Abstract— 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. Basically, the parameters that have an influence on the cutting process should be known and possible to control. Gear manufacturing is highly important in automotive industry. The prevalent manufacturing method is gear hobbing with gear. Through the experimental investigations and theoretical studies of significant parameters such as speed, feed, depth of cut, material, surface finish, cost etc, a continuous process optimization is necessary to satisfy the customer demands. Changing the substrate material is a basic approach in optimization of operation times. Taguchi method can be used for selecting the design of experiments and Principle Component analysis can be used to optimize the process. This research paper focuses on improving the productivity by using different cutter materials.

Keywords- Gear Hobbing, Optimization, Principal Component Analysis, Productivity, Taguchi

I. INTRODUCTION

The competition between companies and industrial countries of industrial and emerging countries is advancing with globalization. In the past years the demand for gears is continuously increasing. The majority of gears are manufactured for the requirement of automobile industry. Therefore high productive and manufacturing processes are needed currently and in the future. Hobbing is the dominating manufacturing process for helical gears and external spur hobbing is of major importance for gear production. In the hobbing both the tool and the machine can be optimised. These components are developed continuously. A basic approach is to fully exploit the potential of existing tools and their substrate material to increase the productivity in an industrial environment [1].

1.1 Gear hobbing

For massive production of external gears, gear hobbing is a highly utilized flexible manufacturing process. Hobbing is a machining process for gear cutting splines, cutting sprockets, and cutting on a hobbing machine, which is a special type of milling machine. The hob is a cutting tool by which the teeth or splines are progressively cut into the workpiece by a series of cuts. Hobbing is relatively inexpensive but still quite accurate as compared to other gear forming processes, thus it is used for a broad range of parts and quantities [1]. Current processes for producing transmission gears involve hobbing, milling or shaping of a forged stock to obtain the gear shape. Gears are typically formed by hobbing tools made from solid tooling material, such as tungsten carbide, and have dozens of teeth [2]. By using higher cutting speeds the productivity of machining operations can be expanded and the quality of products can be improved than the applied traditional methods. Developments in machine tools, work materials and cutting tools have resulted in the spread of high speed cutting (HSC) technology [4].
1.2 Hob tool

A cutting tool used to cut the teeth into the workpiece is known as hob. It is cylindrical in shape with helical cutting teeth. The selection of hob tool mainly depends on

- Selection of number of starts.
- Selection of number of hob gashes.
- Selection of hob diameter.
- Hob accuracy.

![Hob Tool](image1.jpg)

**Figure 1. Hob Tool [13]**

Most hobs are single-thread hobs, but double and triple-thread hobs increase production rates. The downside is that they are not as accurate as single-thread hobs. Depending on type of gear teeth to be cut, there are custom made hobs and general purpose hobs. Custom made hobs are different from other hobs as they are suited to make gears with modified tooth profile [13]. A hard coating with a thickness of 2 to 3 µm increases the life of the hobs or permits higher cutting rates. Coated solid type hobs with a high no. of gashes are ideally suited to high performance hobbing of straight spur gears. The stability of solid type hobs is more than any other type of hob. The no. of gashes are directly proportional to the rate of chip removal, and the tool life is increased substantially by the coating and where applicable, recoating. Compared to conventional hobs, high performance hobs are required to have:

- At least equal if not superior gear quality higher tool life quality;
- Shorter machining times;
- A higher tool life quality.

Hobs can be optimized only in consideration of the machining environment. Based upon the material, the geometry and quality characteristics of the gear in question, the cutting parameters and the hob design must be matched such that the requirements are broadly fulfilled [13].

1.3 Hob tool materials

There are many materials that may be used for the manufacture of gear cutting tools. Cutting tools must simultaneously withstand big mechanical loads and high temperatures. Temperature in the chip/tool interface reaches more than 700 °C in some cases. Additionally, the friction between tool and removed chip, on one hand, and tool against the new machined surface, on the other, is very severe. Bearing this in mind, the main factors for a good tool design and post-manufacturing are:

- Cutting-tool substrate material must be very stable chemically and physically at high temperatures.
- Material hardness must be kept to the high temperatures suffered at the chip/tool interface.
• Tool material has to present a low wear ratio, both for the abrasion and adhesion mechanisms.
• Tool material must present enough toughness to avoid fracture, especially when operation to perform implies interrupted or intermittent cutting.

The most commonly used materials for manufacturing the hob tools are High speed steel and sintered carbide. [12]

II. LITERATURE REVIEW

Prengel et. al [1] discussed for the machining of steels, Cemented carbide is the most commonly used cutting tool material. Despite their high toughness, cemented carbide tools have low hardness values, which restrict their use in the HSM of hardened steels. To improve the machining performance of carbide cutting tools, they are usually coated with single or multi-layers of hard, wear resistant TiCN, TiN and TiAlN coatings by physical vapour deposition (PVD) or chemical vapour deposition (CVD) techniques. Liua et. al [2] presented that gears are typically formed by hobbing tools made from solid tooling material, such as sintered carbide, high speed steel, tungsten carbide, etc. and have dozens of teeth. Aslan et. al [3] 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.

Dewangana et. al [4] done some of the modifications in two sets of experimental data published by the past researchers and the PCA-based approach are analyzed using this modified procedure. It was observed that the PCA-based optimization can give better results than multi response S/N ratio based methods and the constrained optimization, which can be attributed to the fact that the possible correlation among the multiple responses is taken care in the PCA-based approach. 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 weightage 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. Klock et. al [7] investigated the influence of coating, substrate, layout and edge preparation on tool performance and optimized the hobbing process. Nair et. al [8] presented that nowadays there are required high demands on cutting tools for a gear production. Cutting tool live increase is the most important demands which is to be focused. New trends are mainly focused on develop of coating films and high wear-resistance materials which decrease final cost for gear production and increase the tool live. Cutting tool live is dependent on a lot of other factors, which cause cutting tool wear. Research of the factors and their elimination respectively
optimization can decrease wear, maximal increase tool power and extend cutting tool live. Gear manufacturers would like to increase their productivity and reduce their production costs to be competitive on the global market. Therefore, feed rates and cutting speeds have increased significantly over the last years. Klock et. al [9] Hobbing cycle time decreases with the increase in no. of hob start and ultimately it results increase in productivity. Hyatt et. al [10] described the two techniques InvoMilling and five axis machining using gearMILL and compared their quality and production times with those of traditional gear manufacturing techniques. In some cases higher productivity, and higher quality levels are obtained by the agile machines. Hipke [11] presented that gears of case-hardened steel in the module range from 1.5 to 2.8 mm for automobile gear boxes and up to 4 (4.5) mm for truck-gear boxes are produced by hobbing, the most productive procedure (predominantly under automated conditions). Carbide and powder metallurgical high-speed-steel (PM-HSS) are mainly used as cutting materials. In the last few years the usage of the more productive (because of its high temperature hardness) tungsten carbide in hobbing is decreasing, because of its sensitivity to impacts and its high price. Thus, the importance of PM-HSS has increased.

III. METHODOLOGY

It becomes necessary to develop a technique to predict cutting parameters before machining in order to obtain minimum cycle time. Figure 1 shows the research scheme of the methodology carried out in this work. The proposed methodology of the present research scheme is given below.

- Pilot experiments have to be conducted to study the effect of cutting parameters on machining time and surface roughness.
- Find out the suitable levels of parameters for hobbing process based on the pilot experiments conducted for various work piece materials.
- Best non-traditional optimization technique has to be found among the available techniques.
- The best optimization technique has to be implemented in the proposed mathematical model.
- Validation experiments have to be conducted to validate the proposed methodology.

Pilot experiments were conducted on COOPER hobbing machine HSS, M2.0, M35 grade hob tool for cutting the proposed work piece materials. By varying the speed, feed and No. of hob start, hob tool diameter and three levels respectively.
IV. SUMMARY

In order to find out the optimal parameters use of optimization is an effective tool to achieve the required result. To optimize process parameters such as speed, feed, hob start etc, Taguchi method combined with Principle component analysis method can be used in order to take care of the possible correlations between the response variables.

REFERENCES

[12] https://en.m.wikipedia.org/wiki/hobbing