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Abstract: The purpose of this research is to assess the status of implementation of advanced manufacturing technologies (AMTs) in manufacturing small and medium enterprises (SMEs) located in northern India. Evaluation of the implementation of AMTs on the performance of SMEs has been carried out using the percent point score (PPS) method. Four AMTs were selected and their impact on six performance factors has been investigated in detail. This study depicts the actual status of the implementation of AMTs in the manufacturing sector. To make the data highly reliable and represent the exact area of consideration, a significant number (202) of small and medium scale enterprises have been considered for the study. The analysis reveals that the implementation of AMTs enhances the firm performance. This paper fills the gap between in the literature by assessing the present state of implementation of AMTs in SMEs of northern India and analysing its impact on the performance parameters. It can be helpful for the management, entrepreneurs, stakeholders and researchers to take a closer and comprehensive look at the interaction between AMTs and the performance in SMEs.

Keywords: advanced manufacturing technologies; AMTs; percent point score; PPS; small and medium enterprises; SMEs; adoption/implementation of AMTs; classification of AMTs; India.

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1 Introduction

There has been tremendous industrial growth in the last few years (Jaiswal and Kumar, 2018; Kaushik and Singh, 2021). SMEs are often called 'engine of growth' [Rosnah et al., (2004), p.39]. They are the pillars of modern economies and their contribution towards manufacturing of goods according to our emerging and changing needs cannot be ignored. SMEs are defined and categorised on different criteria in different nations. In India, the SMEs are defined in terms of investment in plant and machinery. According to the government of India, the investment in plant and machinery is more than Rs. 25 lakh (2.5 million) but does not exceed Rs. 5 crore (50 million) for small enterprises. The investment in plant and machinery is more than Rs. 5 crore (50 million) but not exceeding Rs.10 crore (0.1 billion) in case of medium enterprises.

In such a dynamic environment, they must respond quickly to cope up for the needs and also their survival. SMEs constantly hunt for remedies which can impart flexibility in their manufacturing and organising system (Singh et al, 2011; Singh et al., 2012).

The major factor that has enabled the SMEs to respond to these emerging and dynamic challenges has been the implementation of advanced manufacturing technologies (AMTs). Koc and Bozdag (2009) defined AMTs as the technologies that control or operate the production processes with the application of electronic, mechanical and computer-based systems. AMTs with the use of computers involves a possible set of technologies such as computer-aided design (CAD), computer aided process planning (CAPP), computer integrated manufacturing (CIM), computer numerical control (CNC), computer-aided manufacturing (CAM), robotics and engineering systems, production planning, scheduling, routing, automated guided vehicles (AGVs), material resource management, enterprise resource planning (ERP), etc. (Dangayach and Deshmukh, 2005). AMTs have assisted the SMEs in providing tools and techniques required to match the increasing demands of customers like better quality, reliability, added features, green standards, varied designs, quicker delivery, precision, accuracy, low cost and range or multiplicity (Kaushik and Singh, 2019; Singh and Khamba, 2013). AMTs help to provide competitive edge by transforming the entire business process (Narayanamurthy and Gurumurthy, 2017; Small and Yasin, 1997).

Alcaraz et al. (2012) and Klocke and Straube (2004) quoted many merits of AMTs implementation which include better management, reduced cost of products, higher competitiveness, reduced inventory, increased profit, improved quality, shorter delivery time, lesser setup time, better plant utilisation, quicker response and many more.

The support and merits of implementation of AMTs in SMEs are quite evident. India being a developing economy is facing such a scenario in which enterprises are struggling to survive and compete (Kaushik and Singh, in press). Significantly less literature and reviews are available regarding the status of implementation of AMTs in SMEs. This research is an attempt to fill the literature gap regarding the status and performance evaluation by the implementation of AMTs. Thus, there is a need to investigate the present situation of such enterprises. This study is also helpful in analysing the AMTs and its impact on various performance parameters, which can motivate the enterprises to implement AMTs.

2 Literature review

Dangayach and Deshmukh (2005) in their survey of 122 SMEs of India concluded that companies give the slightest importance to flexibility and foremost priority to quality. It is realised that flexibility is the competitive priority in adoption of AMTs. The findings show that Indian SMEs are not emphasising satisfactorily on AMT, whereas industries of Japan and USA are giving maximum priority to flexibility (Dean et al., 2000; Sanchez, 1996; Schroder and Sohal, 1999). Raymond (2005) in a survey of 118 Canadian SMEs for the implementation and assimilation levels of AMT quoted that AMTs are guaranteed to take extra standing for many SMEs that are handling the new tasks in terms of growth, competitiveness and survival.

Gupta et al. (1998) concluded that most of the researchers suggest that there is an independent and immediate beneficial influence of AMT implementation on some performance parameters such as lead time, defect rate, inventory level and machine utilisation. They also stated that AMT implementation does not get much effected by the commitment of personnel. Their study reflects their experience in the industries of the USA. Singh and Khamba (2013) in their research of 95 large and medium sized manufacturing industries of northern India highlighted relationships between AMT utilisation initiatives and performance, namely cost, quality, labour productivity and morale. They concluded that AMT utilisation initiatives can increase productivity and help in competing against market challengers.

Cardoso et al. (2012) highlighted the organisational factors that affect implementation of AMTs in Brazilian industries. They highlighted that companies need an integrative and planned approach in order to take benefits. Problems verified after AMTs putting into practice mostly result due to lack of investigation of the organisational characteristics required by the AMT. Allegedly, space and process aspects are lesser significant than structural aspects.

Koc and Bozdag (2009) in a survey sample of 102 manufacturing Turkish SMEs found that LAN, CAM and CAD are most commonly used AMTs whereas AS, WAN and Robotics are less commonly used AMTs. The AMTs considered in the study were CAD, CAM, CNC, LAN, WAN, AS, AI and AP. Fulton and Hon (2010) on the basis of their study and guiding of 73 SMEs of UK assessed the results of the implementation of AMTs on business processes and income. The major factors affecting the implementation time involved coordinating training facilities, procurement procedures and trainees from participating companies. Upadhyay et al. (2011) analysed responses of 98 Indian manufacturing MSMEs. He tried to explore the factors affecting the implementation of

ERP. The major factors affecting its implementation are product and vendor perspective, project execution competency, organisational climate and technical perspective.

Nyori and K'Obonyo (2015) in their survey of 92 companies of Kenya assessed that the level of AMT adoption which was found to be very low. Small and younger companies reported lesser implementation of AMTs. Amongst various AMTs, material handling technology is the least invested in their study. Uwizeyemungu et al. (2015) in their research of 616 Canadian SMEs concluded that the small industries experience a greater impact on performance in terms of product innovation by the adoption of AMTs. Also, there is a need to choose sensibly among the numerous AMTs available to which they will consecrate their limited resources. Tahriri et al. (2015) in a cross-sectional survey of 83 automotive SMEs of Malaysia found that most of the SMEs have adopted 80% sustainable practices. It is also revealed in their research that SMEs are either keen or considering implementation of AMTs with a vision of improvement in their performance.

Murad et al. (2017) in a survey of 120 organisations of Malaysia concluded that organisational commitment is reflected from organisational structure and top management backing. They also concluded that commitment is an important parameter in deciding the role of the members for collectively accomplishing the organisation's decision in implementing advance technology.

Yusuff et al. (2005) in a cross-sectional survey of Malaysian industries showed that industries were focusing more on short-term gains. The focus of industries should remain on strategic benefits offered by AMTs. The deficiency of understanding of technologies and an organic structure, the lower levels of workers, ethos of the companies, etc. are the major factors that obstruct SMEs from achieving the key benefits of AMT and adopting creative management practices. Companies were asked to indicate AMT already implemented from a list of 22 AMTs. Approximately 23% of the firms had not implemented any AMT, 29% each were not in the process of and had no plan to implement any AMT.

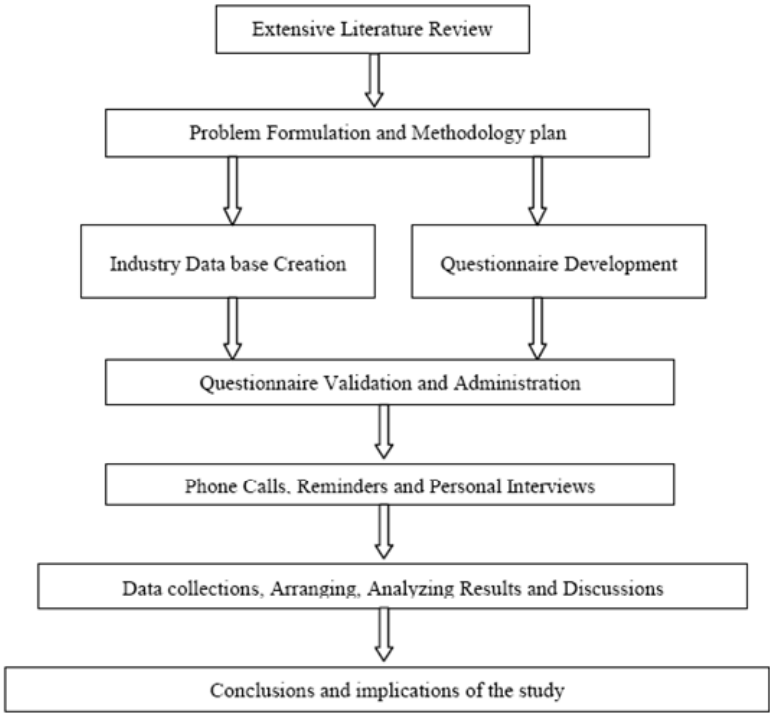
Altuntas et al. (2018) in their research of 310 Turkish manufacturing firms examined the relationships among AMT, export, innovation and firm performance. Their findings reflected strong positive associations between the use of AMT and innovation and between export and firm performance. He stressed that AMTs result in enhancing the performance of the manufacturing enterprises. Cheng et al. (2018) in their comparative study between large and small enterprises revealed that AMTs have a lot to offer to small companies also. It was pointed that the main reason is the lack of funds due to which they are not able to adopt AMTs. Bhandari et al. (2018) in their paper tried to justify the implementation of AMTs in SMEs. The findings indicate that by the sensible application of AMTs, SMEs can improve their performance like flexibility, delivery on time, inventory reduction, reduction in production cost, innovative or new products, etc.

Chan et al. (2001); Chen and Small (1994); Dean et al. (2000); Putterill et al. (1996); Small and Yasin (1997); Swamidass and Waller (1991) several studies have been reported in the literature on AMTs in case of developed economies.

The literature review reflects that a lot of work has been done in implementation of AMTs in SMEs of developed countries as compared to the developing nations. Moreover, due to a large variety of AMTs, it becomes difficult to assess the situation fully. Less literature is available especially in case of Indian manufacturing SMEs. So there is a huge scope of research to assess the situation of implementation of AMTs in SMEs of developing countries like India. It seems that this is the first attempt in which percentage

points (PPS) has been used to relate AMTs and performance in SMEs of northern India. For present research, the following AMTs have been taken into consideration after a rigorous literature review to assess the current situation, namely CAM, CAD, robotics, Automated material handling and storage (AMHS), FMS and ERP. These were validated through peer review from industrialists/entrepreneurs, academicians and managers of the enterprises. This paper will be helpful in understanding the interaction between AMTs and the performance in SMEs.

Figure 1 Methodology for the present work



3 Methodology

The present research is carried out in small and medium scale industries located in northern India. The primary objective of this work is to evaluate the status of implementation of AMTs in SMEs located in Northern India. The block diagram of the research path adopted for this work is shown in Figure 1. The questions were designed on a five point Likert scale. Each AMT was depicted in the sequential manner for the collection of data from industries. The questionnaire was validated through the peer review from industrialists/entrepreneurs, academicians and managers of the enterprises. The data collection followed the following three sequential stages. In the first stage, the owner/employee of the organisation was informed through a telephonic call about the survey being carried out and their consent was taken. In the second stage, the questionnaire was emailed or sent by post to them along with the intent letter. Then, in the third or last stage, reminders were sent and phone calls were made to them to get

them to fill up the data of the questionnaire and mail it back. From the directories of MSMEs in Northern India, 1008 SMEs were randomly contacted through emails and personal interviews for the completion of the work in the region. 231 responses were obtained. Eleven responses were found to be incomplete because of some missing values. After the rejection of unsatisfactory responses, 202 responses were left for consideration, a number sufficient for data analysis in the field (Kaushik and Singh, 2018; Oberoi et al., 2008; Singh et al., 2016).

4 Questionnaire organisation

A simple, relevant and comprehensive questionnaire comprising of around 140 questions was designed. It was based on a five point Likert scale. The questionnaire sought information about the status of implementation of AMTs in the organisation. The first part of the information sought the general information about the type of organisation, the turn over, the number of employees and the size type of the production system. Further, the questionnaire was divided into six sub-sections given below.

a general information of the organisation

b a brief description of AMTs implemented

c detailed information of the status of AMTs implementation

d organisational performance

e critical success factors in the implementation of AMTs

f barriers in the implementation of AMTs.

The Cronbach alpha for various AMTs and performance parameters is depicted in Table 1. The value of Cronbach alpha obtained is more than or equal to 0.80 indicating the high degree of reliability.

Table 1 Cronbach alpha for various AMTs and performance parameters

S. no.	*Construct*	*Abbreviation*	*Cronbach alpha*
1	Computer-aided manufacturing	CAM	0.975
2	Computer aided design	CAD	0.954
3	Automated material handling and storage	AMHS	0.822
4	Enterprise resource planning	ERP	0.951
5	Production	PROD	0.962
6	Quality	QUAL	0.985
7	Profit	PROF	0.960
8	Productivity	PRODV	0.961
9	Health and safety	HS	0.975
10	Flexibility	FLX	0.978

5 General organisation – summary of responses

The responses obtained from various industries in the form of questionnaires are presented schematically in Table 2. The general information in this table reflects that this information would have substantial impact on the motive of research.

Table 2 Fragmentation of responses obtained through questionnaires

Category	*No. of respondents*	*Percentage of respondents*
Industry type		
Medium-scale	62	31.00
Small-scale	140	69.00
Number of employees		
Upto 50	140	69.3
50–100	41	20.29
100–150	7	3.46
>150	14	6.93
Market share		
<10%	152	75.24
10–25%	28	13.86
25–40%	10	4.95
>40%	12	5.94
Products manufactured		
Automotive parts	70	34.65
Metal parts and fabrication	45	22.28
Rubber/plastic parts	39	19.31
Chemicals and distilleries	23	11.39
Miscellaneous	25	12.38
Existence of firm in years		
<5	30	14.85
5–10	46	22.77
10–15	45	22.28
>15	81	40.09

Type of organisation

It is clear from Table 2 that the focus of present study is on small-scale and medium-scale industries of Northern India. Many factors were considered for selecting the organisations. In this study, data was collected from 62 medium-scale and 140 small-scale industries.

Number of employees

Table 2 indicates that 69.3% of the firms employ less than 50 employees. 20.29% firms employ 50–100 employees whereas mere 3.46% companies employ 100–150 employees. Only 6.93% firms employ more than 150 employees.

Market share

The statistics indicate that 75.24% of the firms have a market share of less than 10% while only 5.94% firms have a market share of more than 40% which is quite less.

Type of products manufactured

It is indicated from Table 2 that 34.65% of firms manufacture automotive components, 22.28% deal with metal and fabrication jobs, 19.31% manufacture rubber/plastic parts, 11.39% deal with chemicals and distilleries and 12.38 manufacture miscellaneous products.

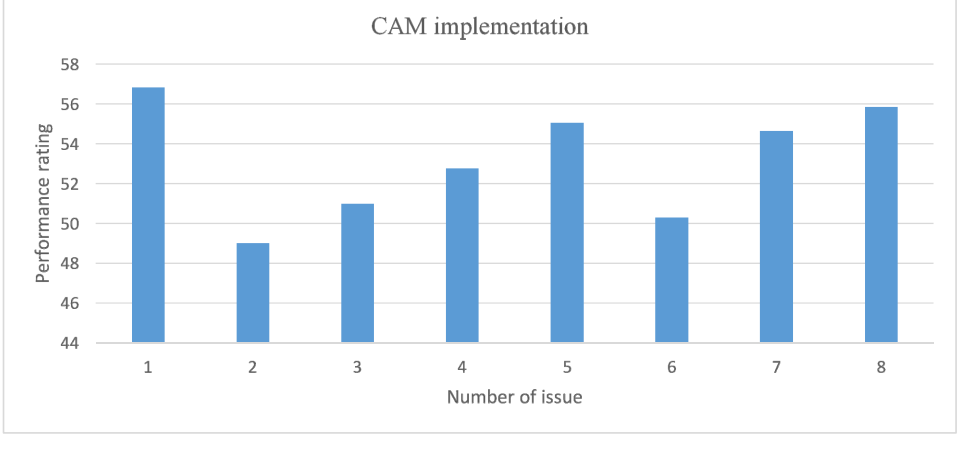
Existence of firms

Table 2 makes it clear that 40.09% firms are operational for more than 15 years. 22.77% organisations are operational from 5–10 years. Almost the same number of firms are in operation from 10–15 years while 14.85% firms are operational from less than five years.

5.1 Advanced manufacturing technologies

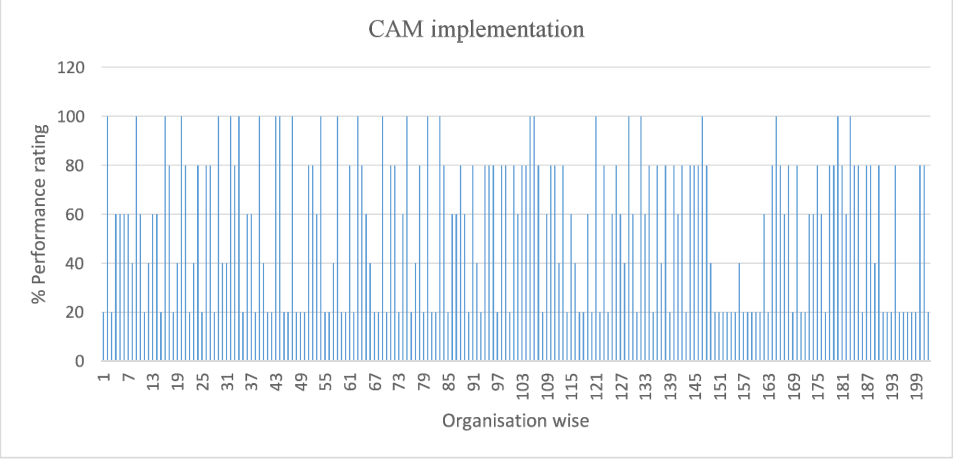
With emerging, changing and dynamic demands, the enterprises must respond speedily in order to fulfil the same. Adoption and implementation of AMTs is a solution to tackle and meet such challenges. AMTs include the use of computers in technologies like CAM, CAD, AMHS, ERP, Robotics, FMS, etc.

Figure 2 (a) Issue wise performance regarding CAM implementation (b) Organisation wise performance regarding CAM implementation (see online version for colours)



(a)

Figure 2 (a) Issue wise performance regarding CAM implementation (b) Organisation wise performance regarding CAM implementation (continued) (see online version for colours)



(b)

5.1.1 Computer aided manufacturing

It involves the use of computer and software to control machine tools and manufacture products with accuracy (Pandey et al., 2016). Table 3 shows the status of CAM being used by various manufacturing organisations. The value of high PPS, (PPS = 56.83%) signifies that CAM is being used to a considerable extent. Figures 2(a) and 2(b) represent the CAM application in the form of PPS, issue wise and organisation wise respectively.

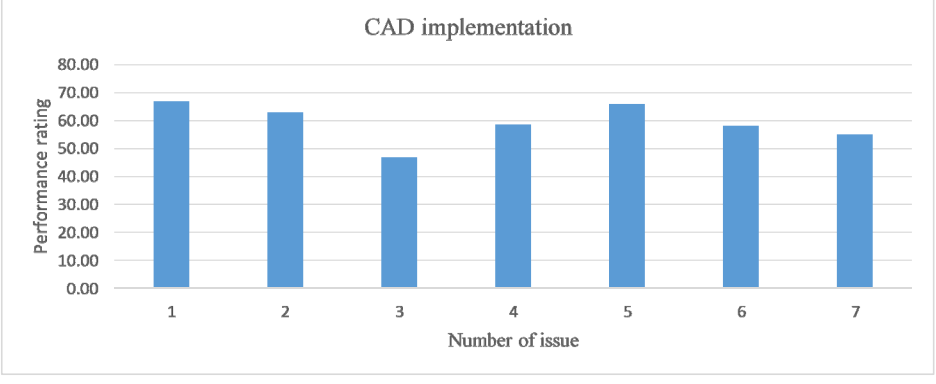
Table 3 No. of issues related to CAM

S. no.	*Computer-aided manufacturing (CAM)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The extent to which the CNC/DNC/AC are being used.	73	16	31	34	48	574	56.83
2	The level of computer aided shop floor control implementation/usage.	79	25	39	46	13	495	49.01
3	The degree of the use of computer aided process planning.	82	21	35	34	30	515	50.99
4	Willingness to pay slightly more for some useful additional features in machines.	80	16	32	45	29	533	52.77
5	Adoption of CAM for developing and manufacturing new processes/products	78	11	33	43	37	556	55.04
6	The level of usage of CAM machines/software of different companies.	81	23	36	37	25	508	50.29
7	The level of usage of customised CAM machines/software.	76	20	26	42	38	552	54.65
8	Training of workers for the ease of use of CAM.	75	16	35	28	48	564	55.84

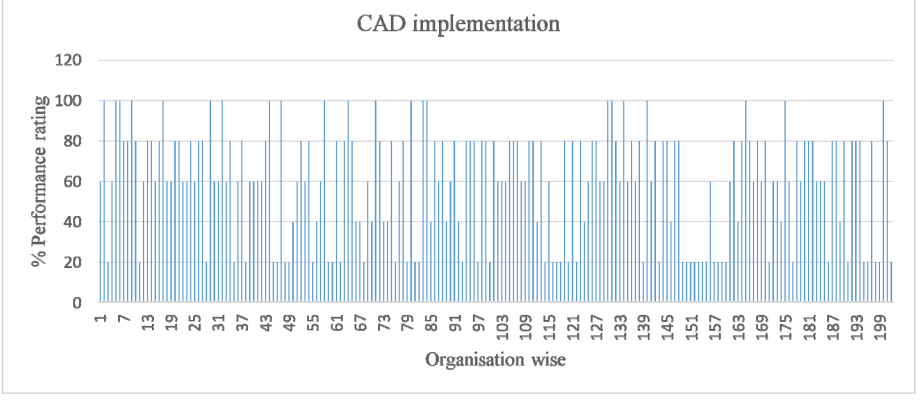
Table 4 No. of issues related to CAD

S. no.	*Computer aided design (CAD)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The extent of the use of the software for preparing/modifying drawings.	49	10	37	34	72	676	66.93
2	The frequency of updating the software(s) being used.	60	22	23	22	75	636	62.97
3	The usage of different software of various companies.	75	36	46	36	9	474	46.93
4	The extent of preparation of drawings in house.	59	22	35	46	40	592	58.61
5	The extent to which part drawings are made.	48	6	33	67	48	667	66.03
6	The extent to which assembly drawings are made.	53	27	36	57	29	588	58.21
7	Timely training of the workers/new employees for the efficient use of software.	58	35	41	34	34	557	55.14

Figure 3 (a) Issue wise performance regarding CAD implementation (b) Organisation wise performance regarding CAD implementation (see online version for colours)



(a)

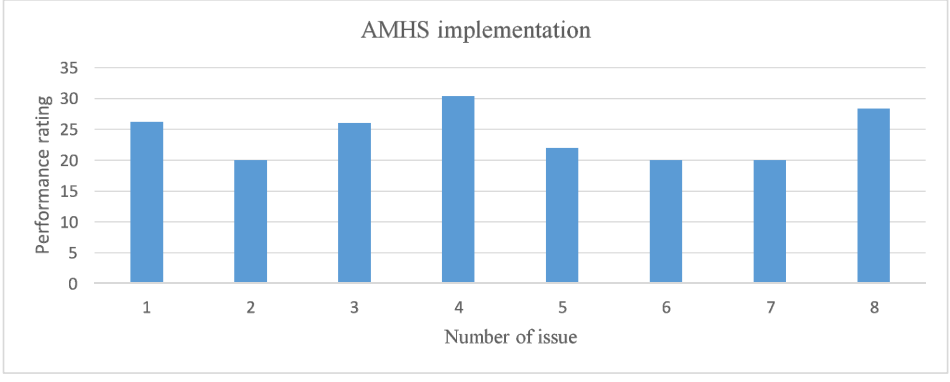


(b)

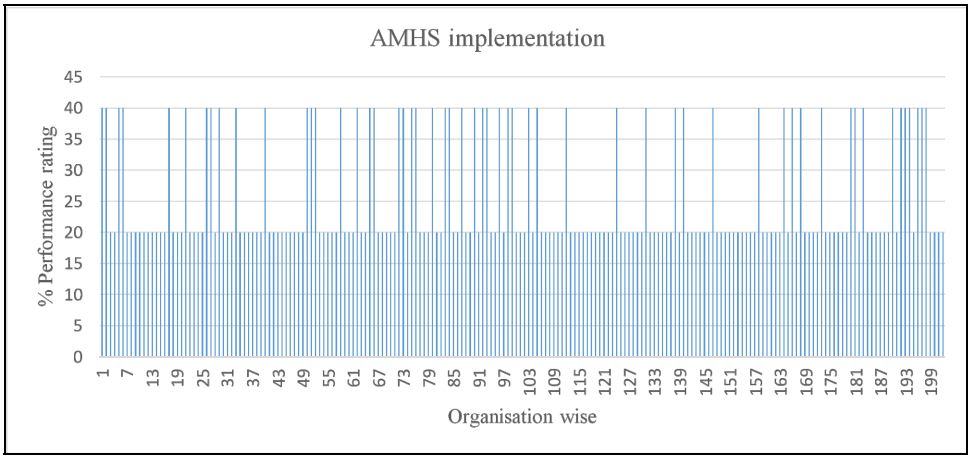
5.1.2 Computer-aided design

It involves the use of computer or workstation and software to help in creation, modification, optimisation, or analysis of a design (Pandey et al., 2016). Table 4 shows the status of CAD being used by various manufacturing organisations. A high PPS, (PPS = 66.93%) signifies that CAD is being used in industries to a large extent. A comparative low value (PPS = 46.93%) signifies firms do not prefer using software of different companies. Figures 3(a) and 3(b) represent the CAD application in the form of PPS, issue wise and organisation wise respectively.

Figure 4 (a) Issue wise performance regarding AMHS implementation (b) Organisation wise performance regarding AMHS implementation (see online version for colours)



(a)



(b)

5.1.3 Automated material handling and storage

AMHS uses an extensive variety of manual, semi-automated and automated apparatus which is used to handle, control and store materials (Woo et al., 1995). Throughout low PPS in implementation of AMHS signifies that its implementation is not significant as

compared to CAM and CAD. Only a few firms have implemented AMHS and that too, to some extent. Table 5 shows the status of AMHS being used by various manufacturing organisations. Figures 4(a) and 4(b) represent the AMHS application in the form of PPS, issue wise and organisation wise respectively.

Table 5 No. of issues related to AMHS

S. no.	*Automated material handling and storage (AMHS)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The extent to which conveyor belts are used.	144	53	5	0	0	265	26.23
2	The level of the use of Automated guided vehicles.	202	0	0	0	0	202	20
3	The extent to which AMHS is adopted over manual storage and retrieval.	146	51	5	0	0	263	26.03
4	The frequency of training workers to use the automated storage and retrieval system.	146	18	27	11	0	307	30.39
5	The level of the use of industrial trucks (lifting).	190	7	2	3	0	222	21.98
6	The level of use of assembly line vehicles.	202	0	0	0	0	202	20
7	The variety of guidance systems adopted to keep the vehicles on path.	202	0	0	0	0	202	20
8	The extent of dedicated storage space allocation than randomised space allocation.	144	37	15	6	0	287	28.41

Table 6 No. of issues related to ERP

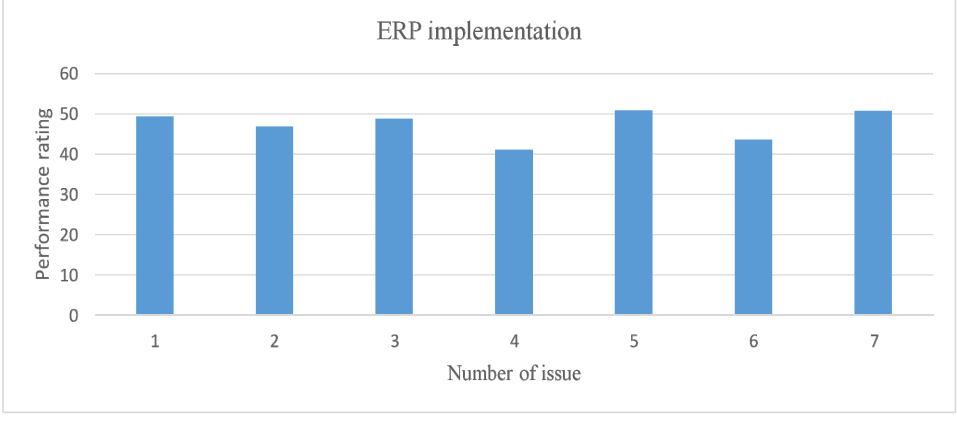
S. no.	*Enterprise resource planning (ERP)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	Whether using all major modules of ERP for managing work.	68	35	51	31	17	500	49.50
2	Module adjustment/changes with the changes in format or work operations with time.	75	29	60	29	9	474	46.93
3	Special training imparted to various workers for multipurpose use.	75	24	59	26	18	494	48.91
4	The frequency of vendors/dealers training for the use of ERP.	90	50	31	22	9	416	41.18
5	Flexibility in the ERP system to various changes in the organisation.	73	23	46	42	18	515	50.99
6	The extent to which the software is optimised In-house.	83	40	46	25	8	441	43.66
7	The level of fear of data loss, privacy and confidentiality after ERP implementation.	74	27	42	35	24	514	50.89

5.1.4 Enterprise resource planning

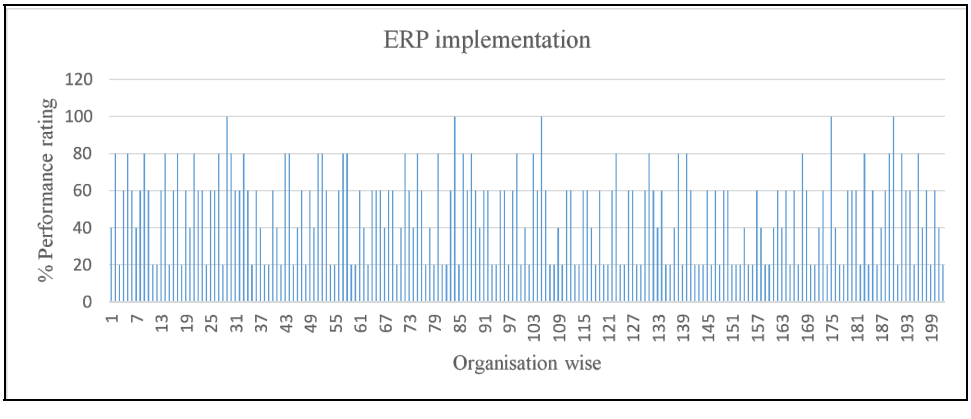
ERP is a vital information system/technological tool for industries to manage their supply chain processes. It is used to identify, capture, integrate and store the flow of information

or data generated by the execution of their business transactions, with both entities inside and outside of the firm (Acar et al., 2017). It can be interpreted from a high score of PPS, (PPS = 50.99%) that ERP system is flexible enough to facilitate changes or moderation in an organisation. Table 6 shows the status of ERP being used by various manufacturing organisations. Figures 5(a) and 5(b) represent the ERP application in the form of PPS, issue wise and organisation wise respectively.

Figure 5 (a) Issue wise performance regarding ERP implementation (b) Organisation wise performance regarding ERP implementation (see online version for colours)



(a)



(b)

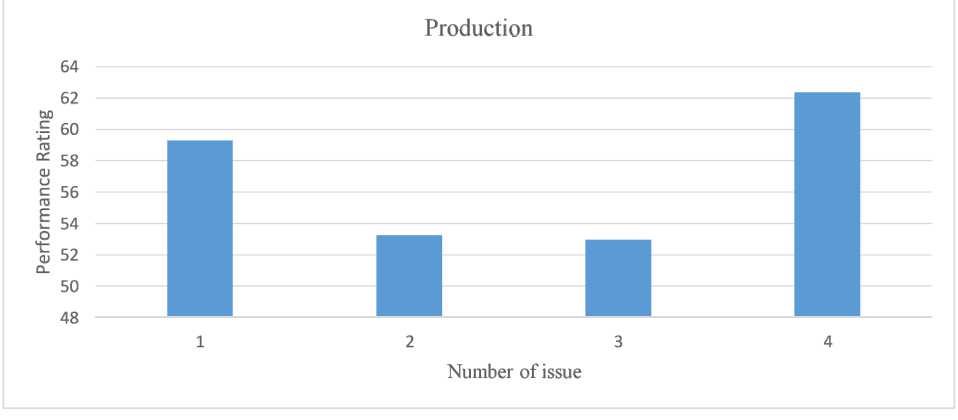
5.1.5 Production

Production (PROD) is the primary concern of the firms which means the amount of something that can be made or produced. Table 7 shows the effect of implementation of AMTs on production by various manufacturing organisations. The high value (PPS = 62.37%) indicates that it is easier to produce with the help of AMTs as compared to manual or conventional processes. Figures 6(a) and 6(b) represent the production in the form of PPS, issue wise and organisation wise respectively.

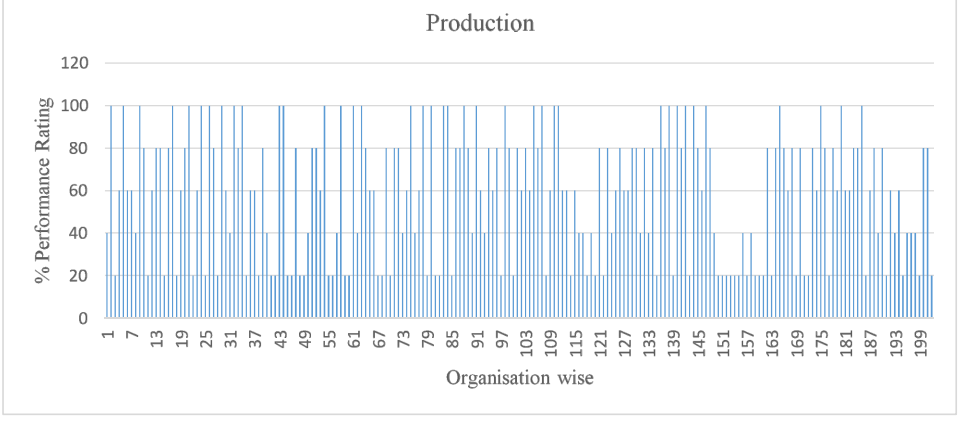
Table 7 No. of issues related to production

S. no.	*Production (PROD)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The increase in the number of products manufactured.	57	24	30	51	40	599	59.30
2	The increase in the number of variety/variants of products.	63	31	42	43	23	538	53.26
3	New products introduced due to the adoption/use of AMTs.	66	29	43	38	26	535	52.97
4	The ease of production using AMTs compared to manual or conventional processes.	57	14	33	44	54	630	62.37

Figure 6 (a) Issue wise performance regarding production (b) Organisation wise performance regarding production (see online version for colours)



(a)

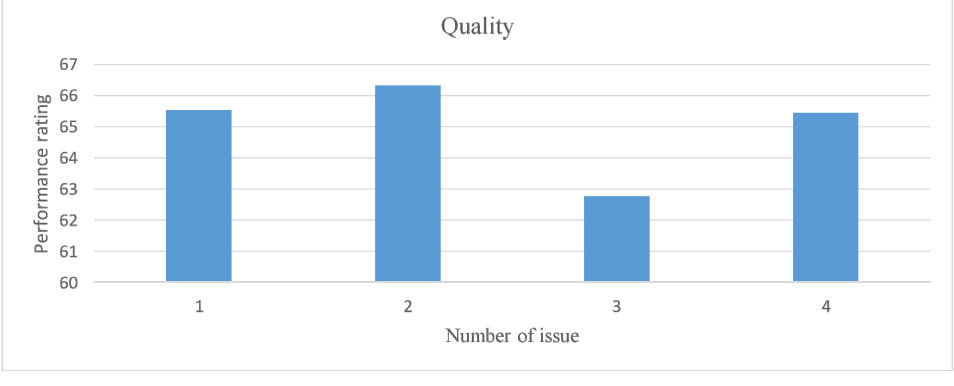


(b)

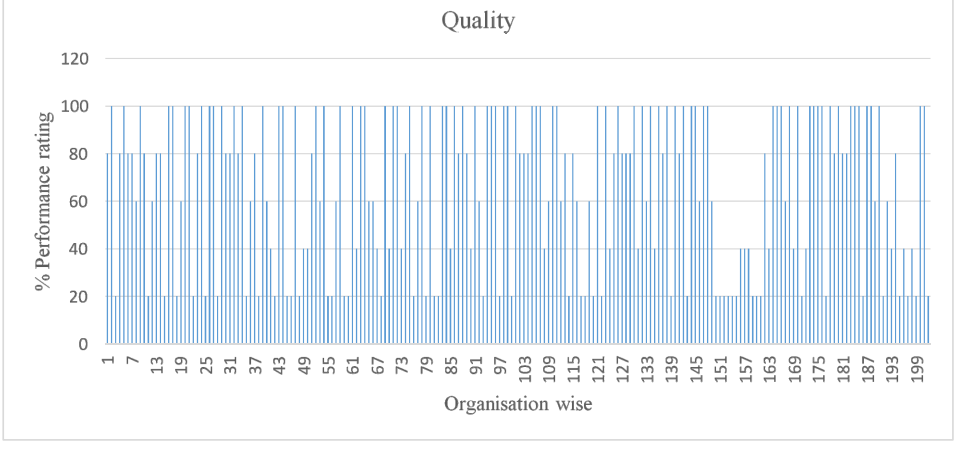
Table 8 No. of issues related to quality

S. no.	*Quality (QUAL)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The increase in the quality of the products.	58	11	22	39	72	662	65.54
2	The reduction in defects at final quality check.	50	22	25	24	81	670	66.33
3	The level of dealer satisfaction regarding quality.	58	27	20	23	74	634	62.77
4	The level of customer/user satisfaction regarding quality.	53	21	26	22	80	661	65.44

Figure 7 (a) issue wise performance regarding quality (b) Organisation wise performance regarding quality (see online version for colours)



(a)



(b)

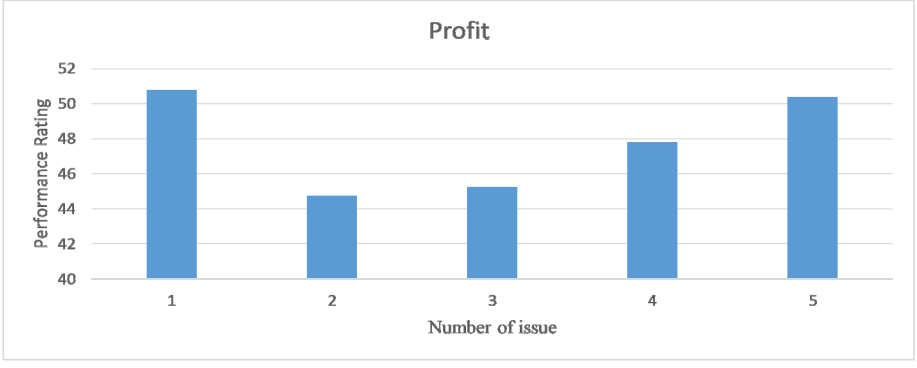
5.1.6 Quality

It is the outcome of the process. Quality (QUAL) is the degree to which a product meets the requirement or standard of the customer. Table 8 shows the effect of implementation of AMTs on quality by various manufacturing organisations. High PPS throughout signifies that quality is improved drastically by the implementation of AMTs. Figures 7(a) and 7(b) represent quality in the form of PPS, issue wise and organisation wise respectively.

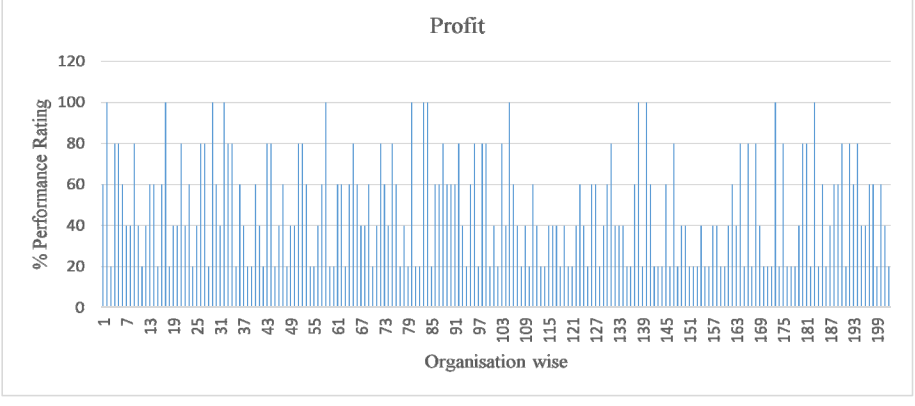
5.1.7 Profit

Maximising the profit (PROF) has been the major priority of business organisations. Profit is the measure of money that can be made after selling the product. It can be interpreted from moderate value (PPS = 50.79%) that firms make profit and bear lesser operating costs by the implementation of AMTs. Table 9 shows the effect of the implementation of AMTs on profit by various manufacturing organisations. Figures 8(a) and 8(b) represent the profit in the form of PPS, issue wise and organisation wise respectively.

Figure 8 (a) Issue wise performance regarding profit (b) Organisation wise performance regarding profit (see online version for colours)



(a)



(b)

Table 9 No. of issues related to profit

S. no.	*Profit (PROF)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The increase in the profit of the company.	64	45	41	24	28	513	50.79
2	Saving of the raw material and reduction in waste.	79	48	36	26	13	452	44.75
3	The value of market share increase.	72	54	40	23	13	457	45.24
4	Net income increase as compared to competitors.	69	45	39	38	11	483	47.82
5	The decrease in operating cost with the use of AMTs.	66	42	39	33	22	509	50.39

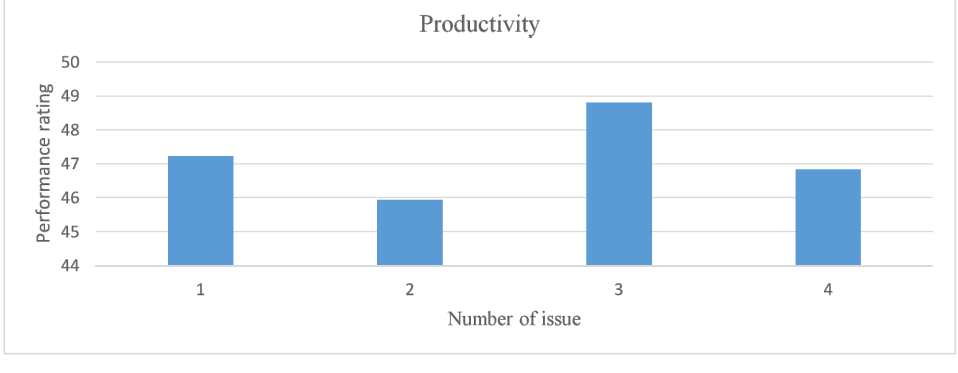
5.1.8 Productivity

It is a major concern for manufacturing organisations. Productivity (PRODV) is the measure of the efficiency of the machine, employee, system, etc. to convert inputs into outputs. Table 10 shows the effect of implementation of AMTs on productivity by various manufacturing organisations. From the values of PPS, it can be interpreted that productivity is not significantly improved, may be due to high costs of AMTs. Figures 9(a) and 9(b) represent productivity in the form of PPS, issue wise and organisation wise respectively.

Table 10 No. of issues related to productivity

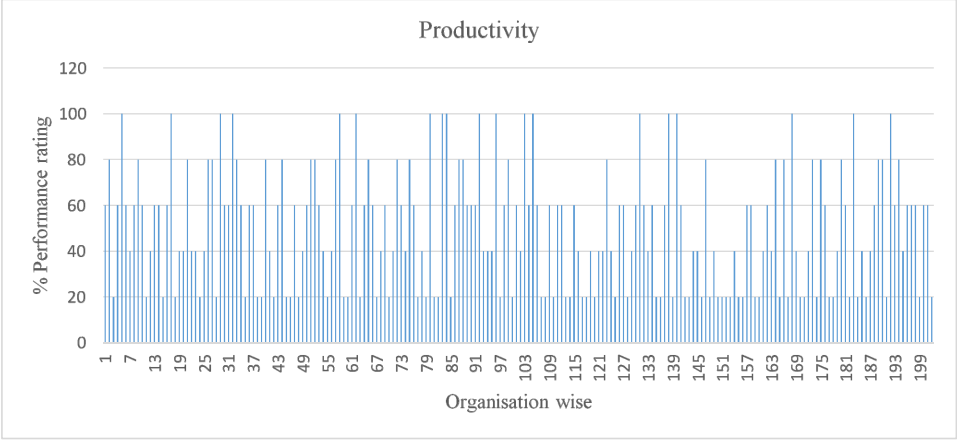
S. no.	*Productivity (PRODV)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The increase in the productivity of the company.	70	43	51	22	16	477	47.22
2	Reduction in the total manufacturing cost of the product.	78	44	39	24	17	464	45.94
3	Saving of the wages of workers after switching/adoption of AMTs.	60	53	44	30	15	493	48.81
4	Increased margin in selling of the product.	72	43	48	24	15	473	46.83

Figure 9 (a) Issue wise performance regarding productivity (b) Organisation wise performance regarding productivity (see online version for colours)



(a)

Figure 9 (a) Issue wise performance regarding productivity (b) Organisation wise performance regarding productivity (continued) (see online version for colours)

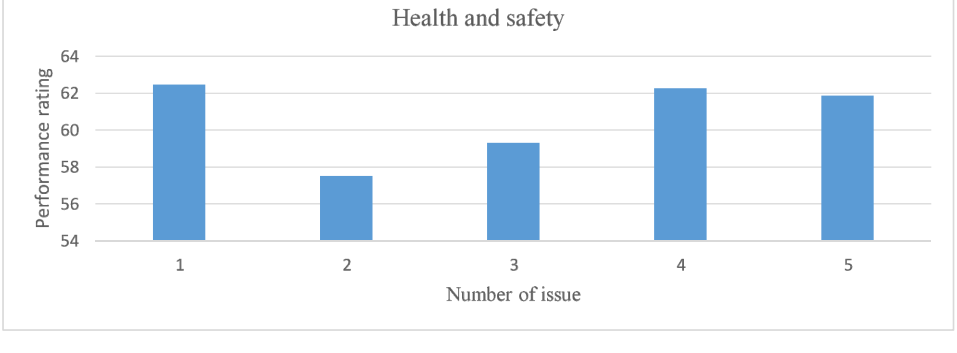


(b)

5.1.9 Health and safety

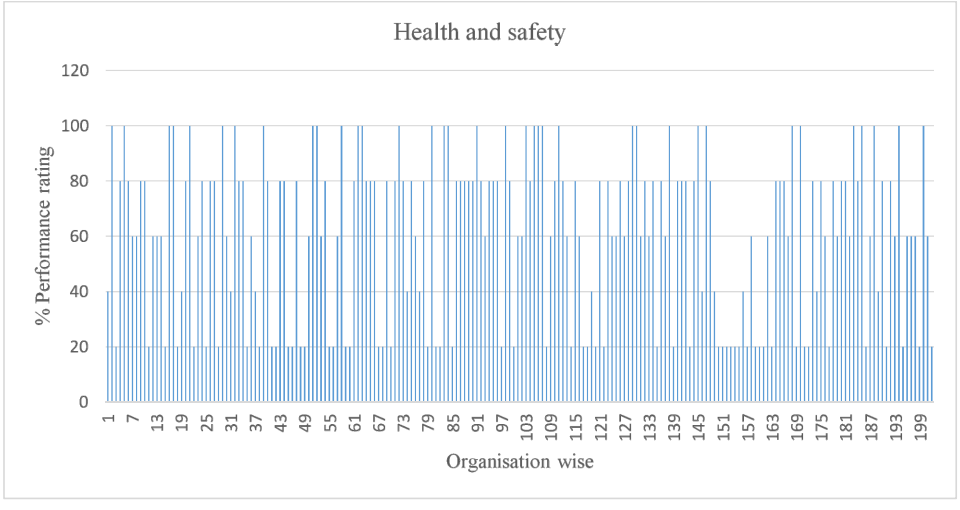
The intent to prevent accident, disease or injury at the workplace is represented by Health and safety (HS). Table 11 shows the effect of implementation of AMTs on HS by various manufacturing organisations. A high value (PPS = 62.47%) signifies that the implementation of AMTs has led to an improvement if the health and wellbeing of the workers/employees. Also, it is safer for workers to work on machines (PPS = 62.27%). Figures 10(a) and 10(b) represent HS in the form of PPS, issue wise and organisation wise respectively.

Figure 10 (a) Issue wise performance regarding HS (b) Organisation wise performance regarding HS (see online version for colours)



(a)

Figure 10 (a) Issue wise performance regarding HS (b) Organisation wise performance regarding HS (continued) (see online version for colours)



(b)

Table 11 No. of issues related to HS

S. no.	*Health and safety (HS)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The overall improvement in health and wellbeing of workers/employees.	57	8	38	51	48	631	62.47
2	Reduction in absenteeism of workers/employees.	58	22	38	55	29	581	57.52
3	Reduction in medical claims/reimbursements.	57	18	37	55	35	599	59.30
4	Improvement in safety of workers while working on machines.	58	11	31	54	48	629	62.27
5	Reduction in number of accidents/mishappenings reported.	57	11	37	50	47	625	61.88

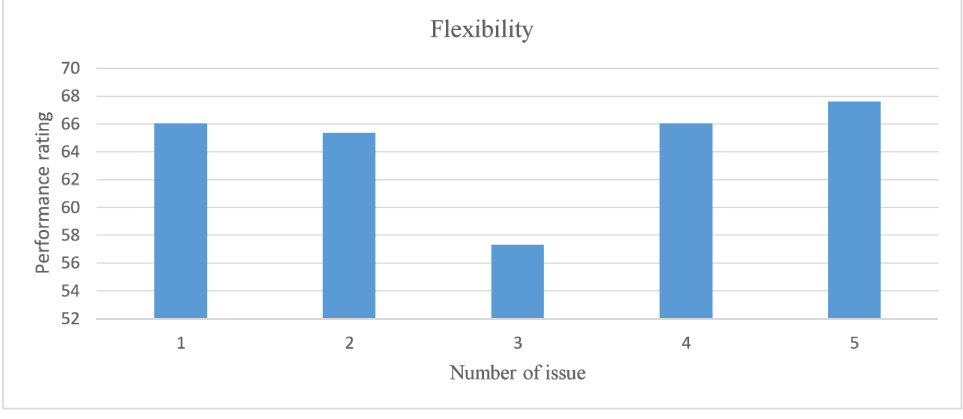
5.1.10 Flexibility

Flexibility (FLX) is the ability to change according to the situation. Table 12 shows the effect of the implementation of AMTs on flexibility by various manufacturing organisations. A very high value (PPS = 67.62%) indicates that flexibility to meet special customer demands is highly increased by the implementation of AMTs. Flexibility in manufacturing a wide range or variety is also enhanced (PPS = 66.03%). .Figures 11(a) and 11(b) represent flexibility in the form of PPS, issue wise and organisation wise respectively.

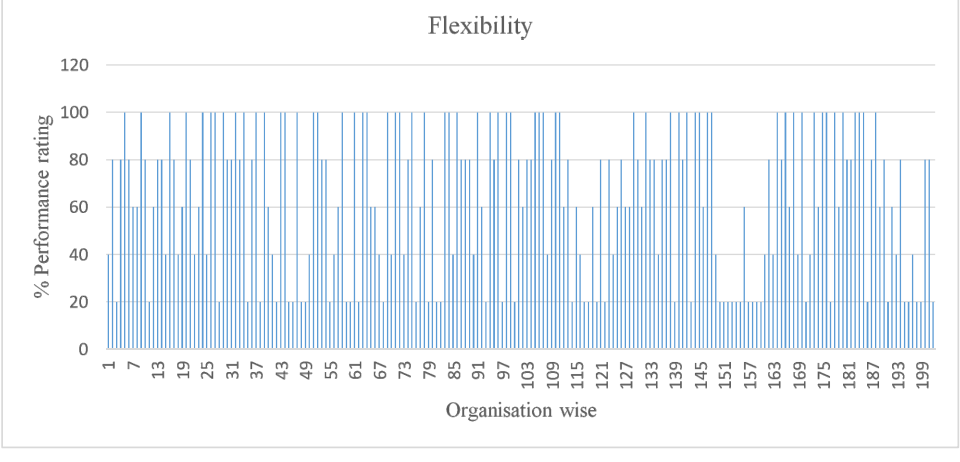
Table 12 No. of issues related to flexibility

S. no.	*Flexibility (FLX)*	*1*	*2*	*3*	*4*	*5*	*TPS*	*PPS*
1	The flexibility in design to accommodate a wide variety of products.	49	8	38	47	60	667	66.03
2	The flexibility in introducing new products quickly.	52	20	18	46	66	660	65.34
3	The flexibility in supply chain management.	62	18	42	45	35	579	57.32
4	The flexibility in manufacturing.	50	21	21	38	72	667	66.03
5	The flexibility in meeting special customer demands.	48	13	26	44	71	683	67.62

Figure 11 (a) issue wise performance regarding flexibility (b) Organisation wise performance regarding flexibility (see online version for colours)



(a)



(b)

6 Conclusions and managerial implications

The aim of present study was to evaluate the status of implementation of AMTs in SMEs located in northern region of India. AMTs provide a complete solution to help the organisations to survive in a highly competitive scenario where survival is possible only for the fittest. Four AMTs were selected and its effect was analysed on six performance parameters after rigorous literature review (Koc and Bozdag, 2009). Out of all the selected AMTs, CAM, CAD and ERP scored better in terms of PPS. It is noticeable that firms mainly concentrate on two concepts, specifically design and integration. From the PPS it can be interpreted that CAD is the most widely used AMT in firms of Northern India, i.e., firms concentrate more on design parameter. It plays a vital role in bringing about a transformation in SMEs. SMEs concentrate on selective implementation of AMTs to improve design capability and meet market demand. But the score of AMHS was found to be comparatively lower. The findings of present research are similar to the findings of Nyori and K'Obonyo (2015). This might be due to the high cost of its implementation. As SMEs generally have limited finances, it becomes difficult for them to invest in such AMTs and they prefer manual handling due to comparatively much lesser cost.

56.83% manufacturing small-scale and medium-scale enterprises have invested in implementing CAM (CNC/DNC/AC) which is quite significant. It is interesting to know that 50.29% of SMEs are using CAM machines/software of different companies/make. This reflects the inquisitiveness of enterprises to hunt for a better and an efficient option. 66.93% manufacturing SMEs use CAD software for preparing/modifying drawings. Thus, the use of CAD is highest amongst all the AMTs taken into account for this study. It is also noticeable that 46.93% SMEs are using different software of various companies. It can be due to the ease and features provided by the software companies for making different types of drawings and designs. The extent to which AMHS is adopted over manual storage and retrieval is 26.03%. AGVs and assembly line vehicles still need to find their place in SMEs. The reason behind this also seems to be their high initial cost and availability of cheap labour. Most of the enterprise are using all the major modules of ERP for managing their work. It can be interpreted from a high PPS, (PPS = 50.99%) that ERP system is flexible enough to facilitate changes or moderation in an enterprise.

62.37% small-scale and medium-scale enterprises agree to fact that it easier to produce using AMTs as compared to manual or conventional processes. 65.54% enterprises reported an increase in the quality of the products due to the implementation of AMTs. Many enterprises reported an increase in the profit of the organisation (PPS = 50.79%). 45.24% enterprises reported an increase in the value of market share. Almost similar number of enterprises (PPS = 47.82%) reported net income increase as compared to competitors due to the competitive edge provided by the AMTs. The implementation of AMTs has led to a saving of the wages of workers (PPS = 48.81%). A significant number of enterprises are satisfied by the overall improvement in health and wellbeing of workers/employees (PPS = 62.47%). 61.88% enterprises acclaimed a reduction in number of accidents/mishappenings reported. 67.62% enterprises admired the flexibility gained in meeting special customer demands by the implementation of AMTs.

The impact of the AMTs implementation cannot be ignored on most of the performance parameters. The PPS signifies that quality, flexibility and production are

comparatively highly enhanced output parameters. HS has also noticeably improved which is obvious due the fact that the implementation of AMTs lead to lesser human contact while manufacturing or machining. Quality is the most significantly improved factor as compared to other performance parameters. Also, it is learnt that it has led to a reduction in defects at the final quality check. The firm's capability to meet special customer needs has increased noticeably with improved flexibility. Production is improved on an average while profit and productivity are comparatively on a lower side. This might be due to the high initial cost and investment in AMTs. Thus, it can be concluded that organisations have been benefited with the implementation of AMTs.

Also, it has been observed that the enterprises manufacturing automotive parts have implemented the AMTs to a larger extent as compared to the rest. Automotive parts need high accuracy, so the enterprises cannot take risk. Hence, CAD, CAM and ERP find an extensive use in this sector. AMHS finds more utilisation in chemical and distillery enterprises due to the presence of hazardous fumes/chemicals, human safety and fear of contamination. Metal parts and fabrication enterprises utilise CAD to a considerable extent. Rubber and plastic manufacturing enterprises utilise AMTs to a lesser extent. The AMT utilisation in miscellaneous category is quite varying depending upon the type of product. Hence, it is justified to say that the level of utilisation of AMTs is maximum in automotive parts manufacturing enterprises and hence, a significant enhancement of performance level.

This research will help the management, entrepreneurs and governments of other developing countries to understand the phase of transformation after introducing AMTs in the manufacturing sector. Also, this will be helpful in understanding the interaction between AMTs and the performance in SMEs. Moreover, the results of the present study can help to motivate the enterprises to invest in and implement AMTs.

7 Limitations and future scope

The emphasis of the present research work was limited to the manufacturing sector. Moreover, it can pertain to a particular category or product manufacturing sector. It may be extended to other sectors, i.e., the non-manufacturing sector and the service sector. Also, this study was based on a limited number of AMTs. Different AMTs can be included future studies. Similarly, different output parameters can be considered in upcoming studies. Another limitation of concern is a single respondent. The collection of data from a single respondent may be biased, since the data is based on observations, experiences and perceptions of the respondents. Thus, forthcoming research on the linked subject may be carried out based on multiple respondents.

Hope, this research helps to inspire other researchers to pursue studies aimed at improving the knowledge about AMTs implementation and the impact of various variables.

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