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Analysis of Process Parameters in Hobbing using Optimization Technique

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Abstract: In automobile industry gear manufacturing is highly important. To increase the production without sacrificing quality one of the most effective ways is by improving the substrate material hob. The influencing parameters for cutting process should be known and possible to control. Through the theoretical studies and experimental investigations of significant parameters such as feed, hob material, feed, surface finish, cost. A continuous process optimization is necessary to satisfy the customer demands. A basic approach in optimization of operation times, is changing the substrate material. Taguchi method can be used for selecting the design of experiments and suitable optimization method can be used to optimize the process. This research paper focuses on improving the productivity by using different cutter materials.

Keywords: Optimization, Taguchi, Gear hobbing, Productivity.

I. INTRODUCTION

Hobbing is a continuous gear generation process widely used in the industry for high or low volume production of external cylindrical gears [1].Gear hobbing is one of the major manufacturing processes in the industry. Modern engineering practice is continually increasing its demands form or egearing of old and new types with a higher and higher degree of accuracy [2]. The traditional gear machining methods hobbing and shaping has limitations on manufacturer's ability to efficiently manufacture gears in small and medium batches [3]. For a spur gear being cut with a single start hob, the work piece will advance one tooth for each revolution of the cutter. When hobbing a 20-tooth gear, the hob will rotate 20 times, while the work piece will rotate once. The profile is formed by the equally paced cutting edges around the hob, each taking successive cuts on the work piece, with the work piece in a slightly different position for each cut. Several cutting edges of the tool will be cutting at the same time[7].

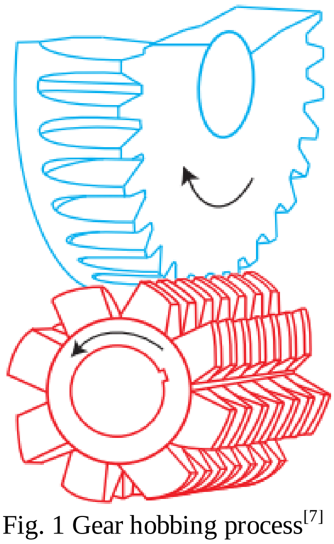

Fig. 1 Gear hobbing process[7]

A. Cutter Selection

1. Selection of number of starts:

The number of starts of the hob depends on pitch, number of teeth, and stage of manufacturing, gear quality and divisibility with number of teeth of the gear.

2. Selection of number of hob gashes:

The more numbers of gashes, the more cutting edges are engaged. Resulting in less cutter load and wear. Greater numbers of gashes also increase the number of enveloping cuts, which make the involute smoother. This is especially important when cutting gears with small numbers of teeth.

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3. Selection of hob diameter:
Smaller hob diameter usually results in less cutting time sincegreater hob RPM 'can be achieved. Limiting factors for reducing further hob diameter are usually minimum number of gashes and lead angle. Maximum lead angle for hobs with straight gashes is usually within 6 to 8 degrees. Sometimes for high production, hob diameter has to be increased to enable utilization,of a longer hob, since very high length over diameter ratio may undermine the system rigidity.

4. Hob accuracy class selection:
Hob accuracy selection is based on AGMA gear quality, stage of manufacturing and number of starts. The productivity increases when hobs with greater number of starts are employed.

II. LITERATURE REVIEW

Endoy [1] discussed that hobbing is a continuous gear generation process depending on the tooth size, gears and splines are hobbed in a single pass or in a two-pass cycle consisting ofa toughing cut followed by a finishing cut. Hobbing cycle time decreases with the increase in no. of hob start and ultimately it results increase in productivity. F. Klocke [2] demonstrated the ability to attain through simulation cheaper, faster process development for gear hobbing. As such, the operating mode of manufacturing simulation software for gear hobbing is explained. [3] Hyatt demonstrated the two technique sand compared their quality and production times and also discussed the additional benefits of two methods into milling and five axis machining using gear mill.

Aslan et. al [4] discussed the most common tool material for machining of castings and alloy steels is carbide. Compared to advanced tool materials such as CBN and ceramics. These tools have high toughness, but poor wear characteristics. In order to improve surface conditions and the hardness, carbide tools are coated with hard materials such as TiAIN, TiN and TiCN by physical vapor deposition (PVD) and chemical vapor deposition (CVD). The cutting tools used in HSC of different work materials.

Ramanujam et.al [5] presented that for the optimization of process parameters Taguchi's robust design method has been extensively used. Taguchi method uses the S/N ratio of the response instead of the response itself to decide the level of the input parameter to optimize the output response. Such a procedure is beneficiary when it is used to optimize single response, but fails to optimize multiple responses. By using MRSN technique such multi response problems can be solved where the total loss function is computed using to summing up weighted loss functions of individual response variables and then transformed to MRSN followed by optimizing the MRSN, determining the weight age for each response which is a difficult task is one of the major limitations of this method. Principle component analysis is one such method which eliminates these problems, where the numbers of variables are reduced to few, interpretable combinations. Each of this combination corresponds to a principal component and is uncorrelated with each other. Karpuschewski et. al [6] observed that powder metallurgical high-speed-steel (PM-HSS) and carbide are mainly used as cutting materials. In the last few years the usage of the more productive tungsten carbide in hobbing is decreasing, because of its high price and its sensitivity to impacts. So, the importance of PM-HSS has increased. In conjunction with high-performance coatings based on chromium-aluminum, the development of dry cutting is increasing regarding rising cutting parameters and productivity.

III. EXPERIMENTAL SETUP

A. Work piece Material
EN8 MS material is being widely used for various industrial applications.

Table I: Chemical composition of work piece

Grade	C (%)	Mn (%)	Si (%)	P (%)	S (%)
EN8	0.35-0.44%	0.60-1.00%	0.10-0.35%	0.05 Max	0.05 Max

B. Selected Level for Experiments
The levels of parameters are selected based on the pilot experiments.

Table II: Levels of parameters

Parameters	Level1	Level2	Level3
Feed Rate mm/rev	1.25	1.6	2.0
Hob Speed RPM	160	180	200
Hob Diameter	40	48	60
Hob Material	M2	HSS	D2

The experiments will be conducted on a vertical hobbing machine shown in fig. 2 speed range 80-500 RPM and feed range 0.34 – 4 mm/rev.

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Fig. 2 Gear hobbing machine

It is most important to identify the cutting parameters before machining to obtain the lowest cycle time1themethodology carried out in this work. Pilot experiments were conducted on COOPER hobbing machine HSS materials grades M2, D2 hob tool for cutting the proposed work piece materials by varying the hob speed, feed and hob tool material, hob tool diameter and three levels respectively.

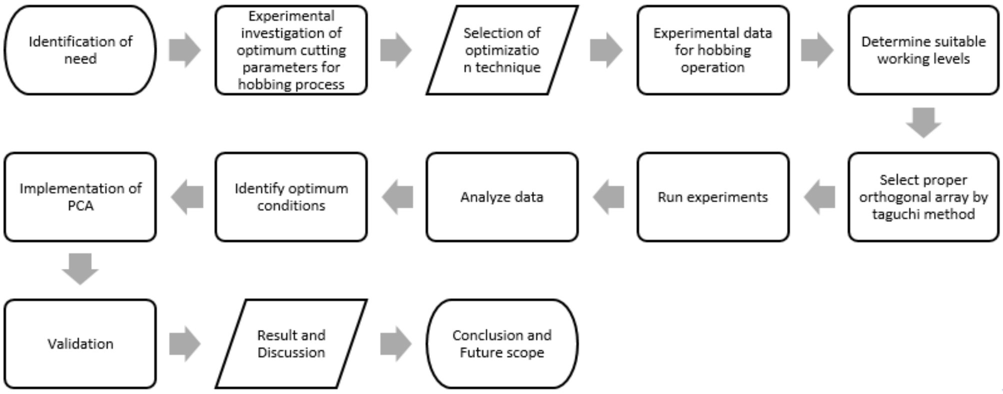

Fig. 3 Work scheme flow chart

IV. SUMMARY

Optimization is the most effective tool to find out the optimal parameters to achieve the required result. To optimize process parameters such as hob speed, feed, hob Material etc., Taguchi method combined with suitable optimization method can be used in order to take care of the possible correlations between the response variables. The different levels are finalized using DOE technique as entitled in table II for comparative analysis, the cutter materials are selected on the properties of material and literature carried out.

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