40 mm having a hardness of 60 HRC on which Turning operation is to be carried out.

The tool being used was an index able turning holder with an Uncoated Carbide Insert.

It has been proposed to use a **CERAMIC** Insert that gave the following advantages over the existing Uncoated Carbide Insert:

1) CERAMIC is a very hard material and is specifically employed to machine hard materials (above 50 HRC).
2) Use of CERAMIC insert enables the use of higher cutting speeds.
3) The absence of any chip former on the CERAMIC insert enabled easy removal of the chips.
4) An additional T-Land has been provided on the cutting edge to improve its life and to increase the rate of heat removal from the cutting edge.

The various technical details and data regarding the cutting parameters have been tabulated below:

Table 1.1: Cutting parameter of turning tools

Machine Description			LMW Turn	
Part Identification			Sleeve	
Material / Hardness:			Hardened 60 HRC	
TOOL			NORMAL	ADVANCED
(A) MACHINE COST			Current	Proposed
1A	Machine Hour Rate	N / Hour	1102	1102
2A	Feed rate	mm/rev	2	2
3A	Index / Change time	minutes	5	5
4A	Parts produced per index	Numbers		

			2	100
5A	Cut Length	mm	40	40
6A	Tool Life in mm, per edge set	mm	80	4000
7A	Spindles/Machine	Numbers	1	1
8A	Machining / Uncut Time	minutes	0.08	0.08
9A	Machine cost per part	N	47.5	2.37
(B)DURABLE TOOLING COST				
1B	Annual production	Numbers	2500	2500
2B	Purchase price of tool	N	6,612	6,612
3B	Grinds or Indexes per tool	Numbers	100	100
4B	Tools required for Annual Production	Numbers	12.5	0.3
5B	Tool cost per part	N	33	0.66
(C) TOOL MAINTENANCE				
COST				
1C	Tool Room burden rate	N / Min	0	0
2C	Tool Room Index time	minutes	0	0
3C	Tool index cost	N	0	0
(D) INSERT COST				
1D	Parts per index	Numbers	2	100
2D	Number of Inserts in Tool Holder (Z)	Numbers	1	1
3D	Cutting edges per insert	Numbers	3	3
4D	Cost each	N	1,928	2755

5D	Inserts for Annual Production	Numbers	417	8
6D	Insert cost for Annual Production	N	803540	22960
7D	Insert/Blade cost per part	N	321.2	9.36
	(E) TOOL COST			
1E	Total tool cost per part	N	354.3	9.92
	(F) MACHINE & TOOL COST			
1F	Machine and Tool cost per part	N	401.7	12.1

Savings Per part (Ns) 389.5, Annually 974,350, Percent 97%

(b) The Drilling operation has been analyzed on which the current tool being used was an Index able Drill of Diameter 19 mm.

An advanced tool (Index able Drill Diameter 19 mm) has been proposed that has the following advantages over the SECO drill:

1) Through coolant system in the drill body, thereby helping the coolant to reach directly at the cutting edge and constant cooling of drill flutes as well.

2) Chemical Vapour Deposition coating of Ti –Al- N on the inserts instead of Physical Vapour Deposition coating being used earlier thereby enabling us to use higher feed rates which directly affected the Tool Life.

3) Highly finished and precisely ground flutes of the drill body for minimum resistance to chip flow and enabling quick removal of chips from the cutting edge.

4) Wiping edge on the Insert for instant burnishing of the hole thereby improving the surface finish.
5) Better Tool geometry by having different included angles of the drill for various materials to be machined.

6) Special SUMO CHAM mechanism for better clamping and butting surface area.

The various technical details and data regarding the cutting parameters have been tabulated in the table:

Table: 1.2 Cutting parameter of drilling tools

Part Identification		Anchor Bush		
Material / Hardness:		180-200 BHN		
TOOL			NORMAL	ADVANCED
(A)	MACHINE COST	Unit	Current	Proposed
1A	Machine Hour Rate	N / Min	33	33
2A	Feed rate	mm/min	150	204

3A	Index / Change time	minutes	5	5
4A	Holes produced per index	Numbers	90	135
5A	Cut Length	mm	72	72
6A	Tool Life in mm, per edge set	mm	6480	9720
7A	Spindles/Machine	Numbers	1	1
8A	Machining / in cut Time	minutes	0.48	0.35
9A	Machine cost per part	N	16.5	11
(B)	DURABLE TOOLING COST			
1B	Annual production	Numbers	25,000	25,000
2B	Purchase price of tool	N	55100	88160
3B	Grinds or Indexes per tool	Numbers	100	100
4B	Tools required for Annual Production	Numbers	2.8	1.9
5B	Tool cost per part	N	6.1	6.6
C. CUTTER MAINTENANCE COST				
1C	Tool Room burden rate	N / Min	0	0
2C	Tool Room Index time	minutes	0	0
3C	Tool index cost	N	0	0
(D) INSERT COST				
1D	Parts per index	Numbers	90	135
2D	Number of Teeth in cutter (Z)	Numbers	2	2
3D	Cutting edges per insert	Numbers	4	4
4D	Cost each	N	1791	2479
5D	Inserts for Annual Production	Numbers	139	93
6D	Insert cost for Annual Production	N	248,715.3	229,583.5
7D	Insert/Blade cost per part	N	9.92	9.34
(E) TO OL COST				
1E	Total tool cost per part	N	16	16

(F) MA CHINE & TOOL COST				
1F	Machine and Tool cost per part	N	33.6	28.6

SAVINGS: Per part (Ns) 4.95, Annually (Ns) 129,248, Percent 15.3%

CASE STUDY- B: (KAIZEN USED IN WIRE HARNESS)

Introduction

Kaizen is the process of continuous improvement (Applied in small scale organizations) concerns with the cost reduction by some modification in processes of small scale industries. The study is focused on the improvements that can give the minimum rejection level in the products.

Kaizen is a Japanese word for the philosophy that defines management's role in continuously encouraging and implementing small improvements involving everyone. It is the process of continuous improvements in small increments that make the process more efficient, effective, under control and adaptable. Improvements are usually accomplished at little or no expenses, without sophisticated techniques or expensive equipment. It focuses on the simplification of the process by breaking down complex processes into their sub-processes and then making them more efficient. For the study, some experiments have been completed before and after the improvements and modifications in the process. Data have been collected before and after modifications and on the basis of these observations the cost and rejection levels of the products have been recognized. Then calculations have been done on standards cost basis. After calculations some conclusions have been deduced that have been represented with the help of tables. In this study some data have been collected by experimenting specially in the wire harness manufacturing companies for automotive vehicles. Some examples of kaizen improvements in the above mentioned industry and their effect on cost and rejections levels are shown with the help of tables. To find out the results the following procedure is followed:

Procedure applied for Cost reduction

1. Identification of problems
2. Selection of the problem
3. Objective
4. Defining the problem
5. Data collection: Before and after
6. Root cause analysis
7. Data analysis
8. Action
9. Developing solutions
10. Achievements
11. Effectiveness
12. Tengible benefits

Problem: Lock reverse bend in terminal

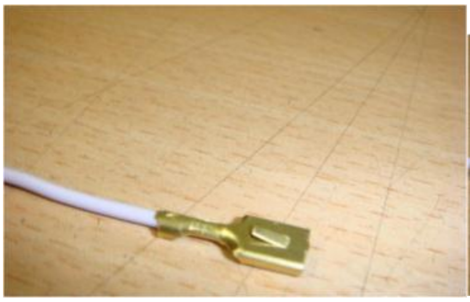
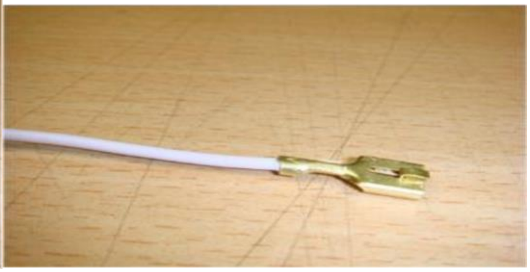

Figure 4(a): Terminal locks correct Figure 4(b): Terminal Lock Bend condition

This is the general problem that occurs on wire and terminal crimping machine while feeding the terminal chain from feeder. The causes of this type of problems may be:

- Terminal lock stuck in terminal chain
- Terminal lock striking in cutter guide
- Loose binding of terminal roll (a) Defining the problem:

Figure 5: Terminal feed in machine(Problem)

Table 3 : Data collection of automatic wire processing

PRODUCTION AREA					
Problem Stage	AUTOMATIC WIRE PROCESSING				
	LOCK BEND (in pcs) IN ONE MONTH				
	I week	II week	III week	IV week	TOTAL
AWP area	200	250	225	210	885
WIP area	10	12	159	30	211
Wire inspection area	155	125	165	138	583
Wire assembly area	6	8	4	10	28
Coupler assembly area	6	5	7	5	23
total	377	400	560	393	1730

Table 4: Data Analysis of automatic wire processing

S.No.	CAUSE	OBSERVATION	NO. OF FAILURES	
			NOS.	IN%

1.	Terminal lock get stuck in terminal chain	15 times	8	53
2.	Terminal lock striking in cutter guide	15 times	4	27
3.	Loose binding of terminal roll	15 times	3	20

Table 5: Action of automatic wire processing

S.No.	Problem	Action
1	Terminal lock stuck in terminal chain	Modified the hanger guide
2	Terminal lock striking in the cutter	Lock height controlled at vendor end
3	Loose binding of terminal roll	Training provide to the operator at vendor end


Figure 6 (a): Before improvement Figure 6 (b): After improvement

Tangible benefits I. Material cost:

Monthly rejection of terminal=1730 Pieces. Cost of rejection of terminal=1730x1.98=N 3,425 **II. Manpower cost:**

Operator cost for processing: 2x1730=58 hrs.x121.2=N 7029 One piece rework time: 2Min.

III. Machine cost:

N 4.13 per terminal, Total machine cost: 1730x4.13= N 7,145/month, Tool broken (punch + cutter guide) = 48 Nos.

Cost of punch or cutter guide =N 1,377.5, Total cost per month = N 66,120

Total cost saving = 3,425+7029+7,145+66,120= N 83,719/month **Total cost saving per year =83,719x12 = N 1,004,628**

CONCLUSION

In this paper, a survey of Indian manufacturing industries has been carried out to study various AMT issues. Four main sectors have been encompassed in the survey which are automobile, electrical and electronics, machine tools and process sector. The level of investment on advanced manufacturing technologies by different sector is variable. The purpose of the case studies presented in this study is to ascertain the impacts of AMT in manufacturing industries. The implementation of new technology within an industry for the purpose of improving efficiencies, developing flexibility and enhancing output represents an innovative development. It is concluded that efficiency enhancement of manufacturing industries can be accomplished through advanced manufacturing technologies.

REFERENCES

Alcaraz Jorge Luis and Alvarado Alejandro, (2012) Benefits of Advanced Manufacturing Technologies, African journal of business management Vol.6, pp 5524-5532.

Arbnorl.,and Bjerke, B. (1997),. Methodology for creating business knowledge (2nd ed.) Thousands Oaks, CA: Sage.

Boyer, K.K. and Mcdermott, C., (1999) Strategic consensus in operations strategy, Journal of operations Management, 17, 3, 289-305.

Chan, M.H., LAU, H., (2001). Investment appraisal techniques for advanced manufacturing technologies: a literature review, Integrated Manufacturing Systems, 12, 1, 35-47

Dangayach, G.S. and Deshmukh, S.G (2000), Implementation of advanced manufacturing technologies (AMTs) in industries, National Conference on World Class Manufacturing Systems (WCMS-2000), Jhansi, 174-180.

Dangayach, G.S. and Deshmukh, S.G (2000), Implementation of advanced manufacturing technologies (AMTs) in industries, National Conference on World Class Manufacturing Systems (WCMS-2000), Jhansi, 174-180.

Dangayach, G.S. and Deshmukh, S.G., (2004), Advanced Manufacturing Technologies: Evidences from automobile companies, International Journal of Manufacturing Technology and Management, 6, 5, 426-433.

Dangayach, G.S. and Sharma, A.D. (2006), AMT: A way of improving technological competitiveness, International journal of global business and competitiveness. Vol 2 No.1 ,pp1-8

Diaz, M.S., M. J. A. and Machuca, J. A. D., (2005). Performance measurement systems, competitive priorities, and advanced manufacturing technology: Some evidence from the aeronautical sector, International Journal of Operations & Production Management, 25, 8, 781-799.

Diaz, M.S., Machuca, J.A.D. and Gil, M.J.A., (2003). A view of developing patterns of investment in AMT through empirical taxonomies: new evidence, Journal of Operations Management, 21, 577-606.

Ramamoorthy,C, Selladurai,V , (2011), Efficiency enhancement of manufacturing industries through lean principles. International journal of research and reviews in mechatronics design and simulation Vol.1 No. 2.

Raymond, L., (2005). Operations management and advanced manufacturing technologies in SMEs: A contingency approach. Journal of Manufacturing Technology Management, 16(8), 936-955.

Safsten, K. Winroth, M. and Stahre, J., (2007). The content and process of automation strategies, International Journal of Production Economics, Available on line 27 march 2007.

Udo, G.J., and Ehie, I.C. (1996). Advanced manufacturing technologies: determinants of implementation success. International Journal of Operations and Production Management, 16(12), 6-26.

Zhou, Y., and Chauh, K.B., (2002). Computer integrated manufacturing in China, International Journal of Operations and Production Management, 22, 3, 271-288.