Recent Trends in Production and Manufacturing in India

Prof. R.G. Chouksey and Prof. Nishith Dubey

Abstract—In recent years large amount of research has taken place to improve productivity in machining and manufacturing. Production and Manufacturing has become automatic in India. One such research area developed to increase the metal removal rate is High Speed Machining (HSM). Machining of materials at four to six times the cutting speed used in conventional machining is called as High Speed Machining. The high speed machining technique has great economic potential due to high metal removal rate, better surface finish and ability to machine thin walls. The newer materials such as composite materials, heat resistant and stainless steel alloys, bimetals, compact graphite iron, hardened tools steels, aluminum alloys etc., needs this new machining (HSM). High Speed Machining offers a means to shorten delivery times boost productivity and increase profitability. The aim of this paper is to give an overview of HSM and related technologies used in production systems in India for obtaining increased efficiency, accuracy and quality of finishing. A High Speed Machining Center can reduce the need for polishing the surfaces of dies and moulds. It can produce EDM Electrodes more efficiently. The high speed machining center also produces complex tooling competitively in a single setup. The HSM requirements, such as machine tool, cutting tools etc are discussed in this paper. The application of high speed machining to die and mould machining is also presented.

Keywords—HSM, Manufacturing, Production, Trend

I. INTRODUCTION

Traditional machining techniques have been largely heuristic i.e. the knowledge has been transferred from one machinist to other via apprenticeships or on-the-job training. Instead of using machinery's handbooks, often machining problems are conservative cutting parameters that are discovered over a time period through trial and error. HSM through combination of tool size and speed yields 1.0 to 1.5 million Dn (diameter of the main bearing in millimeters times the speed [rpm] of the spindle).

HSM is attained when a 1/2-inch end mill turns at more than 8,000 rpm and its feed rate is 250 in/min or higher. According to Machine Tool Research Center of the University of Florida at Gainesville, High speed machining occurs when the tooth passing frequency approaches the dominant natural frequency of the system. HSM increase productivity and reduce costs and lead-time while simultaneously improving the machining accuracy of complex features.

II. OPPORTUNITIES FOR HSM

Some parts are a challenge to conventionally machine due to their inherent tendency to vibrate and distort after solution heat treatment. Because of these tendencies, chatter marks and distortion features appear even when the part is heavily damped during the machining process. To avoid chatter and excessive vibration, conventional machining techniques use slow machine feeds and speeds requiring lengthy machining times to complete the stock removal and to ensure feature accuracy, thus decreasing productivity. Aluminum clevis configurations can be machined with high-speed machining techniques without chatter as much as four times faster than by conventional machining techniques with the same accuracy when the raw material is made from heat-treated aluminum bar stock. In this case fewer tools (such as face mills and finish end mills) are needed, since the carbide end mill performed all milling operations without significant difference in the machining processes High-speed machining (HSM) is achieved by using small cut depths at very high spindle speeds (often over 20,000 RPM) and aggressive chip loads without a derogation of part accuracy or quality [1]. A light cut depth allows for high feed rates while avoiding damage to the work piece, spindle and cutter. Numerous light passes at extremely small axial depths [2] is often less efficient than taking fewer passes since the increase in the overall tool path length exceeds the gains from using a high feed rate.

III. KEY ELEMENTS OF CAM

Three key elements in high-speed machining are the computer-aided machining (CAM) programming, the CNC machine and tooling [3]. These are closely inter-related, and the correct combination leads to productivity gains, improved quality and cost reduction. In case of wrong combination high generation of waste, tool breakage or excessive chatter can occur. Therefore programming is an important aspect of HSM where tool path and feed rate optimization allows for the optimum cutting path to be generated in order to maximize machine throughput and productivity. Other features like trochoidal path generation minimizes tool loading while maintaining a high cutting speed, thereby improving tool wear characteristics. The physical characteristics of the CNC machine also play an important role in the successful
IV. HSM TOOLING

Trochoidal path generation is beneficial in HSM as it transforms a straight-line tool path into a series of circular arc tool path’s with a smaller tool and HSM machining parameters. Thus a smaller tool can be used, in slotting operations, where larger tools may suffer from cooling issues. Using the smaller tool, greater clearance is available for chip evacuation and cutting fluid access and increases tool life. The effects of vibration become more pronounced with HSM processes. The rigidity of the CNC machine affects how the machine responds to vibration. More rigid the machine better its suitability for HSM. A more rigid machine vibrates less and improves tool life by ensuring an even chip loading, while reducing the propensity for chatter to occur. Machine rigidity is therefore critical when applying HSM methodologies. Small to medium sized tool holders, and feature direct drive spindle motors are used in HSM. Due to the less mass of spindle with a smaller tool holder taper has significantly less mass than a larger spindle and reduced rotating mass improves the dynamics of the spindle, allowing the CNC control system to control the spindle speed more accurately [4]. Direct-drive spindles eliminate the use of gearbox and improve the dynamics of the spindle and are better suited to HSM.

It is desirable that the CNC machine can achieve an axial acceleration of 1.2G to 2.0G with real time closed-loop positioning throughout the range of cutting speeds. Because of higher speeds, the servo motors have to be able to keep up with the higher speeds and loads. In addition, axial acceleration is critical during abrupt tool path direction changes. Therefore the CNC control features conducive to applying HSM methodologies features include: high speed program data storage, block look ahead, constant surface feed rate, automatic acceleration/ deceleration control, and high speed/high precision contouring control. The capacity of the CNC control’s program memory needs to be large enough to cope with large HSM-optimized programs. Modern CNC controls come with block look ahead where the controller loads in multiple lines (typically 30 or more lines) of CNC code ahead of the current code block being executed. The pre-loaded blocks are preprocessed by the CNC controller, allowing it to adjust the optimum feed rate for the projected tool path, and eliminate inherent delays in the servo system, which increase with higher feed rates.

V. QUALITY ESSENTIALS

At high cutting rates, abrupt direction changes can cause a loss of accuracy and degradation in surface finish. To compensate, CNC controllers include automatic acceleration and deceleration features. Using block look ahead, the CNC control identifies the abrupt tool path changes by determining the extent of direction (by calculating the tangential change in direction), and automatically accelerates or decelerates the table or work piece from the programmed feed rate before the change in direction.

VI. HSM METHODOLOGY

A systematic approach is proposed for applying HSM methodologies in order to reduce the amount of trial-and-error. The steps in transitioning an existing process to a HSM process are as follows.

1. Identify the performance conditions of the CNC machine, tooling limitations, and cutting performance baselines.
2. Observe the potential areas of improvement in the current process.
3. Re-program CNC code for optimization.
4. Monitor quality, tool wear, and cycle times through test-runs.
5. Incorporate outcomes of test run in the program for optimization.

VII. CONCLUSION

HSM is being widely used by Indian industry for enhancing quality and productivity. New materials and improved tools have eased the process. A High Speed Machining Center reduces the need for polishing the surfaces of dies and moulds.

REFERENCES


Prof. R. G. Chouksey is working as Professor and Head in Department of Vocational Education and Entrepreneur Development at NITTTR, Bhopal. He is B. Tech. Agriculture Engineering, M. Tech. Agriculture Engineering- Crop Process Engineering from IIT Kharagpur and MBA from Bhopal University. He is the Ex Joint Director of PSS Central institute of Vocational Education, Bhopal. He has a vast experience of 33 years in Teaching and research. His field of specialization includes Curriculum Development, Scheme of Community Polytechnics in India, Scheme of Polytechnics for Persons With Disabilities in India, Management and Rural Development, Vocational Education and Training. He is life member of Indian Society of Technical Education,(ISTE), New Delhi, Indian Society of Training and Development (ISTD), New Delhi, Life Member, Indian Society of Agricultural Engineers (ISAE) Member Vigyan Sabha, Madhya Pradesh,
Bhopal – Executive Committee Member and Vice President – Bhopal Chapter of ISTD – 2009-10. He received UNEVOC Centre Award for furthering UNESCO goals in Technical and Vocational Education and Training from UNESCO-UNEVOC Bonn, Germany, 2007. He has published 63 papers at national and international level.

Dr. Nishith Dubey is Professor - Entrepreneurship, at National Institute of Technical Teacher’s Training Institute and Research, Bhopal. He is Ph.D. in Management, M.E. in Industrial Engineering and Management and M.B.A in Marketing Management. He has 26 years of academic and corporate exposure. He also has F.D.P. to his credit from world famous E.D.I.I. His area of interest includes Entrepreneurship, Intrapreneurship, Operations Management, Strategic Management, Service Marketing and Education Technology. He has at his credit 30 papers at National and International level. He has coordinated and conducted many National Seminars, Conferences, Faculty Development Programs, Executive Development Programs, Workshops, Entrepreneurship Development Programs and Management Development Programs. He was President and National Council Member, Indian Society for Training and Development and Chairman of Indian Society for Technical Education, Indore Chapter.