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Concurrent Optimization and an Experimental Analysis of Face Milling Operation Parameters for Optimal Performance on Mild Steel Work Piece

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***Abstract:** All the available Materials are manufactured from different different manufacturing processes like casting, forging and extrusion processes, which have higher typical dimension tolerances due to its producing ability. So the machining processes were introduced to achieve close tolerance assembly and improve the product quality. Today's a lot of machining processes are available such as turning, milling, drilling and grinding to overcome these problems. This research work give particulars about the assessment of machining performance. The models was developed based on experiments on Mild steel (MS) material with spindle speed, feed rate and depth of cut as machining parameters. The needs of the manufacturer necessitate formulating the new objective function which consists of MRR and SR. Finally, the empirical equations of MRR and SR are used to formulate the Combined Objective Function (COF) and the Genetic Algorithm (GA) is used to optimize the face milling parameters. The best outcomes from GA were validated and it is recommended to manufacturing industries.*
***Keywords:** Milling Machine, Cutter Mild Steel, MRR, SR.*

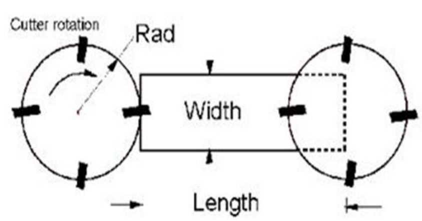
I. INTRODUCTION

A. Machining Operation

All the types of Materials which produced or machined from casting, forging, extrusion and other primary manufacturing processes have higher typical dimensional tolerances due to its producing ability. Hence, materials need required operation called machining for improving quality of the product. So, machining processes were introduced for close tolerance assembly and improve the product working efficiencies for overcoming the market competitiveness or become the market leader. For realizing this aim, one of the concerns is by optimizing the machining process parameters such as the spindle speed, feed rate and depth of cut

B. Face Milling Operation

Face milling is one of the basic machining process that allow large amount of material to be removed quickly. In this processes, material is removed from the top of the work piece material. Face milling is a process of removing material by feeding the work piece under a rotating multipoint cutter.



C. Optimization

In recent years, the main aim of manufacturing organization is to attain the reasonable machining condition. Many researchers were developed the mathematical models for particular outputs. Mathematical modeling of machining parameters is more important for process planning engineers to decide on the required parameter for achieving desired output. The investigations of machining parameters in face milling operation are very essential. So this work develops the machining parameters for face milling operation of milling machine with Mild Steel work piece materials and cemented carbide milling cutter. The proposed research scheme is presented.

D. Material Removal Rate (Mrr)

The material removal rate, MRR, can be defined as the volume of material removed divided by the machining time. Another way to define MRR is to imagine an "instantaneous" material removal rate as the the rate at which the cross-section area of material being removed moves through the workpiece. Since the depth of cut is changing the material removal rate changes continuously during the process.

MRR= W x f x d mm3/min

Where,

W = Width of cut (mm)

f = Table Feed rate (mm/min)

d = Depth of cut (mm)

E. Surface roughness (sr)

Surface roughness often shortened to roughness, is a component of surface texture. It is quantified by the deviations in the direction of the normal vector of a real surface from its ideal form. If these deviations are large, the surface is rough; if they are small, the surface is smooth. In surface metrology, roughness is typically considered to be the high-frequency, short-wavelength component of a measured surface. It is denoted by µm.

II. LITERATURE REVIEW

Metal cutting is one of the widely used manufacturing processes in manufacturing industries. The investigation of metal cutting focuses on the structures of tool, work material, and machine parameters selection background and responses (Montgomery 1990). A main development in process effectiveness may be attained by process parameters optimization that recognized and determined the regions of critical process control factors leading to desire outputs or responses with acceptable variations ensuring a lower cost of manufacturing (Indrajit Mukherjee & Pradip Kumar Ray 2006). So, the maximized productivity and better product quality is decided based on the machining parameter selection. This literature review comprehends optimization techniques used in past decades and reveals beneficial and disadvantageous of optimization techniques.

Machining operations have been the core of the manufacturing industry since the industrial revolution (Ojolo Sunday Joshua et al. 2015). So the further operation is required for assembling the components in machine tool structure and also lot of machining processes were used. Turning, drilling, milling and grinding are the important machining processes (Markos et al. 1998). From these milling is one of the important machining processes which is used to machining flat, curved or irregular surfaces by feeding the work-piece against a rotating cutter containing a number of cutting edges (AslaliyaKinijalet al. 2014), (Dabhi&Parmar 2015).

In order to enhance the quality of machining products, to reduce the machining costs and to increase the machining effectiveness, it is very crucial issue to select optimum machining parameters in manufacturing industry where economy of machining operation plays a key role in competitiveness in the global market (Ali R Yildiz 2013). So this work reviews the research work carried out on face milling optimization.

A. Optimization Technique In Face Milling Operation

Producing products with low cost, less time, and high quality is always a fundamental concern for manufacturing enterprises. Machining parameter optimization shows a vital role in decreasing machining time and production cost in metal cutting. In industrialized countries, the value of manufactured products contains 20 % of cost of machining amounts used in production.

Optimization techniques generally classified into two major titles, conventional and non-conventional optimization techniques.

In that conventional techniques are playing with statistical techniques such as Taguchi, response surface design and iterative mathematical search technique and non-conventional optimization techniques deals with heuristic and Meta heuristic techniques. Heuristic-based search techniques can be beneficial for problems where conventional optimization techniques are not suitable, like problems with high-dimensional search space with many local targets (Vob 2001, Zintzler&Theile 1999, Deb 2002, Lacksonen 2001). From heuristic techniques, researchers found the results are not specific (De Werra & Hertz 1983, Glover 1986, Glover &Laguna 2002). Now- a- days lot of meta heuristic algorithms are developed such as Genetic Algorithm, Simulated Annealing, Particle Swarm Optimization etc. So this work utilizes Genetic Algorithm for optimization.

B. Genetic Algorithm

Genetic Algorithm are adaptive experimental search algorithm based on the evolutionary concepts of natural selection and genetics. As such they signify an intelligent exploitation of a random search used to solve optimization problems. Although randomised, GAs are by no means random, instead they exploit historical information to direct the search into the region of enhanced performance within the search space. The basic methods of the GAs are considered to simulate processes in natural systems essential for evolution, specially those follow the principles first laid down by Charles Darwin of "survival of the fittest.". Since in nature, competition among individuals for scanty resources result in the fittest individuals controlling over the weaker ones.

Genetic Algorithm is one of the best non-conventional methods for identify the best value. This works optimize the machining parameter for face milling operation. The work piece material, Mild Steel with cemented carbide as a cutter materials. This section use the rank order selection for selecting best fitness function worth. The 8 bit chromosomes are used for mating pool array. Only point cross over is selected for cross over action. The mutation probability is 0.1 is use for all iterations.

C. Combined Objective Function

Manufacturers expected to maximize the MRR and also minimize the SR of the work piece. The needs of the manufacturer necessitate formulating the new objective function which consists of MRR and SR. The Combined Objective Function (COF) is formulated based on the empirical equations of SR and MRR. The COF is given below in equation:-

$$MinCOF = 0.5 \times SR \,/\, Min.\mathrm{SR}(Exp.Valu) - 0.5 \times MRR \,/\, Max.M\mathrm{RR}(Exp.Value)$$

III. EXPERIMENTAL SET UP

The experiments were conducted on work piece material MS using vertical machining centre. The key objective of this work is to study and analyse the effect of machining parameters on spindle speed, feed rate and depth of cut on MRR and surface roughness when face milling of MS work piece material. The effects of spindle speed, feed rate and depth of cut on these responses are described.

The responses MRR and SR are studied for face milling parameters spindle speed, feed rate and depth of cut. The WC face milling cutter are used for milling the MS material. The Vertical Machining Centre (VMC) is used to study the face milling performance.

A. Tool And Work Piece Materials

Milling Cutter A 50 mm diameter with 5 numbers of cutting edge WC cutter is used for MS material for evaluating the machining performance.

Mild Steel E250 (IS 2062 : 2011)							
Elements	Fe	C	Si	Mn	P	S	Ni
%	98.55	0.26	0.21	0.50	0.039	0.022	0.066

The chemical composition of the MS work piece material are given in Table

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MILD STEEL SPECIMEN

B. Machine Used

The CNC milling machine is presently used in various major manufacturing industries. The Milling machine used in this research work is CNC controlled Vertical Machining Centre (VMC) VF-2 HAAS Machines manufacturer, ,INC, USA .

The specifications of the machine (VMC)

Work piece size of 80x45 mm was clamped on machine vise, this setup was bolted with machine table T - slots. The 50 mm WC cutters was mounted on machine spindle.

C. Experimental Data

Sl. No.	Spindle Speed	Feed rate	Depth of cut	MILD STEEL	
	rpm	mm/min	mm	MRR	SR
				mm3/min	Mm
01	800	1	1	5377	1.862
02	800	1	2	10719	1.624
03	800	1	3	16007	2.029
04	800	2	1	6524	1.838
05	800	2	2	13024	1.991
06	800	2	3	19449	2.676
07	1000	1	1	5493	2.626
08	1000	1	2	10974	1.885
09	1000	1	3	16409	2.864
10	1000	2	1	6575	1.898
11	1000	2	2	13087	2.124
12	1000	2	3	19573	2.426
13	1200	1	1	5177	2.552
14	1200	1	2	10302	1.655
15	1200	1	3	15407	2.238
16	1200	2	1	6508	2.228
17	1200	2	2	12967	1.153
18	1200	2	3	19294	2.986

From above Table the experimental data ranges are for face milling of mild steel, the minimum and maximum calculated MRR are 5177mm3/min and 19573mm3/min and evaluated surface roughness are 1.153µm and 2.986 µm.

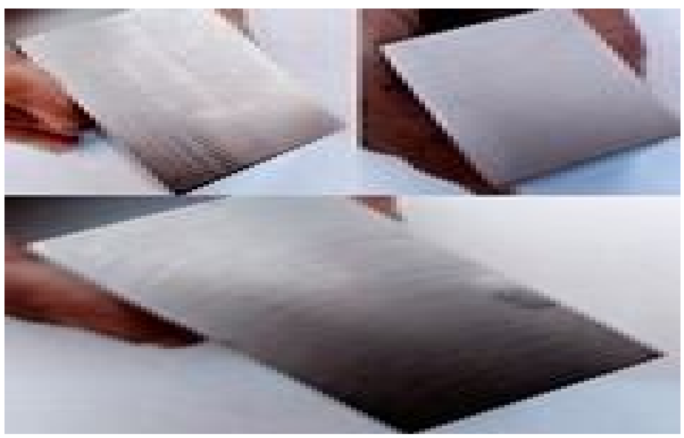
IV. RESULTS AND DISCUSSION

This research work is concentrated on face milling of MS material using WC cutter. Based on the experimental results the machining responses behave differently for every parameter. So the process planning engineers should have knowledge about empirical optimization of face milling parameters. This work proposed the best machining parameter for MS with face milling cutters (WC). The process planning engineer must possess the knowledge to choose the best parameters for work piece material and tool material combinations. The best parameters are identified and the results are validated. This eases the process planning engineer to choose the best parameter in face milling operation.

V. CONCLUSION

The Experimental time and associated cost are reduced. The factorial design is used to develop the experimental plan and also the different levels of experiments are conducted. The machining time and machining cost of components is decided the survival in the market. The machining time and cost are depends on the selection of machining parameters. So the optimization technique is required to select the suitable machining parameters. In this work, the machining parameters can optimized by using GA. In this work, face milling experiments are carried out on MS material with WC face milling cutter. The effect of spindle speed, feed rate and depth of cut on MRR and SR are analyzed .

A. *Workpiece Sample*



VI. SCOPE AND FUTURE WORK

In this research work, the spindle speed , feed rate and depth of cut are only considered to analyse the MRR and SR using Genetic Algorithm But face milling is important machining operation, so inclusion of machining constraints such as arbour deflection, thrust force, cutter inserts coatings, etc. may enhance the prediction. Burr categories dimensions and chip formation responses also can be considered for face milling operation. This work can be extended to other milling cutters such as cemented carbide, ceramic, diamond etc. This work is used the input parameters such as spindle speed, feed rate and depth of cut. But in future the material properties such as hardness, tensile strength etc., may be considered as input parameters.

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