A Review on Optimization of Internal Cylindrical Grinding Process Parameters Using DOE

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Abstract- *In today's rapidly changing scenario in manufacturing industries, applications of optimization techniques in metal cutting processes is essential for a manufacturing unit to respond effectively to severe competitiveness and increasing demand of quality product in the market. With the advent use of sophisticated and high-cost machines coupled with higher labor costs, optimum operating parameters are essential for producing the parts economically. Optimization of operating parameters is an important activity for operating machine tools, particularly Computerized Numerical Control (CNC) machine tools. In many industrial operations, the grinding parameters are still commonly selected according to machining data handbooks or machine operator experience. The optimization of internal cylindrical grinding process is an important task due to accurate and economical means of shaping the parts into final product with required surface finish and high dimensional accuracy. It is required to systematically investigate the process or product variables in order to enhance the product's manufacturability, reliability, quality, and field performance.*

Keywords- CNC, Grinding, Surface finish.

I. INTRODUCTION

Traditional machining operations such as turning, milling, drilling, and grinding are used extensively in the manufacturing industry to remove material from a workpiece and form the final part shape with the desired dimensional characteristics. Unlike the turning, milling, and drilling processes that utilize a cutting tool with well-defined cutting edge geometry, the grinding process utilizes a cutting tool with a large number of small, multipoint cutting edges in the form of hard abrasive particles bonded to a matrix material. The abrasive particles have a stochastic geometry, orientation, and spatial distribution on the surface of the cutting tool.

II. LITERATURE REVIEW

Jun Qian, Wei Lib, Hitoshi Ohmori [1] studied precision internal grinding with a metal-bonded diamond grinding wheel. It was predicted that a metal-bonded grinding wheel, compared with conventional grinding wheels, offers the advantage of high hardness, high holding ability and finer usable abrasive grit mesh sizes. The truing and dressing of a metal-bonded diamond (MBD) wheel, in practice, are very difficult. To grind small-diameter internal cylindrical surface with MBD-wheels, an interval electrolytic in-process dressing (ELID) method was utilized. Experiments were carried out on an ordinary cylindrical grinding machine with an attached internal grinding set-up, and straight type grinding wheels of different grit sizes were used. The grinding wheels were trued, using the electrical discharge method, and the effects of electrode shapes, grinding parameters, and grit sizes were evaluated experimentally.

M. Weck, N. Hennes, A. Schulz [2] investigated dynamic behaviour of cylindrical traverse grinding processes. It was explained that compared to cylindrical plunge grinding processes the conditions of contact in cylindrical traverse grinding processes are much more complex, so that it is hardly possible to derive an analytical stability criterion. Because of that, a numerical simulation tool was developed, to research the dynamic behaviour in the time domain and to determine stable machining parameters of cylindrical traverse grinding processes.

Rogelio L. Hecker et al. [3] adopted analysis of wheel topography and grit force for grinding process modeling. It was presented a 3-D methodology to evaluate the static parameters of the wheel topography and to calculate the dynamic parameters based on a probabilistic chip thickness approach. The topography of grinding wheels and the forces per active grain in grinding provide the basic understanding of grinding edges and workpiece interaction. This understanding is important to the modeling, planning, and optimization of the grinding process as a whole. It was adopted a 3-D analysis of the grinding wheel topography to evaluate static parameters of the wheel such as the effective grain diameter and the static grain density as function of the radial distance from the wheel surface.

R. Cai, W. B. Rowe [4] performed an experimental study for Assessment of vitrified CBN wheels for precision grinding. In their work methods of measuring topographical features of grinding wheels were reviewed. It was showed that each technique has advantages and limitations for resolution, measuring depth, ease of application, data analysis and interpretation. Results obtained vary according to the method and instrument employed. Advantages and difficulties experienced with different techniques were discussed. Different replication techniques and materials are compared and suggestions made.

Jeremiah A. Couey et al. [5] predicted that aerostatic spindles were used in precision grinding applications requiring high stiffness and very low error motions (5–25 nm). It was observed that forces generated during precision grinding were small and presented challenges for accurate and reliable process monitoring. These challenges were met by incorporating non-contact displacement sensors into an aerostatic spindle that were calibrated to measure grinding forces from changes in the gap between the rotor and stator. It was conducted four experiments to demonstrate the results of the force-sensing approach in detecting workpiece contact, process monitoring with small depths of cut, detecting workpiece defects, and evaluating abrasive wheel wear/loading. It was found that monitoring cylindrical grinding is advantageous in optimizing process conditions, improving process control, and producing high quality parts.

III. PROBLEM STATEMENT

Optimization of grinding parameter is usually a difficult work where the following aspects are requiring such as knowledge of machining and specification of machining tools capabilities. In precision grinding operations, it is often important to set the correct grinding machine parameters so as to manufacture products of required quality. In order to decrease the cost and increase the production rate, the grinding machine must be set to operate within the shortest possible grinding cycle time. Despite of the industrial prominence of grinding operation, it seems that internal cylindrical grinding still appears to be a “black art” and receives the least understanding among all the material removal processes.

Objectives of the Present Work

The objective of this study is;

1. To investigate the effect of input parameters of internal cylindrical grinding process that influences surface roughness and cycle time.
2. To determine optimal combination of internal cylindrical grinding process parameters by using Taguchi’s design of experiments (DOE) method.

IV. SYSTEM METHODOLOGY

Design of Experiments (DOE) is a powerful statistical technique introduced by R. A. Fisher of England in the 1920's. A designed experiment is a test or series of tests where preplanned changes are made to the controllable variables of a process or system so that the reason for changes in the response can be observed and identified. So, design of experiments refers to the systematic and scientific methods which are followed for planning the experiments such that the experiments can be performed in the most efficient and economical way to get the required data that will result in valid and objective conclusions. This type of statistical approach to experimental design is required if one wishes to draw a meaningful conclusion from the observed data. Hence, basically, DOE refers to the process of planning, designing & analyzing the experiment so that valid & objective conclusion can be drawn effectively and efficiently. In performing DOE, one will intentionally make changes to the input process variables or factors in order to observe corresponding changes in the output process.

Brief Overview of Taguchi Method

Taguchi technique is a powerful tool for design of high quality systems. It introduces an integrated approach to find the best range of designs for quality, performance and computational cost in a simple and efficient manner. This method has been utilized widely in engineering analysis to optimize performance characteristics within the combination of design parameters because of its proven success in greatly improving industrial product quality. The main theme of Taguchi Method is stated like this, “quality variation is the main enemy and every effort should be made to reduce the variations in quality characteristic”.

REFERENCES

[1] Jun Qian, Wei Li, Hitoshi Ohmori., “Precision internal grinding with a metal-bonded diamond grinding wheel” Elsevier Journal of Materials Processing Technology 105 (2000) 80-86.
[2] M. Weck , N. Hennes, A. Schulz., “Dynamic Behaviour of Cylindrical Traverse Grinding Processes” International journal of Machine Tools, Aachen, Germany Received on January 7, (2001).
[3] Rogelio L. Hecker, Igor M. Ramoneda, Steven Y. Liang., “Analysis of Wheel Topography and Grit Force for Grinding Process Modeling” ASME Journal of Manufacturing Processes Vol. 5/No. 1 (2003).

[4] R. Cai, W. B. Rowe, "Assessment of vitrified CBN wheels for precision grinding" International Journal of Machine Tools & Manufacture 44 (2004) 1391–1402.

[5] Jeremiah A. Couey, Eric R. Marsh, Byron R. Knapp, R. Ryan Vallance., "Monitoring force in precision cylindrical grinding" Elsevier journal of Precision Engineering 29 (2005) 307–314.

[6] Ersan Aslan a, Necip Camus cu, Burak Birgoren., "Design optimization of cutting parameters when turning hardened AISI 4140 steel (63 HRC) with Al2O3 + TiCN mixed ceramic tool" Elsevier Journal of Materials and Design 28 (2007) 1618–1622.

[7] Anderson P. Paiva, Joao Roberto Ferreira , Pedro P. Balestrassi., "A multivariate hybrid approach applied to AISI 52100 hardened steel turning optimization" Elsevier Journal of Materials Processing Technology 189 (2007) 26–35.

[8] M. Nalbant , H. Gokkaya, G. Sur., "Application of Taguchi method in the optimization of cutting parameters for surface roughness in turning" Elsevier Journal of Materials and Design 28 (2007) 1379–1385.

[9] Qiang Liu, Xun Chen, Nabil Gindy., "Fuzzy pattern recognition of AE signals for grinding burn" International Journal of Machine Tools & Manufacture 45 (2005) 811–818.

[10] James J. Govindhasamy, Sean F. McLoone, George W. Irwin, John J. French, Richard P. Doyle, "Neural modelling, control and optimisation of an industrial grinding process" Elsevier Journal of Control Engg. Practice 13 (2005) 1243–1258.