Productivity Improvement of Gear Hobbing Process by Analysing Process Parameters

S. V. Shewale,
Assistant Professor,
Mech. Dept., MET BKC IOE ,
Savitribai Phule Pune University,
Nashik, Maharashtra India,

S. R. Suryawanshi
Assistant Professor,
Mech. Dept., MET BKC IOE ,
Savitribai Phule Pune University,
Nashik, Maharashtra India,

***Abstract* - In automobile industry gear manufacturing is highly important. To increase the production without sacrificing quality, one of the most effective way is by improving the substrate material of hob tool. The influencing parameters for cutting process should be known and possible to control. Through the theoretical studies and experimental investigations of significant parameters affecting on productivity are speed, hob material, feed, surface finish, hob diameter, cost. The proper selection of the parameters is very important to reduce the cycle time thus to improve the productivity. In this paper analysis has been done. The experimentation has been carried out by using hob speed, feed, hob diameter and hob material parameters and their different levels. For the experimentation three grades of high speed steel were used namely M2, M3, M35 for hob tool material. For cutter material it is found that, feed is the most dominating factor into reduce the cycle time than the others. M3 material is obtained as the best material to reduce the cycle time of gear hobbing process.**

Keywords- Hobbing, Productivity, Hob Material

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 for more gearing of old and new types with a higher and higher degree of accuracy [2].

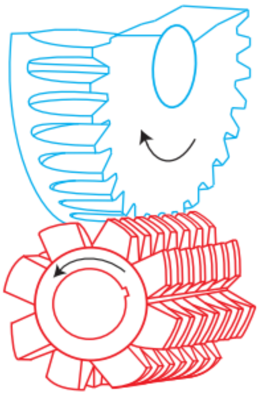

Fig. 1 Gear Hobbing Process

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 workpiece will advance one tooth for each revolution of the cutter. When hobbing a 20-tooth gear, the hob will rotate 20 times, while the workpiece will rotate once. The profile is formed by the equally paced cutting edges around the hob, each taking successive cuts on the workpiece, with the workpiece in a slightly different position for each cut. Several cutting edges of the tool will be cutting at the same time [7].

II. LITERATURE REVIEW

Hyatt et al. [1], compared two techniques and their quality and production times and discussed the additional benefits of two methods InvoMilling and five axis machining using gear mill. Kane et al. [2], investigated effect of feed and cutting speed on hob tool life by using different hob start. Tapoglou et al. [3], investigated effect of module, gear geometry, axial feed and cutting strategy on cutting forces. Litecka et al. [4], discussed effect of hob wear on cutting tool. Tapoglou et al. [5], developed simulation code HOB3D to calculate cutting forces. Azizpour et al. [6] compared M2 & ASP30 material and optimum value of cutting speed was investigated. Fradkin et al. [7], compared single turn & multi turn hob to investigate their effect on cycle time. Kotlyar et al. [8], discussed the selection of proper process parameters. Skrebnev et al. [9], investigated effect of feed no. of gear teeth, module on load distribution between hob tooth. Seker et al. [10], investigated effect of speed & feed on cutting force. Cutting force decreases with speed & increases with increase in feed. Endoy et al. [11], calculated cycle time & it reduces with increase in hob start. Kuljanic et al. [12], determined hob tool life equation and optimum speed and feed conditions. Bhattacharya et al. [13] investigated the equations for tangential and radial cutting force during hobbing. Klocke et al. [14], Presented simulation tool to shorten production time & calculate cutting forces. Tarney et al. [15] discussed material properties and performance consideration for HSS. Maiuri [16], discussed the parameter to improve the tool life.

Based on the literature survey performed, venture into this research was amply motivated by the fact that a little research has been conducted to obtain the optimal levels of machining parameters that yield the best productivity. Most of the researchers have investigated influence of a limited number of process parameters on the performance measures of hobbing process. Moreover, the effect of hob tool diameter (one of the tool geometry) and tool material has not been incorporated in the previous research to enhance the effectiveness of the hobbing process. Moreover no study has been performed in improving the productivity of hobbing process. Therefore, the effort can be made to study its effects by using DOE technique, as it is also observed that this technique had been rarely used. To decide the range of experiments and suitable parameters can be chosen based on the output performance and the best one can be selected to maximize the production efficiency.

III. METHODOLOGY

Experiments were done by using cooper hobbing machine by using HSS tool of different diameter and material.

A. Workpiece Material

AISI 1040 MS material is being widely used for various industrial applications so experiments is been carried out by hobbing AISI 1040 MS blank gear of diameter 60 mm and width 25 mm on hobbing machine at different speed, feed, hob diameter, and different cutter materials. MS 1040 is widely used for manufacturing gears.

TABLE I Chemical Composition Of Workpiece

Grade	C(%)	Mn(%)	Si(%)	P(%)
AISI 1040	0.36-0.44	0.60-1.00	0.10-0.40	0.050 Max
Grade	S(%)	Cr(%)	Ni(%)	N(%)
AISI 1040	0.050 Max	-	-	-

B. Cutting Tool

To meet the future goals of higher productivity and lower production costs, the cutting speeds and feeds in modern gear hobbing applications have to increase further. These specialized gear cutting tools often require properties, such as toughness or manufacturability, that are difficult to achieve with carbide, hence the HSS tools are used for the experimentation. HSS M2, M3, M35 are used as hob tool materials, tools of diameter 40, 50, 60 were used for experimentation.

C. Selected Response Variable

The response variable Cycle time is the "Smaller the better" type of quality characteristic.

D. Selected Level for Experiments

Table Ii Level of Parameters

Parameters	Level 1	Level 2	Level 3
Hob Speed(RPM)	160	180	200
Feed (rev/min)	0.8	1.0	1.25
Hob Dia.(mm)	40	50	60
Hob Material	M2	M3	M35

E. Experimental set-up

Fig. 2 Hobbing Machine

F. Specification of hobbing Machine

The Hobbing experiments were conducted on a hobbing machine shown in figure has speed range 80-500 RPM.

IV. RESULTS

Taguchi analysis technique used to find out the rank of hobbing parameters affecting on the cycle time of hobbing process.

TABLE III RESPONSE TABLE FOR S/N RATIO

Level	Hob Speed	Feed	Hob Diameter	Hob Material
1	30.24	32.73	27.51	27.69
2	27.13	26.83	27.14	26.49
3	23.53	21.34	26.25	26.73
Delta	6.70	11.39	1.26	1.20
Rank	2	1	3	4

TABLE IV RESPONSE TABLE FOR MEANS

Level	Hob Speed	Feed	Hob Diameter	Hob Material
1	30.24	32.73	27.51	27.69
2	27.13	26.83	27.14	26.49
3	23.53	21.34	26.25	26.73
Delta	6.70	11.39	1.26	1.20
Rank	2	1	3	4

Determination of the optimal cutting parameters is one of the most important element in any process planning. By using taguchi analysis technique the results and effect of process parameter on cycle time are predicted, these are as follows.

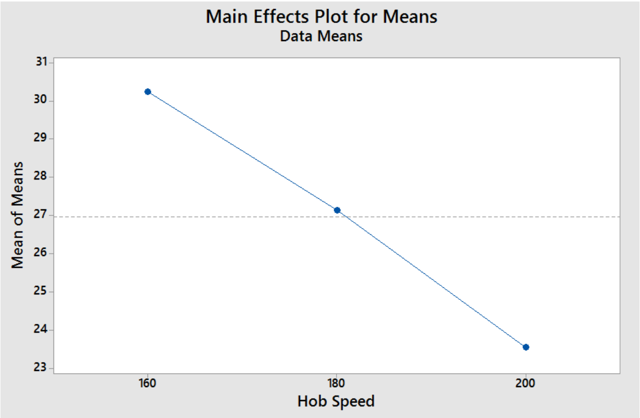

Fig. 3 Hob Speed Vs Mean of Means

From the nature of the graph shown in fig. 3 it is clearly seen that, the effect of speed on cycle time is maximum as compare to material and diameter of hob. It can be observed that the cycle time decreases with increase in the speed. This shows minimum cycle time at 200 RPM means, 200 rpm is the optimum condition for reducing the cycle time.

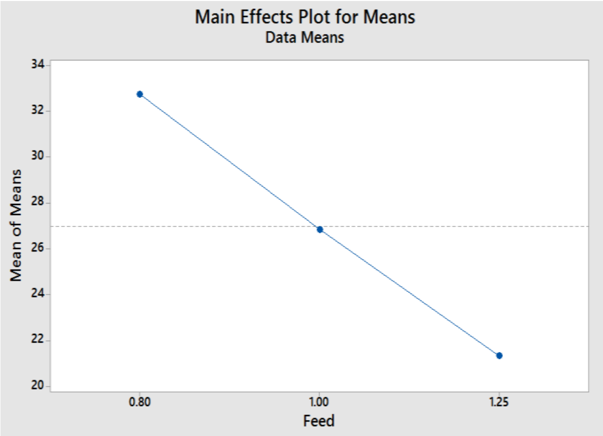

Fig. 4 Feed Vs Mean of Means

From the above figure 4 it has been observed that the effect of feed is maximum as compare to the other parameters on the cycle time. This shows that the cycle time reduces with the increase in feed. Means, 1.25 mm/Rev is the optimum condition for reducing the cycle time.

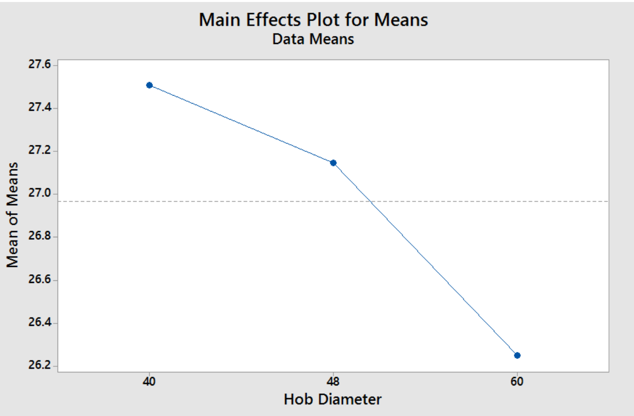

Fig. 5 Hob Diameter Vs Mean of Means

From the nature of the graph shown in fig. 5 it is clearly seen that, the effect of hob diameter is less on the cycle time. The effect is less than speed and feed but it is slightly greater as compare to the hob material on the cycle time. The cycle time slightly decreases with increase in the hob diameter. Means, 60 mm is the optimum condition for reducing the cycle time.

From the nature of the graph shown in fig. 6 it is clearly seen that, the effect of hob material is very less on the cycle time than the other process parameters. It shows the dual nature, means cycle time negligibly decreases from material A to B and again slightly increases form material B to C. Thus M3 i.e. Material B is the optimum material for reducing the cycle time. However, the effect of material is negligible.

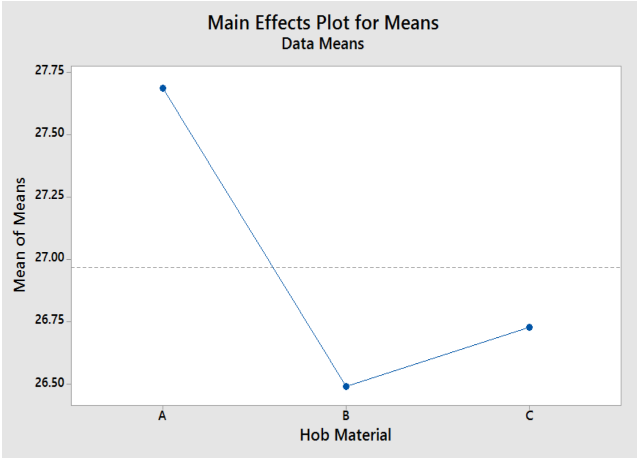

Fig. 6 Hob Material Vs Mean of Means

At the time of experimentation the hob tool failure occurred so to find the failure reasons the analysis has been done.
From the fig. 7 it has been observed that at the time of actual hobbing process the failure occurs at the base of the teeth.

Fig. 7 Failure of Hob Tool

Fig. 8 shows that the maximum deformation occurs at the tip of the hob tooth which are in contact with the workpiece. The maximum deformation is 0.012467 mm at the teeth tip and it is in permissible limit for given boundary condition.

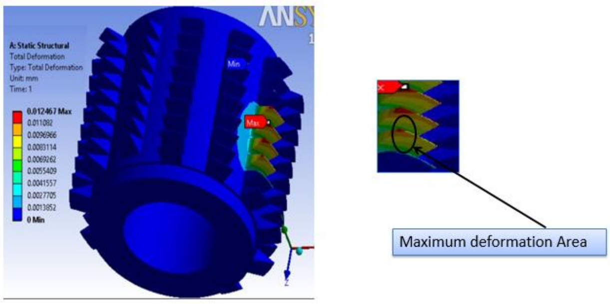

Fig. 8 Deformation of Hob Tool

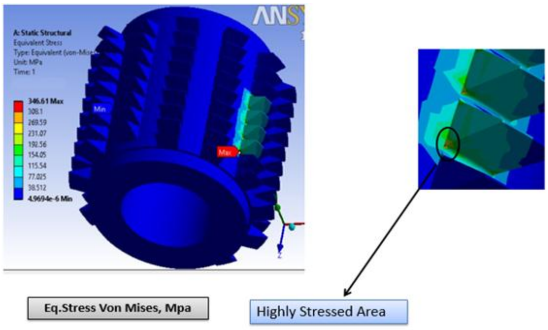

Fig. 9 Stresses in Hob Tool

From fig. 9 it has been observed that the maximum stresses are occurred at the base of the hob tool teeth which are in contact with the workpiece. The maximum stresses are 346.81 MPa at the base of the teeth. Therefore, after the period of cycles the teeth failure will occur at the base of the teeth.

A. Remedies on Hob Failure

The failure of the hob tool can be avoided in following two ways.

1) To run the machine below 200 RPM
2) By changing the hob tool material.

M42 is less prone to chipping or breakage than conventional M2 on tougher applications. Rockwell "C" scale hardness for M2 is 61 to 64; M42 is up to 68. M42 is much harder to machine than M2. M42 differs from M2 in the following general chemical analysis. Manufacturers vary these percentages within certain parameters.

V. CONCLUSION

In this experimental study, performance evaluation of hobbing is carried out in terms of cycle time for different combination and variation of hob speed, feed, hob material, and hob diameter. From above experimental study following conclusions are revealed.

- Feed is the most significant factor influencing the cycle time.
- Hob speed is the second dominant factor influencing cycle time.
- Hob diameter is less influencing parameter than the feed and hob speed.
- Hob material does not affect much on cycle time. Its effect on cycle time is very less than all other parameters. M3 Material is optimum material to reduce the cycle time.
- Max. stresses occurred at hob teeth base area which causes the failure of hob teeth at higher speed and feed.

VI. ACKNOWLEDGMENT

I wish to thank my colleagues at MET's IOE BKC and the sponsor Shree Ram Enterprises for providing me the opportunity to work in their industry.

VI. REFERENCES

[1] Hyatt G., Piber M., Chaphalkar N, Kleinhenz O., and Mori M., A Review of New Strategies for Gear Production, 6th CIRP International Conference on High Performance Cutting, 2014, pp. 72-76.
[2] Kane M. M., Ivanov B. V., and Zagorskaya N. B., Hob Life in Cylindrical Gear Cutting, Russian Engineering Research, 33(9), 2013, pp. 545–548.
[3] Tapoglou N. Andreas M. and Aristomenis A., Influence of machining data on developed cutting forces in gear hobbing, Int. J. Machining and Machinability of Materials, 14,(1), 2013, pp. 66-76.
[4] Litecka J, Horvat T, and Fecova V, Classification of Factors Affecting Hob Wear, pp. 69-61.
[5] Tapoglou N., Antoniadis A, Hob3D: A Novel Gear Hobbing Simulation Software, Proceedings of the World Congress on Engineering, 1, 2011, London, U.K.
[6] Azizpour M. J., Majd H. M., Wear Mechanisms in High Speed Steel, International Journal of Chemical, Molecular, Nuclear, Materials and Metallurgical Engineering, 4 (9), 2010, pp. 626-628
[7] Fradkin E. I. and Efimova O. M., Cutting Gears with a Large Number of Teeth by Means of Single and Multiple Turn Hobs, Russian Engineering Research, 2008, 28(10), pp. 998–1001.
[8] Kotlyar Y., Selection of Hobbing Data, Gear Technology, Dec. 1987, pp. 38-41.
[9] Skrebnev G. G. and Ananev A. S., Load Distribution between Hob Teeth, Russian Engineering Research, 2014, 34(11), pp. 680–686.
[10] Seker U., Kurt A., and Ciftci I., The effect of feed rate on the cutting forces when machining with linear motion, Journal of Materials Processing Technology, 146, 2004, pp. 403–407.
[11] Endoy R., Estimating Hobbing Times, Gear Technology, Ford New Holland, July/August 1989 pp. 34-39.
[12] Kuljanic E., A Method for Optimization of Hobbing, Annals of the CIRP, 34, 1985, pp. 75-78.
[13] Bhattacharya A., Deb, Mechanics of gear hobbing, Journal of engineering for industry, Transaction of ASME, February 1970, pp. 103-108.
[14] Klocke F, Gorgels C, Schalaster R, Stuckenberg A., An innovative way of designing gear hobbing processes, Proceedings of the International Conference on Gears, October 4th-6th 2010, Munich, 2108(1), 2010, pp. 393-404.
[15] Tarney E and Beckman J, Material Properties and Performance Considerations for High-Speed Steel Gear-Cutting Tools, Gear Technology, August 2001, pp. 17-21.
[16] Maiuri T.J., Hob Tool Life Technology Update, Gear technology, April 2009, pp. 50-59.

BIOGRAPHY

Prof. Swapna V. Shewale did her Master of Engineering (CADM & Engineering) from SPPU, Pune. She did her Bachelor of Engineering (Mechanical Engineering) from NMU Jalgaon. She has 5 years of industrial and 3 years of teaching experience. Currently she is working as an Asst. Professor at MET's IOE Nashik. Her main areas of interests include design engg.

Prof. Shubham R. Suryawanshi is pursuing Ph.D. in Mechanical Engineering from SPPU, Pune. He did his Bachelor of Engineering (Mechanical Engineering) and Master of Engineering (Design Engineering) from SPPU, Pune. He has 7 years of teaching experience. He has published more than 20 research papers in National /International Conference & Journals, and handled conferences as a session chair as well as reviewer. He is the Member of IIIE, SMFRA. Currently he is working as an Assistant Professor at MET's IOE Nashik. His main areas of interests include design, Vibration Analysis, Tribology, Automobile engineering.