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"Review of Elimination of Grinding Operation by Hard Turning Method"

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Abstract

Hard turning and grinding are two prevalent manufacturing processes used for the machining of hard materials, typically with hardness greater than 45 HRC. This study compares the performance, cost-effectiveness, and quality outcomes of hard turning versus grinding for finishing hardened steel parts. Hard turning offers several advantages, including faster setup times, lower tooling costs, and the ability to produce complex geometries. Grinding, on the other hand, is well-known for its superior surface finish and dimensional accuracy. This research investigates the differences in surface roughness, material removal rates, and tool wear between the two methods. Experimental results indicate that hard turning can achieve similar or superior surface quality and productivity compared to grinding under specific conditions. The study concludes that while grinding remains essential for applications requiring extremely tight tolerances and fine surface finishes, hard turning is a viable and often preferable alternative for many applications due to its flexibility and cost savings. These findings provide valuable insights for manufacturing industries looking to optimize their machining processes for hardened materials.

Keywords: Hardness, Hard Turning, Tool Wear, HRC, Grinding

1.Introduction

1.1 Grinding

Grinding is a finishing process, broadly used in manufacturing of components requiring fine tolerances, good surface finish and higher dimensional and geometrical accuracy. Compared with other material removal processes as an example of turning, milling and boring, the grinding process is more complex and more difficult to control. In addition to the static parameters of the grinding machine tool, there are many dynamic factors that contribute to resulting dimensional accuracy. Surface finish is very important for parts which will be in contact with other metal surfaces. The lower value of surface roughness causes less wear and friction. The lowest value of surface roughness gives the best surface finish. The surface quality produced in surface grinding is influenced by various parameters such as i. wheel parameters – abrasives, grain size, grade, structure, binder, shape and dimension; ii. Work piece parameters – fracture mode, mechanical properties and chemical composition; iii. process parameters – wheel speed, depth of cut, table speed and dressing condition; Machine parameters – static and dynamic characteristics, spindle system, and table system.

1.2 Hard Turning

Hard turning refers to the metal machining process for the various hardened steels with the help of single point super abrasive tool on modern CNC turning machine. The hardness of steels is usually ranges from 48 to 68 HRC [1-4]. Hard turning is applicable for the machining of various steel materials such as case-hardened steels, alloy steels, full hardened tool steels, super alloys, steels coated with hard chrome surface coatings, nitride steels, and heat-treatable sintered powder metal parts [5]. Finish machining of hardened steels, (e.g. through or full hardened steel AISI-52100, SAE-01 for bearing parts and case-hardened steel 20Mn5Cr5 or 16MnCr5 for automotive transmission parts) by hard turning process using super abrasive cutting tools (poly-crystalline cubic-boron-nitride - PCBN), ceramics, and cemented tungsten carbide were very well recognized in past by the automotive and bearing industries for the manufacturing of precision transmission parts . Grinding was the only choice as a conventional or traditional machining process for the manufacturing of precession parts. Now-a-days, hard turning is establishing itself as a better alternate manufacturing methodology to grinding for the manufacturing of various dies, moulds and transmission parts (e.g. gears, crank shafts, bearings and cam shafts) due to some of its distinct features over traditional grinding such as; better flexibility as manufacturing of intricate shapes can possible on a single setup resulting into lower machining time. The machining feasibility in dry environment is one of the top most advantages of hard turning; it is possible to carryout machining without the environmentally harmful lubricants, coolants. All such benefits of hard turning resulted in substantial reduction in manufacturing time and cost.

2.LITERATURE REVIEW OF HARD TURNING OVER GRINDING

Ravi Kumar1, P. Sudhakar Rao Volume 5, Issue 05, May-2019. “REVIEW OF HARD TURNING AND HARD MILLING”. Hard turning offers a number of benefits over grinding including lower setup times, low machine cost, flexibility in operations and accuracy and elimination of high usage of cutting fluid. Surface roughness and MRR are performance parameters and are significantly affected by cutting parameters, work hardness, cutting tool materials and tool vibrations. From this study, it is found that feed rate is most important factor followed by depth of cut in case of surface roughness and cutting speed is most significant factor for tool wear.

Debabrata Samantaraya and Sanjay Lakade 2020 IOP Conf. “Hard Turning Cutting Tool Materials used in Automotive and Bearing Manufacturing Applications – A review” The benefits of hard turning over traditional grinding includes substantial amount of reduction in manufacturing time and costs, achievement of grinding comparable surface quality.

Dilbagh Singh. P. Venkateswara Rao, 7 March 2006. “A surface roughness prediction model for hard turning process”. The investigations of this study indicate that the parameters cutting velocity, feed, effective rake angle and nose radius are the primary influencing factors, which affect the surface finish. The results also indicate that feed is the dominant factor affecting the surface roughness, followed by the nose radius, cutting velocity and effective rake angle. First order surface roughness prediction model has been found to represent the hard turning process very well.

Panda et al. [8] The objective of the present work has been set to have a study on hard turning of EN 31 steel (55HRC) using Tin/TiCN/Al2O3 multilayer coated carbide inserts through Taguchi L16 orthogonal array design and investigates surface roughness under dry environment. The mathematical model has been developed for better prediction of responses using response surface methodology and correlated for its significance. The mathematical model presented high correlation coefficients (higher R2 value) and fitted well. Feed is found to be most dominant parameter for affecting the surface roughness. A Taguchi technique has been utilized for parametric optimization of surface roughness. From the study, the potential and effectiveness of multilayer coated carbide insert has been noticed while turning hardened steels under dry environment. Following conclusions can be drawn. Better surface quality generated using coated carbide insert even 0.2 microns at run 9 justify its application during hard machining. The improved surface roughness obtained from coated carbide may be attributed to the retained cutting-edge geometry with better hardness, wear resistance and low friction properties. An increase of feed deteriorates the surface finish with feed noted as a detrimental factor and highly significant noticed from ANOVA study. The RSM model presented high determination coefficient (R2 = 0.97 and 0.95 close to unity) explaining 97% and 95% of the variability in the Ra and Rz which indicates the goodness of fit for the model and high significance of the model. The experimental and predicted values are very close to each other .From main effect plot of S/N of Ra and Rz, the optimal parametric combination for Ra has been found to be d4 (0.4 mm)-f1 (0.04 mm/rev)-v2 (110 m/min) and for Rz, it has been found to be d3 (0.3 mm)-f1 (0.04 mm/rev)-v2 (110 m/min).The improvements of S/N ratio from initial parameter level to optimal parameter level are found to be 1.5145dB and 1.8551 dB respectively for Ra and Rz respectively. From the experimental investigation and observations on surface roughness in hard turning with multilayer coated carbide tools, it has been concluded that the coated carbide tool out performs over the range of parameters chosen.

Chaudhari [7] In this study, three levels of each parameter viz. Hardness (HRC), Speed(mm/min), Feed(mm/rev) and three different tool materials are evaluated for process quality characteristics such as tool wear. The three different tool materials used are High CBN, Low CBN, Mixed ceramic. AISI H 11 was taken as work piece material. The experiment is designed using Taguchi Method. The results obtained from the experiments are transformed into signal to noise (S/N) ratio and used to optimize the value of tool wear. The analysis of variance (ANOVA) is performed to indentify the statistical significance of parameters. The conclusion is that for tool wear optimum condition can be achieved with work piece of 45HRC while using High CBN tool bit at speed of 230 mm/min and feed of 0.12 mm/rev. And the most affecting parameter on tool wear is hardness which has impact of about 43.30%'.

Dong et al. [12] .The hard turning process is widely used in automobile and heavy machinery industries. Extreme cutting conditions like high temperature and tool wear rate are associated with the hard turning process. Cubic boron nitride (CBN) cutting tool is generally preferred for hard machining operations. However, higher tool cost, and tool failure due to thermal shock limits its widespread usage. In machining performance analysis, tool wear is an important parameter which is directly related to the cost of the machining process. Previous studies have reported the improvement in tool life by using cryogenic coolant as a cutting fluid. Objective of this paper is to investigate the effect of cryogenic cooling on the tool wear of CBN and Ti-coated alumina ceramic cutting tools used in the hard turning Of AISI 52100 hardened steel. High pressure cryogenic jet (HPCJ) module was optimized and configured to use it for hard turning case. Computational fluid dynamics (CFD) based simulation was used to test and optimize the nozzle design for the flow of cryogenic coolant. It was validated by fundamental heat removal test. Ceramic and CBN cutting tools were then used for hard turning of parts using HPCJ module. Flank wear lengths for various cooling conditions were measured and analyzed. It was observed that the higher tool life of a Ti-coated alumina ceramic can be achieved under cryogenic cooling technique, as compared to the CBN insert under dry conditions. Cost analysis of these hard turning cases was also conducted to check the feasibility of its usage under realistic shop floor conditions. It was observed that the machining using Ti-coated ceramic under cryogenic jet may reduce the total tooling cost compared to CBN cutting tool conducted under dry conditions

Li and Guo [4] Studied the surface integrity of AISI H13 tool steel samples which were milled by using PVD (Physical Vapour deposition) coated inserts. A flank wear of three levels was used to study the effects of cutting speed radial depth and feed.ie. VB=0mm, Vb=0.1mm and VB=0.2mm. Analysis of evolution of surface finish obtained by different combinations of milling perimeters was carried out. The evolution of tool flank wear was inspected on a CNC integrated optical inspection tool.

3.CONCLUSION

Hard turning presents a compelling alternative to grinding for machining SAE52100 steel, offering significant advantages in terms of reduced energy consumption, cost savings, environmental impact, and operational flexibility. By achieving comparable surface finishes and dimensional accuracies, hard turning not only meets the quality standards required for many applications but does so in a more efficient and sustainable manner. Industries seeking to optimize their machining processes for SAE52100 and similar materials should consider integrating hard turning into their operations, particularly where reducing costs and environmental impact are critical factors. With appropriate tool selection and parameter optimization, hard turning can provide a robust, reliable, and economically viable alternative to traditional grinding methods.

4.FUTURE WORK AND SCOPE

Research could focus on developing new cutting tool materials and coatings that enhance tool life and performance in hard turning. This includes exploring the potential of nanostructured coatings, diamond-like carbon (DLC) coatings, and other advanced materials to improve wear resistance and reduce friction. Further investigation into the wear mechanisms of different tool materials when used in hard turning could provide insights for enhancing tool durability. Developing advanced optimization algorithms that can predict and control the outcomes of hard turning processes, such as surface finish, tool wear, and material removal rate, in real-time. Surface Integrity and Performance Residual Stresses and Microstructure Analysis: Detailed studies on how hard turning affects residual stresses and microstructural changes in the workpiece material. Understanding these effects can lead to better predictions of component life and performance. Hybrid Processes Combining Hard Turning and Grinding: Research into hybrid machining processes that combine the advantages of both hard turning and grinding, such as using hard turning for roughing operations and grinding for finishing. This could lead to processes that provide both efficiency and high-quality surface finishes.

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