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A Preferential study of Key factors for implementation of E- Manufacturing in Indian Industries

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Abstract

Modern manufacturing organizations in all over world has been facing huge challenges that are mainly induced by continuous change in global and competitive market as well as change in customer's demands, regional change, change in governmental rules and environmental change. This paper introduces e-manufacturing technology as a new concept to answer all the need of business activities for complete and successful integration of all business function through internet in order to make manufacturing agile. The term e-manufacturing also refers to the ability of manufacturing system to integrate the various inputs by using internet in order to provide products according to the demands of customer, and this will also results in decreasing the gap between demand and supply of a product. This paper tries to identify the key factors which are mandatory to understand for the implementation of e-manufacturing system.

Keywords: e-manufacturing, factors for e-manufacturing.

Introduction

In modern era, all manufacturing units have to work hard to obtain not only high quality of product, productivity and reduced cost, but also the ability of system to react quickly with changing culture in manufacturing and to meet with the variant requirement of customer, responsively and effectively to the market, which is becoming more dynamic and customer oriented. For instance, many European manufacturers are designing their products in Europe and manufacturing these products in East Asia, and then selling their products at high volume in all over world. These global-wide manufacturing phenomena are getting to be much common in manufacturing industry in all over world. Maintaining design feasibility and manufacturing agility while working on the extended product design improvement is the key for these manufacturing companies to be successful and to withstand with such kind of phenomena.

Though Advanced Manufacturing Technology (AMT) was thought as sufficient for customer driven market approach, success was only partial in today's internet-driven economy, that is, quick response to demand of customer. A quick response to the demand of customer can only achieve by combining AMT with internet which results in important part of e-business[1]. It is a system methodology that enables the manufacturing operations to successfully integrate with the functional aspects of an organization through the use of internet, tether-free (i.e. wireless) and predictive recent technologies. Today we are using information technology almost everywhere whether it is in banks, airports, corporate, educational institutions. Now days, we are using it on the shop floor or in manufacturing unit also[2].

Literature Review: According to, Kai Cheng and Bateman Richard J "E-Manufacturing technology increases the opportunities for data intensive process such as on-line monitoring of equipments and controlling of machine tools conditions and knowledge intensive processes including new product design creation, complex systems modelling and simulation, and real time decision making supports in quick time and complex problems solving at a faster rate." Large networks of engineers, working together from different areas using common product data are technically feasible, and many larger manufacturers are using this opportunity for reducing product manufacturing time and sharing of information's related to product design at a common level, as well as support for engineering innovation and solving complex problems in quick time[3].

Web-enabled technology play important role in solving and enabling the complexity of product design and manufacturing operations by providing the mechanisms for managing and controlling the integrated system with the higher system levels such as SCM and ERP. E-Maintenance is the major and important pillar of the system that supports the success of combination of e-Manufacturing system and e-business.

The combination of all three technologies i.e. e-Maintenance, e-Manufacturing, and e-business system, if implemented properly in any organization then organization will gain priceless benefit from the increased operation reliability with less breakdown and maintenance.

E-Procurement offers the replacement of stock with data and offers direct access to spares at reasonable cost. For the successful implementation of E-Manufacturing there should be

a good relationship and effective communication between supplier and customer. The primary goal of e-manufacturing is to deliver good quality product as quickly as possible and it also ensure good return on capital.

This paper discussed some important factors or enablers of E-Manufacturing which when implemented properly will leads to more benefits to an industry that works for it. Effectiveness of e-manufacturing is also important as its implementation is. The effective implementation of E-manufacturing results in increase in productivity and overall performance of the organization, while at the same time it reduces the cost of production. For the success of e-manufacturing, the co-operation between all departments of the organization is very important.

Factors of e-manufacturing

Advance manufacturing technology: Conventional manufacturing process is being replaced by new, fast response customer focussed techniques that maximize the manufactures return on all resources. The manufacturing technology which we are going to adopt in e-manufacturing should be agile. Advance manufacturing technology can be viewed as encompassing computer and numerical-based system (software and hardware) design to accomplish or support manufacturing support[1].

Web enabled interface and services: With the help of web-enabled tether-free technology used in an e-Manufacturing system, the massive data bottle-necks between the production shop and business systems of an organization can be eliminated by converting the raw data and process capability data into useful information for quick and accurate decision making. Users from different plants, factories or different locations can also share these informations through the internet facilities. These services encourages users for high-quality communications between them since they are sharing the same set of data or information without any restriction or language barriers[4].

Stockholder interface and feedback: All the stakeholders of e-manufacturing environment should have a proper interaction with the system to react quickly. The participation of stakeholders brings the surety of correct input data or information.

As define by Rajeev Saha, Sandeep Grover[1] The feedback mechanism in any system recognize any error by comparing current process with correct process. E-manufacturing strategy provides a direct exchange of information's between organization, Customer Relationship Management system and supply chain management system.

Automation: Automation is the systematic use of application of technology to monitor and control the production in effective way and delivery of products and services at faster rate. Automation is the combination applications of mechanical, computer and electronics engineering in order to make the system labour free or fully automated. There are some main advantages of the automated manufacturing which includes: higher consistency of work, better quality of work, reducing fatigue to workers, simplification of manufacturing process, improving the overall performance of organization when a good and effective implementation of automation is done.

Network security and data security: As the success of e-manufacturing system depends on the fact that how well data flow across different agents of manufacturing from different region of world, therefore the security of network which carry all this important data related to manufacturing becomes more important for the successful and efficient working of this e-manufacturing system. So there should be no compromise allowed regarding any kind of interference with data which if allowed may result in corrupt data and which ultimately results in wrong interpretation regarding work or manufacturing. The network used for flaw of this data should be protected from any kind of virus. All the data at the product and machine level need to be identified and corrected at time[5].

Data management system: Data management system is that system which gathers all data from various machines and processes stations using internet and manage this data accordingly. Since this massive data which is available is not useful until unless it is reduced to required data and transformed into required information for responsive actions[1]. As the large amounts of initial data collected during a manufacturing process is useless, unless this data is gathered and transformed into required information which may be easily understandable or compatible for particular system.

Synchronization tools: As rightly depicted by Shivanand et al.[6], this is an important tool of the E-Manufacturing technology, which can integrates various groups such as customer, suppliers and manufacturers, where information needs to be sent to these groups during or after operation, e.g. – if a tool requires replacement or regrinding then this information is being sent from manufacturer to supplier who provides new tool or same tool after regrinding process.

"The new connectivity and communications tools will boost productivity, profits, speed to market, and flexibility for those manufactures who are willing to upgrade". Another definition by Shivanand et al[6].

Optimization tools: When we are working in e-manufacturing based organization, the required data could be from anywhere at any time. There will be different type of data for a particular problem. In order to effective monitoring the required performance of working operations in any organization with all available data, it become necessary to compare the values at different stages. Hence these tools are needed for optimization of data and for providing the results which are easy to read or understand[7].

Electronically supported process: For rapid and error free working of e-manufacturing system the system must be electronically supported. Mechanical and computer applications should be collaborated with electronics application for making the system agile and fast responsive. Electronic supported system can help a company to reduce expenditure expends on providing training and it helps in increasing productivity and performance of organization. With the implementation of this system the workers, especially new joined workers in any organization, will not only be able to complete their task more quickly and efficiently but also learn more about their job and organization.

Effective training: Provide proper and effective training to workers and engineers in order to make them capable of pacing with the speed of information flow and understanding the overall structure. The success of e-manufacturing will ultimately depend on how well all stakeholders understand and become an integral part of it. For the purpose, it is necessitated to educate and train each stakeholder for all enabling tools and techniques. They must know their participative responsibilities to optimize the performance of e-manufacturing system.

Methodology

Step 1: Data Gathering: In this paper in the preference of factors is found out with the help of Topsis method. The very first step in Topsis method is to gather data. This data is gathered from employees of different companies. In this paper data is collected from ten employees regarding the implementation of E-manufacturing in any industry. Views from different employees are taken, and they provide rank to ten factors which are helpful in implementation of e-manufacturing. And then this data is arranged in 10*10 matrixes, as shown in table-1.

Table 1, shows the ranking provided by different respondents about ten respondents fill the questionnaires. Each respondents provides rank to each factor according to him like (1= least important, 2= important, 3= important and necessary, 4= highly important, 5= most important) Table 2, shows the results that were taken from the questionnaire. All the data is analysed and then results are kept in table.

Table-1
Collected data from different viewers

Sr. no	Factors	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
1	AMT	3	2	2	4	2	3	4	3	2	3
2	Stockholder interface and feedback	2	2	1	2	2	2	5	2	3	2
3	web enabled interface and services	2	3	2	2	3	2	2	4	4	3
4	Automation	2	4	3	3	3	3	3	4	4	4
5	Network and data security	3	5	4	5	2	3	3	5	5	5
6	Data management system	4	3	4	5	3	4	4	3	2	3
7	Synchronization	4	3	3	4	4	2	5	3	3	2
8	optimization tools	5	4	2	5	5	5	4	4	3	3
9	Electronically supported system	3	2	3	3	3	3	3	3	4	2
10	Effective training	4	5	2	5	2	5	3	3	3	3

Table-2
Results of questionnaire

Factors	Least imp.	Important	Imp. And necessary	Highly important	Most important
1	0	4	4	2	0
2	1	7	1	0	1
3	0	5	3	2	0
4	0	1	5	4	0
5	0	1	3	1	5
6	0	1	4	4	1
7	0	2	4	3	1
8	0	1	2	3	4
9	0	2	7	1	0
10	0	2	4	1	3

First Step: Each cell of matrix is multiply by itself.

Table.3. shows the first step of TOPSIS method. In this each cell is multiply by itself and put the result in its own cell and then for each cell would be calculated and accordingly the square root of number of sum is calculated. Each cell of table 3 is divided by its related square root. It will change it into table 4. For example 16 in second columns are divided by 10.295630.

After doing second process, it's time to have 5*5 matrix in which each element is zero expect the diagonal element. Then these two tables (table 4 and table 5) should multiply by each other by, matrix multiply method. In normalising method the first step is to add the each element of each column and then the grand total of these five values is calculated. Then each value is divided by its grand total. Now again we have five values and arrange these five values as diagonal element and all other elements should be zero. One thing should be kept in mind that the total of these diagonal values should be one.

Second step: Now multiply the table 4 with corresponding weights and change the decision matrix to matrix.

Table-3
First process on result of questionnaire by multiply each cell by itself

Factors	Least imp.	Important	Imp. And necessary	Highly important	Most important
1	0	16	16	4	0
2	1	49	1	0	1
3	0	25	9	4	0
4	0	1	25	16	0
5	0	1	9	1	25
6	0	1	16	16	1
7	0	4	16	9	1
8	0	1	4	9	16
9	0	4	49	1	0
10	0	4	16	1	9
Sum	**1**	106	161	61	53
Sqrt	**1**	10.29563014	12.68857754	7.810249676	7.280109889

Table-4
Second process step by dividing each cell of last table on related SQRT

Factors	Least imp.	Important	Imp. And necessary	Highly important	Most important
1	0	1.554	1.261	0.512	0
2	1	4.759	0.0788	0	0.137
3	0	2.428	0.709	0.512	0
4	0	0.0971	1.97	2.048	0
5	0	0.0971	0.709	0.128	3.434
6	0	0.0971	1.261	2.048	0.137
7	0	0.388	1.261	1.152	0.137
8	0	0.0971	0.315	1.152	2.197
9	0	0.388	3.861	0.128	0
10	0	0.388	1.261	0.128	1.236

Table-5
Matrix of weight calculated after normalizing method

0.0255	0	0	0	0
0	0.2634	0	0	0
0	0	0.3247	0	0
0	0	0	0.1998	0
0	0	0	0	0.1863

Table.6. shows the multiplication of table 4 and table 5 by matrix multiply method. Each cell is multiplied by its weight.

Third step: To specify positive ideal and negative ideal: Now we have to find positive ideal and negative ideal. Now it's time to have positive ideal and negative ideal of table no.6. Table.7. shows the max and min. of each column of table. 6. A+ represents the max numbers and A- represent the min. numbers.

Fourth step: Now it's time to find out the distance of each point from positive ideal and negative ideal. Minus each cell of table.6 from maximum and minimum of related column in table.7.

In this step first find the distance of each point of table 6 from corresponding value of positive ideal and negative ideal. There are five parts of this step and therefore five tables are formed.

Table-6
The matrix multiply of table 4 by matrix 5

0	0.409324	0.409447	0.102298	0
0.0255	1.253521	0.025586	0	0.025523
0	0.639535	0.230212	0.102298	0
0	0.025576	0.639659	0.40919	0
0	0.025576	0.230212	0.025574	0.639754
0	0.025576	0.409447	0.40919	0.025523
0	0.102199	0.409447	0.23017	0.025523
0	0.025576	0.102281	0.23017	0.409301
0	0.102199	1.253667	0.025574	0
0	0.102199	0.409447	0.025574	0.230267

Table-7
Max. and min. of each column of table 6

Positive ideal A+ = (max. Vij+)				
Max Vi1	Max vi2	Max Vi3	Max Vi4	Max Vi5
0.0255	1.253521	1.253667	0.40919	0.639754
Negative ideal A- = (min. Vij-)				
Min Vi1	Min Vi2	Min vi3	Min Vi4	Min Vi5
0	0.025576	0.025586	0	0

Table-8
Fourth step in Topsis method (it has five parts)-distance between max point and each point

[Vij-(Vij+)]	[Vij-(Vij+)]^2		[Vij-(Vij+)]	[Vij-(Vj+)]^2	[Vij-(Vj+)]	[Vij-(Vj+)]^2	[Vij-(Vij+)]	[Vij-(Vij+)]^2	[Vij-(Vij+)]	[Vij-(Vij+)]^2
-0.0255	0.00065		-0.8442	0.712669	-0.84422	0.712708	-0.30689	0.094183	-0.63975	0.409285
0	0		0	0	-1.22808	1.508182	-0.40919	0.167436	-0.61423	0.37728
-0.0255	0.00065		-0.61399	0.376979	-1.02345	1.04746	-0.30689	0.094183	-0.63975	0.409285
-0.0255	0.00065		-1.22794	1.507849	-0.61401	0.377006	0	0	-0.63975	0.409285
-0.0255	0.00065		-1.22794	1.507849	-1.02345	1.04746	-0.38362	0.147161	0	0
-0.0255	0.00065		-1.22794	1.507849	-0.84422	0.712708	0	0	-0.61423	0.37728
-0.0255	0.00065		-1.15132	1.325542	-0.84422	0.712708	-0.17902	0.032048	-0.61423	0.37728
-0.0255	0.00065		-1.22794	1.507849	-1.15139	1.325691	-0.17902	0.032048	-0.23045	0.053109
-0.0255	0.00065		-1.15132	1.325542	0	0	-0.38362	0.147161	-0.63975	0.409285
-0.0255	0.00065		-1.15132	1.325542	-0.84422	0.712708	-0.38362	0.147161	-0.40949	0.16768

In fourth step of Topsis method each value of column is subtracted from maximum value. The maximum value is the positive ideal that we have calculated in table-7. All the values of first column are subtracted from first value of positive ideal that is 0.0255.Then all the values of second column are subtracted from second value of positive ideal from table 7 that is 1.253521. Similarly all the values of five columns are subtracted from the corresponding value of positive ideal and placed in different table as shown above. Then square of each value is calculated and placed in same table. This step has five parts and therefore five tables are formed.

In next step the sums of these values which are calculated after subtracting from positive ideals, are calculated and placed in next table i.e. Table. 9. Then square root of these values are also calculated which is placed in similar table as shown on next page.

In this table all the values [Vij-(vij+)] are added and then square root of these values is calculated as shown above. And these values of square root are named as di+ or distance from positive ideal.

Now the value of each cell of column is subtracted from minimum value that is negative ideal. This is the distance between maximum point and each point. This also requires five steps and value of each is kept in cell and then square of each value is calculated as shown.

Table-9
Shows the sum square root of $[Vij-(Vij+)]^2$ –max point

SUM
1.929496
2.052898
1.928556
2.29479
2.703119
2.598486
2.448228
2.919347
1.882638
2.353741

	SQRT
d1+	1.389063
d2+	1.432794
d3+	1.388725
d4+	1.514856
d5+	1.644117
d6+	1.611982
d7+	1.564681
d8+	1.70861
d9+	1.372093
d10+	1.534191

Table-10
Shows the distance between min point and each point

[Vij-(Vij-)]	$[Vij-(Vij-)]^2$	[Vij-(Vij-)]	$[Vij-(Vij-)]^2$	[Vij-(Vij-)]	$[Vij-(Vij-)]^2$	[Vij-(Vij-)]	$[Vij-(Vij-)]^2$	[Vij-(Vij-)]	$[Vij-(Vij-)]^2$
0	0	0.383748	0.147262	0.383861	0.147349	0.102298	0.010465	0	0
0.0255	0.00065	1.227945	1.507848	0	0	0	0	0.025523	0.000651
0	0	0.613959	0.376946	0.204626	0.041872	0.102298	0.010465	0	0
0	0	0	0	0.614073	0.377086	0.40919	0.167437	0	0
0	0	0	0	0.204626	0.041872	0.025574	0.000654	0.639754	0.409285
0	0	0	0	0.383861	0.147349	0.40919	0.167437	0.025523	0.000651
0	0	0.076623	0.005871	0.383861	0.147349	0.23017	0.052978	0.025523	0.000651
0	0	0	0	0.076695	0.005882	0.23017	0.052978	0.409301	0.167527
0	0	0.076623	0.005871	1.228081	1.508182	0.025574	0.000654	0	0
0	0	0.076623	0.005871	0.383861	0.147349	0.025574	0.000654	0.230267	0.053023

Table-11
Shows the sum and square root of $[Vij-(vij-)]^2$ –min point

SUM
0.305076
1.50915
0.429283
0.544522
0.451811
0.315437
0.20685
0.226387
1.514707
0.206897

	SQRT
d1-	0.552337
d2-	1.228475
d3-	0.655197
d4-	0.737918
d5-	0.672169
d6-	0.561638
d7-	0.454807
d8-	0.475802
d9-	1.230734
d10-	0.454859

Table-12
Shows the di+ and di- and sum of them

Distance from positive ideal		Distance from negative ideal		Sum
d1+	1.389063	d1-	0.552337	1.9414
d2+	1.432794	d2-	1.228475	2.661268
d3+	1.388725	d3-	0.655197	2.043921
d4+	1.514856	d4-	0.737918	2.252774
d5+	1.644117	d5-	0.672169	2.316286
d6+	1.611982	d6-	0.561638	2.17362
d7+	1.564681	d7-	0.454807	2.019489
d8+	1.70861	d8-	0.475802	2.184411
d9+	1.372093	d9-	1.230734	2.602827
d10+	1.534191	d10-	0.454859	1.98905

Table-13
Shows the "cli+" means distance between A_i and ideal solution

	Cli+	**Sort cli+**	**Ranking**	**factors**
Cl1+	0.157142	0.102427	10	7
Cl2+	0.567079	0.103638	9	8
Cl3+	0.210029	0.104018	8	10
Cl4+	0.241712	0.145121	7	6
Cl5+	0.195059	0.157142	6	1
Cl6+	0.145121	0.195059	5	5
Cl7+	0.102427	0.210029	4	3
Cl8+	0.103638	0.241712	3	4
Cl9+	0.581947	0.567079	2	2
Cl10+	0.104018	0.581947	1	9

Results:

Preference	**factors**
1	Electronically supported system
2	Stockholder interface and feedback
3	Automation
4	web enabled interface and services
5	Network and data security
6	AMT
7	Data management system
8	Effective training
9	optimization tools
10	Synchronization

From the above table it is concluded that the rank 1 obtained is of factor 9, which shows that value 0.581947 is distance between A_9 and ideal solution as shown in table 13. Accordingly all the ranking values are calculated by formula $d_i / (d_{i+}+d_{i-}) = Cli+$. Rank 2 has value 0.567079 which is related to factor 2, similarly all the values of Cli+ are arranged in ascending order of the contributing factor value.

Conclusion

Results depicts that ranking order gives the importance for deciding factor "electronically supported system" is more important and should be given preference for better results. And factor "synchronization" should be given low preference as per the above calculated ranking order in table 13.

As the name e-manufacturing indicates that it cannot be implemented without electronic system. E-manufacturing is totally based on network conjunction, which needs that all the system should be well electronically supported. The capability of E-manufacturing system depends upon the reliability of electronic system and their sync with computers. Though Synchronization is also important but from given number of factors it does not hold so much importance as compared to other factors.

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