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A Review on Multi Response Optimization on Machining Parameters in Spur Gear Hobbing process by using Taguchi based GRA.

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Abstract :- Gear hobbing is one of the major manufacturing processes in the industry. Hobbing is an efficient method to manufacture high quality and high performance gears.

Optimization is one of the techniques used in manufacturing sectors to arrive at the best manufacturing conditions. This is an essential need for industries for manufacturing of quality products at lower cost.

This project focuses on improving the productivity & quality of gear hobbing process by parametric optimization. Taguchi method is used for selecting the design of experiments and Grey Relational Analysis is used to optimize the performance characteristics like Material Removal Rate & Surface Roughness.

Keywords – *Optimization, Taguchi method, Grey Relational Analysis, hobbing* process.

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1. INTRODUCTION

A. Gear Hobbing

Hobbing is a continuous gear generation process widely used in the industry for high or low volume production of external cylindrical gears.

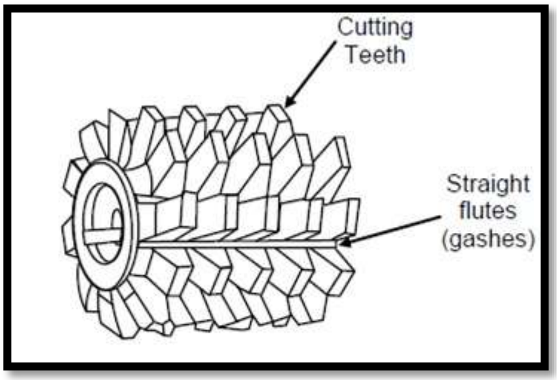

Fig-1: Hob Tool

Hobbing is the dominating manufacturing process for helical gears and external spur gears.

Therefore hobbing is of major importance for gear production.

With the traditional gear machining methods of hobbing and shaping, there are limitations on manufacturer's ability to efficiently manufacture gears in small and medium batches.

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.

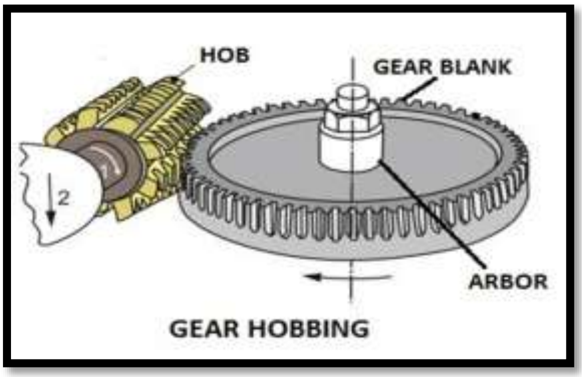

Fig-2: Gear Hobbing

B. Taguchi Method

Taguchi Method is developed by Dr. Genichi Taguchi, a Japanese Quality Management consultant. The method explores the concept of quadratic quality loss function (Fig-3) and uses a statistical measure of performance called Signal-to-Noise (S/N) ratio.

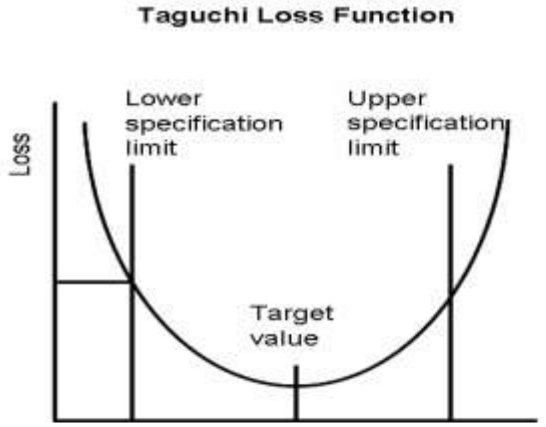

Fig-3: Taguchi Loss Function

The S/N ratio takes both the mean and the variability into account. The S/N ratio is the ratio of the mean (Signal) to the standard deviation (Noise).

The ratio depends on the quality characteristics of the product/process to be optimized.

The standard S/N ratios generally used are as follows: - Nominal is Best (NB), Lower the Better (LB) and Higher the Better (HB). The optimal setting is the parameter combination, which has the highest S/N ratio.

Types of Signal-to-Noise (S/N) Ratios:

Larger the better:

S/N = -10 * Log_{10} [Mean of Sum of Squares of reciprocal of measured data]

S/N = -10 * Log_{10} $(1/n * \sum 1/y_i^2)$

Here, i = 1 to n, n = number of replications.

Applied to the problems where Maximization of quality characteristics is needed.

Smaller the better:

S/N = -10 * Log_{10} [Mean of Sum of Squares of measured data]

S/N = -10 * Log_{10} $(1/n * \sum y_i^2)$

Applied to the problems where Minimization of quality characteristics is needed.

Nominal the best:

S/N = - 10 * Log_{10} (Square of Mean / Variance)

S/N = -10 * Log_{10} $(1/n * \sum (y_i - m)^2)$

Applied to the problems where one tries to minimize the mean squared error around the specific target value.

Taguchi Methodology

Taguchi method is described in step wise manner as below.

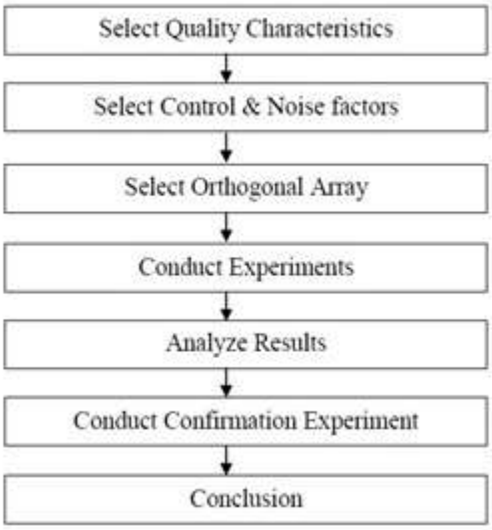

Fig-4: Taguchi Method Flowchart

C. GRA

Grey relational analysis is used for optimization of multi-performance characteristics.

In grey relational analysis, experimental data i.e. measured features of quality characteristics of the product are first normalized ranging from zero to one. This process is known as grey relational generation.

Next, based on normalized experimental data, grey relational coefficient is calculated to represent the correlation between the desired and actual experimental data.

Then overall grey relational grade is determined by averaging the grey relational coefficient corresponding to selected responses. The overall performance characteristic of the multiple response process depends on the calculated grey relational grade.

This approach converts a multiple response process optimization problem into a single response optimization situation, with the objective function as overall grey relational grade.

The optimal parametric combination is then evaluated by maximizing the overall grey relational grade.

D. Material Removal Rate -MRR

Material Removal Rate relates to the productivity of the machining process. In this study our attempt is to maximize the Material Removal Rate.

Material Removal Rate is calculated by taking the difference of work piece weights before & after the machining & noting the time required for machining.

$$\mathbf{MRR = (W_b - W_a) / T}$$

Here,

W_b - Work piece weight before the machining

W_a - Work piece weight after the machining

T - Machining Time.

E. Surface Roughness- SR

Surface Roughness relates to the quality of the machining process.

In this study our attempt is to minimize the Surface Roughness.

Roughness is often a good predictor of the performance of a mechanical component, since irregularities in the surface may form nucleation sites for cracks or corrosion.

Roughness is a measure of the texture of a surface.

It is quantified by the vertical deviations of a real surface from its ideal form. If these deviations are large, the surface is rough; if small, the surface is smooth.

Roughness is typically considered to be the high frequency, short wavelength component of a measured surface.

The parameter mostly used for general surface roughness is Ra.

It measures average roughness by comparing all the peaks and valleys to the mean line, and then averaging them all over the entire cut-off length.

The surface roughness can be measured using a surface roughness tester. One of the popular surface roughness tester is Taylor Hobson's, Talysurf-4.

2. LITERATURE REVIEW

To increase the productivity in an industrial environment a basic approach is to fully exploit the potential of existing tools and their substrate material.

Hipke 2011, the latest research work for hobs made of powder metallurgical high speed steel (PM-HSS) showed that this substrate is highly efficient up to 250 m/min.

A major advance in productivity can be achieved by switching from HSS based substrates to cemented carbide hobs. It is well known that higher cutting speeds can be realised with hobs made of cemented carbide. With about 20%, only the minority of all hobbing tools are fully made of cemented carbide.

Falk 2013, the majority (60%) of all hobs used in industry are made of HSS and PM-HSS. Also Hobs with cemented carbide inserts do exist (20%)

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 of a toughing cut followed by a finishing cut.

Hobbing cycle time decreases with the increase in number of hob starts and ultimately it results in increase in productivity.

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.

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 by summing up weighted loss functions of individual response variables and then transforming to MRSN followed by optimizing the MRSN. Determining the weight age for each response is a difficult task. This is one of the major limitations of this method.

Principle component analysis is one such method which eliminates these problems, where the number of variables are reduced to few, interpretable combinations. Each of this combination corresponds to a principal component and is uncorrelated with each other.

Karpuschewski [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.

Hyatt [3] demonstrated the two techniques and 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 [4] discussed the most common tool material for machining of castings and alloy steels is carbide. Compared to advanced tool materials such as CBN (cubic boron nitride) 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.

3. CONCLUSION

1. From the research work mentioned, it can be concluded that Taguchi method is an efficient tool to design the experiments.
2. Grey Relational Analysis is used to convert multi objective problem to single objective problem.
3. Integration of Taguchi method and Grey Relational Analysis forms an effective methodology of optimization of hobbling parameters.
4. Productivity and Surface Roughness are two important performance characteristics of hobbing process.
5. From the above literature, it has been reviewed that different optimization techniques were used for optimization of different process parameters for different industrial materials.
6. Main objective of this literature survey is to identify different hobbing process parameters, performance characteristics, materials and optimization techniques and to find out some research gap for future research work, beneficial to industry.

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