International Journal on Recent Technologies in Mechanical and Electrical Engineering (IJRMEE) ISSN: 2349-7947
Volume: 6 Issue: 11 01 – 06

Optimization of Manufacturing Processes using Modern Automated CNC Milling Machines

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Abstract— The economy growth rate of a country depends upon the innovation & research in manufacturing industry. Thus to increase growth rate of country or organization, optimization of manufacturing process or product using modern automated CNC milling machine is necessary. In this research paperan attempt has made to optimization of manufacturing processes using modern automated CNC machines. In today's world market quality, time factor, efficiency & complexity of the manufacturing process are the major problem dictated by modern era. Hence, it is necessary to adopt modern machines tools which increases efficiency of manufacturing process & reduces the manufacturing times. This study based on efficiency of manufacturing process between automated CNC milling machines & traditional systems.

Keywords- *Automation, Milling, Optimization and Manufacturing process.*

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I. INTRODUCTION & HISTORICAL BACKGROUND OF CNC MILLING MACHINE

In Whitney, 1798 first Milling machine was designed for producing muskets and gun parts. Joseph Brown an American Engineer presented universal milling machine at Paris exhibition in 1827. After this invention the applications and use of milling machine are increasing continuously in manufacturing sector. Development of computer numerically controlled (CNC) machines has also made possible the automation of the machining processes with flexibility to handle production of small to medium batch of parts. In the 1940s when the U.S. Air Force perceived the need to manufacture complex parts for high speed aircraft. This led to the development of computer-based automatic machine tool controls also known as the Numerical Control (NC) systems. Commercial production of NC machine tools started around the fifties and sixties around the world. As computer technology evolved, computers replaced the more inflexible controllers found on the NC machines; hence the dawn of the CNC era. In 1980 CNC machine are introduced. In which the computer used to link directly to controller.CNC milling is a specific form of computer numerical controlled (CNC) machine. Where the programmer feed the pre-generated program.CNC machine tools use software programs to provide the instructions necessary to control the axis motions, spindle speeds, tool changes and so on. CNC machine tools allow multiple axes of motion simultaneously, resulting in 2D and 3D contouring ability. CNC milling devices are the most widely used type of CNC machine. Virtually every type of material that can be drilled or cut can be machined by a CNC mill, although most of the work performed is done in metal. CNC technology also increases productivity and quality control by allowing multiple parts to be produced using the same program and tooling. Modern CNC machine has several advantages like energy saving, less time required for production, easier to program, avoid human effort& error and cost saving over traditional machines.

II. LITERATURE REVIEW

Gopalsamy et al., (2009) [6] putted an effort to optimize process parameters for end milling process. The Taguchi method was applied to study the performance characteristics of machining (cutting speed, feed rate, depth of cut and width of cut) with consideration of surface finish and tool life. It result showed that cutting speed was most influencing parameter. Ghani et al., (2004) [5] performed an experiment on AISI H13 with TiN coated P10 carbide insert tool under semi-finishing and finishing condition of high speed cutting. The three input process parameters such as cutting speed, feed rate and depth of cut were consider and Taugchi approach has been implemented for process parameter optimization. The Analysis of variance (ANOVA) was so employed to get the significance level of experimental values. It was concluded that to achieve the low resultant cutting force and good surface finish the values of cutting speed must be high and value of feed rate as well as depth of cut must be low. Zhang et al., (2006) [7] did experimental work to optimize surface quality in a CNC face milling operation. The two methods such as Taguchi method and Analysis of variance (ANOVA) were carried out to identify the significant factors affecting surface roughness and the optimal cutting combination. It has been observed that Taguchi design was successful in optimizing milling parameters for surface roughness. Camuscu, (2005) [8] used three different tool materials such as coated carbide, coated cermet,alumina (Al 2 O 3)based mixed ceramic & cubic boron nitride (CBN) to analyze the response parameters such as tool life and surface finish. The experimental work was done on AISI D3 Cold work tool steel hardened 35HRC. Moshat et al, (2010) [4] made an attempt to optimize the CNC end milling process parameters to achieve good surface finish and high removal rate (MRR). The Principal Component

Analysis (PCA) based on Taguchi method was used for optimization. It has been found that PCA method makes result more reliable for multi-objective problem as it has characteristics to eliminate multi-correlation..

III. PROBLEM DEFINITION

Small medium manufacturing industries facing main problem like high cost, high energy consumption & high production time. This problem sorted out in this study.

IV. PROPOSED METHODOLOGY (MANUFACTURING PROCESS OPTIMIZATION)

For Elimination of this problem I have followed this stepwise methodology which includes problem identification, Impact of problem, Analysis of problem & their best solution. In these studies, modern software systems AutoCAD and CATIA were used for performing the generation of production for the designed part. Design, modeling, sketching as well as test software are the most use of this software.

Figure 1. Modern CNC machine

Figure 2. Traditional Milling machine

Due to its complexity in contrast to product design, it requires more attention & while preparation of the technological preparation of the production. The development of technologies of required and sufficient quality should be built on the principles of systematic approach, which is showes that from latest manufacturing & research studies. Computer aided process planning (CAPP) systems have a complex task that involves the integration with other functions like quality assurance, requirement flows, quality control, production planning & scheduling and manufacturing resource planning.

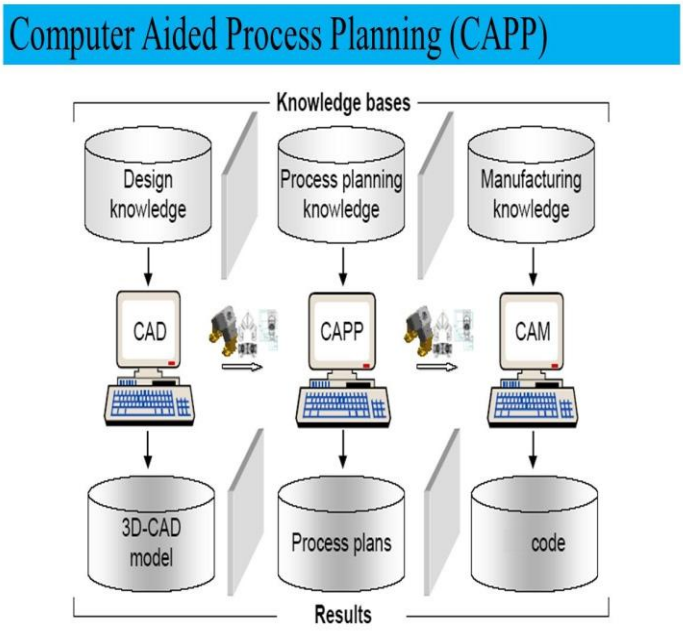

Figure 3. Model of CAPP system

Preparation of production, manufacturing process can be optimized by implementing CAPP & use of Autocad, CATIA for energy saving, minimize cost & error. By doing this delays that occur during the manufacturing on CNC milling machines may be avoided.

There are many influential factors one of them major is power consumption. 0.6KW power required in modern CNC machine to achieve 50 to 3500 RPM, whereas the same working parameter achieved in traditional milling machine by using 3KW power. In India Per KWh cost is 9 INR for commercial use & generally 12 hours of working day so on this basis I have calculated energy cost per day required for traditional machine & modern CNC machine.

$E_{(\text{Modern CNC machine energy cost per day})}$ = Energy consumption X KWh cost in india X Number of working Hours per day.

= 0.6 KW X 9 INR X 12 Hrs

= 64.8 INR required per day.

$E_{(Traditional\ machine\ energy\ cost\ per\ day)}$ = Energy consumption X KWh cost in india X Number of working Hours per day.

= 3 KW X 9 INR X 12 Hrs

= 324 INR required per day.

For considering this comparison there is 259.2 INR difference between traditional & modern machine per day.

$E_{(Difference\ in\ traditional\ \&\ modern\ milling\ machine\ energy\ consumption\ per\ year)}$ = Energy consumption difference per day X Number of working day per month X Number of month.

= 259.2 INR X 26 Days X 12

$E_{(Difference\ in\ traditional\ \&\ modern\ milling\ machine\ per\ year)}$ = 80870.4 INR.

Thus,This difference per year will be around like 80870.4 INR.

Now, considering time domain difference in between traditional & modern machine. CNC milling machines have installed automatic tool change in their machine control unit, including toolbox that is automatically positioning above the workpiece. So time required for modern CNC machine is 15 second , whereas traditional milling machine it is required 85 second per part. Considering 500 parts in per day production, differences calculated are as follows.

$T_{(Modern\ machine\ time\ required\ )}$ = Number of parts X Time required per part

= 500 Number X 15 seconds

= 7500 seconds.

= 2.08 Hours.

$T_{(Traditional\ machine\ time\ required\ )}$ = Number of parts X Time required per part

= 500 Number X 85 seconds

= 7500 seconds.

= 11.81 Hours

Considering this calculation for 500 parts there is difference of 9.73 Hours between traditional & modern CNC milling machine. This difference ultimately affects the labor cost & energy cost. Automatic tool changer significantly increase productivity & reduce production time.

Following image represents automatic tool changer used in CNC milling machine.

Figure 4. Automatic tool changer.

Based on above calculation its affect the labor cost too. In India labor cost per hours is 42 INR. So the difference per day & per year calculated are as follows:-

$L_{(modern\ milling\ machine\ labor\ cost\ per\ day)}$ = Modern CNC milling machine in Hours .X Labor cost per hour .

= 2.08 Hrs X 42 INR

= 87.36 INR per day.

Simultaneously we can calculate cost per year considering 26 days per month & 12 month per year.

$L_{(modern\ milling\ machine\ labor\ cost\ per\ year)}$ = Modern milling machine labor cost per day X Number of working day per month X Number of month.

= 87.36 INR X 26 Days X 12

$L_{(modern\ milling\ machine\ labor\ cost\ per\ year)}$ = 27256.32 INR per year.

Whereas for traditional machine calculation are as follows :-

$L_{(Traditional\ milling\ machine\ labor\ cost\ per\ day)}$ = Traditional CNC milling machine in Hours .X Labor cost per hour .

= 11.18 Hrs X 42 INR

= 469.56 INR per day.

Simultaneously we can calculate cost per year considering 26 days per month & 12 month per year.

$L_{(Traditional\ milling\ machine\ labor\ cost\ per\ year)}$ = Traditional milling machine labor cost per day X Number of working day per month X Number of month.

= 469.56 INR X 26 Days X 12

$L_{(Traditional\ milling\ machine\ labor\ cost\ per\ year)}$ = 146502.72 INR per year.

So, thus difference in traditional & modern milling machine per day & per year calculated are as follows

$L_{(Difference\ in\ traditional\ \&\ modern\ milling\ machine\ per\ day)}$ = 382.2 INR.

$L_{(Difference\ in\ traditional\ \&\ modern\ milling\ machine\ per\ year)}$ = 119246.4 INR.

Similarly, energy consumption difference in between traditional & modern milling machine per day & per year with respect to time required for toll changing calculated are as follows :-

$ET_{(modern\ milling\ machine\ energy\ cost\ per\ day)}$ = Modern CNC milling machine time required for tool change . X power cost per Hr in India .

= 2.08 Hrs X 9 INR

= 18.72 INR per day.

Simultaneously we can calculate cost per year considering 26 days per month & 12 month per year.

$ET_{(modern\ milling\ machine\ energy\ cost\ per\ year)}$ = Modern CNC milling machine time required for tool change . X Number of working day per month X Number of month.

= 18.72 INR X 26 Days X 12

$ET_{(modern\ milling\ machine\ energy\ cost\ per\ year)}$ = 5840.64 INR per year.

Whereas for traditional machine calculation are as follows :-

$ET_{(Traditional\ milling\ machine\ energy\ cost\ per\ day)}$ = Traditional CNC milling machine time required for tool change . X power cost per Hr in India .

= 11.18 Hrs X 9 INR

= 100.62 INR per day.

Simultaneously we can calculate cost per year considering 26 days per month & 12 month per year.

$ET_{(Traditional\ milling\ machine\ energy\ cost\ per\ year)}$ = Traditional CNC milling machine time required for tool changing in Hour . X Number of working day per month X Number of month.

= 100.62 INR X 26 Days X 12

$ET_{(Traditional\ milling\ machine\ energy\ cost\ per\ year)}$ = 31393.44 INR per year.

So, thus difference in traditional & modern milling machine per day & per year calculated are as follows

$ET_{(Difference\ in\ traditional\ \&\ modern\ milling\ machine\ per\ day)}$ = 81.9 INR.

$ET_{(Difference\ in\ traditional\ \&\ modern\ milling\ machine\ per\ year)}$ = 25552.8 INR.

Thus with the help of this optimization in CNC milling machine we can reduce our production cost , production time & reduction in overall energy consumption. Thus to increase & improve the efficiency of overall productivity optimaztion in traditional technology is necessary.

V. RESULT

By the using Autocad, CATIA, Computer aided process planning CAPP & automatic tool changer, we can significantly increase efficiency of organization. We can easily identify that with the help of modern CNC milling machine there is reduction in time for production, Reduction in energy, Reduction in energy cost, Reduction in Labor cost, Reduction in human effort. Summary of this result shows with the help of above calculation in the below table.

Sr No	Description	Traditional Machine	Modern CNC Machine	Difference in between Traditional & Modern CNC machine
1	Energy cost per year (E. in INR)	101088	20217.6	80870.4
2	Time required for tool change for 500 qty (T. in Hr)	11.81	2.08	9.73
3	Labor cost per year (L. in INR)	146502.72	27256.32	119246.4
4	Energy cost per year w.r.t. Time (ET. in INR)	31393.44	5840.64	25552.8
5	Total cost per year (in INR)	278984.16	53314.56	225669.6

Figure 5 .Overall results in total cost INR & in Hr between Traditional &Modern CNC machine.

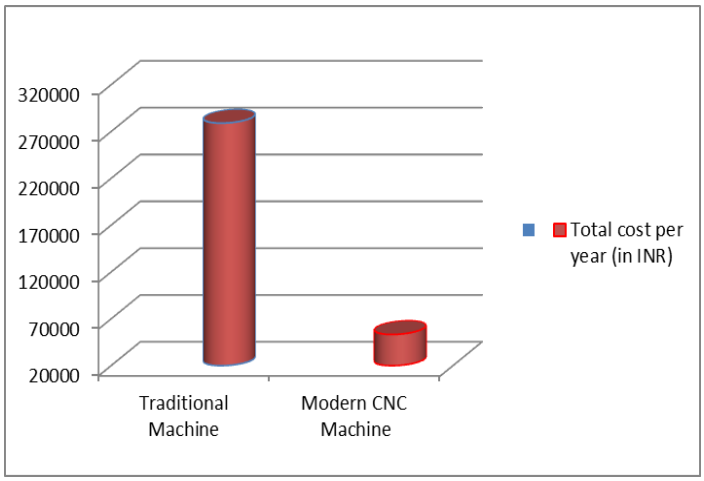

Figure 6 . Chart shows Overall total cost per year in between traditional & modern CNC milling machine

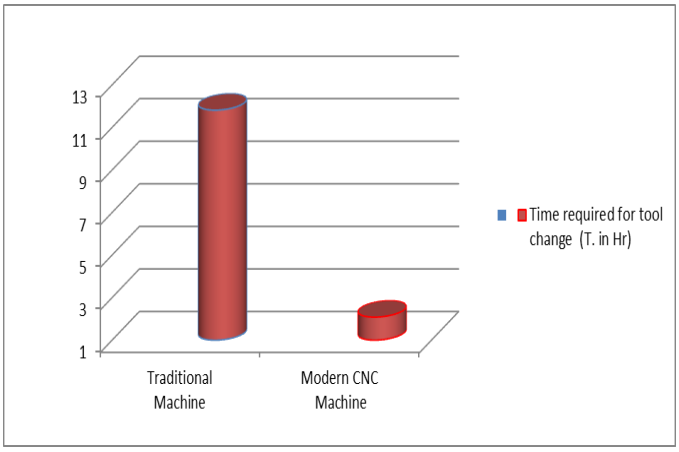

Figure 7 . Chart shows Overall time required per 500 qty in between traditional & modern CNC milling machine

From the above calculation , table & chart there is 225669.6 INR per year between traditional & modern CNC milling machine. Thus to fulfill and integrate modern market demands, higher degree of productivity & profitability it is necessary to introduce an certain level of manufacturing automation.

VI. CONCLUSION

The period post industrial revolution saw and still continues to witness tremendous advancements in all aspects of our lives, be it the standard of living, rapid economic growth or the unprecedented technological and scientific progress. A major contributor to these advancements is the Manufacturing technology sector. Manufacturing technology is the backbone of several industries. This is the one of the biggest reason automation in manufacturing is necessary.

In order to cope with today's and tomorrow's manufacturing needs, new solutions are required. This research study represented in brief the following points How to increase Efficiency of Organization with the help of automation & optimization of modern CNC milling machine.

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