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INFLUENCE OF CUTTING MEDIUM ON DEFORMATION OF THIN RIBS

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Abstract

Influence of cutting medium on tool life or quality of workpiece is well-known. This paper deals with the influence of cutting medium on deformation of thin ribs made by milling. The machining of thin ribs exhibits various problems. The paper describes some of these problems and contains basic information on several types of cutting media used in machining. Chatter is generated by machining of thin ribs. This chatter causes surface waviness. If the chatter is oversized, it is possible to measure the deformation. In the experiment, TRITOP noncontact measuring system for measuring thin ribs' deformation was used.

Key words

cutting medium, deformation, thin ribs, non contact measuring, milling

Introduction

Machining can be defined as the process of removing material from a workpiece in the form of chips. This process is performed within MTWJ (M - machine, T- tool, W- workpiece, J – jig) system. The cutting media are integral parts of this system. In general, the cutting medium can be divided into the following categories [2]: gaseous, liquid and solid.

Cutting medium has influence on dimensional accuracy and surface quality of workpiece, especialy in case of thin ribs. This type of workpiece is used particularly in aircraft industry, as well as energetic and automotive industry mainly because of weight decrease of final product (e.g. aircrafts, turbine, etc.). Thin ribs are made by milling.

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Milling is a multiple point, interrupted cutting operation. Because of the multiple teeth, each tooth is in contact with the workpiece for a fraction of the total time [3]. The finished surfaces, therefore, consists of a series of elemental surfaces generated by the individual cutting edges of the cutter. Due to the nature of relative contact between the workpiece and the tool, the chip thickness is not constant, but starts with a zero thickness and increases in up-milling and starts with a finite thickness and decreases to zero in down-milling. The peripheral milling of flexible thin-walled parts is a commonly required operation. During the milling, tool and workpiece are in contact. The effect of cutting forces is that there is a deflection from the ideal component shape.

Cutting medium characteristics

The prime functions of cutting fluid are effective cooling and lubrication. With the supply of cutting fluids, the friction is also reduced. These functions and effects require the cutting fluids to be in a fluid form. There are also consistent media such as fats or powder lubricants. Though the friction can be reduced, they are not able to decrease the heat in cutting area and that is the reason why they are not used so frequently. The main application fields for these lubricants are thread cutting or special forming operations [4]. Only the gas media have not been employed in manufacturing so far, because their application is difficult. If particular gases are applied properly, they can remove the heat and also reduce the friction if their chemical properties are suitable [8]. Nowadays, the air-mist cooling is also expanding but the cutting fluids are still the most applicable cooling medium in metal machining. Besides cooling and lubrication effects, they also have other functions [4]. Main functions of cutting fluid involve [1]: cooling, lubrication, removing chips and metal fines from the tool/workpiece interface, flushing and prevention of corrosion.

Thin ribs

Thin rib can be described as a workpiece consisting of very thin plates. Thin plate in machining is that, even at a minimum cutting forces, is so deformed, that the local thickness in critical place is different, such as guide value after milling or surface waviness are formed due to chatter. The concept of a thin wall component means that it consists of walls; the thickness is extremely small compared with other dimensions such as wall height and wall length. The shape of thin-walled parts can vary. Thin-walled parts can be divided into single-walled parts and thin-shape complex parts. Deformation of thin-walled parts in the machining process is shown in Fig.1. Material ABCD (Fig. 1) should be ideally cut, but, due to the oscillation, A'BCD material is cut. After milling, the machined surface material passes back and BDB 'material which should be removed is cut off. This causes, that the wall thickness is thinner at the top and wider at the bottom of the wall.

3D Coordinate measuring system TRITOP

TRITOP^{CMM} (Fig.2) is an industrial, non-contact optical measuring system for exact 3D coordinate acquisition of discrete object points. As shown in Fig. 2, the system consists of a laptop including the evaluation software, the digital TRITOP camera, coded and uncoded reference points and a scale bar set with accessories [6]. Coded reference points ensure an image set that can be evaluated and allow for automatic calculation of the camera positions. In addition, so-called orientation crosses are available which are factory-equipped with several coded points. Uncoded reference points are used to determine the 3D coordinates of the measuring object and are identified automatically by TRITOP software. In each TRITOP measuring project, the scale bars are the reference for determining the dimensions. We used photogrammetry camera system with resolution of 12.32 million pixels. The cameras are based on professional digital reflex camera housings (e.g. Nikon, Canon, Fuji) in connection with a manual fixed focus lens and a ring flash. Each TRITOP camera system is factory-verified and certified in order to guarantee the measuring accuracy.

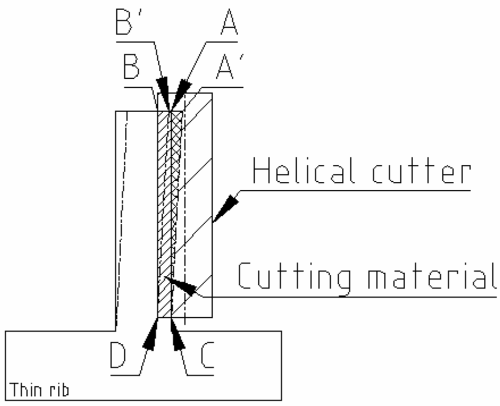

Fig. 1 *Thin rib milling*

Fig. 2 *Non-contact optical measuring system TRITOP*

This mobile technology supports time-optimized measurements for on-site quality control and deformation analysis. All relevant object points are marked and, using a photogrammetric camera, images of the object to be measured are recorded from various angles of view. Then, the TRITOP software automatically calculates the 3D coordinates of the adhesive markers and object characteristics from these digital images [7]. Photogrammetric is the technique of measuring objects (2D or 3D) from photo-grammes.

Experiment

The cutting tests were carried out on a 5-axis high-speed milling centre HSC 105 linear, with a 42 000 rpm spindle. The tool was a carbide cylindrical end mill with two cutting edges, 16 mm diameter, 30° helix angle, 0.5 mm corner radius, and *L*= 50 mm overhang (*L*/*D*=3). A small overhang is necessary to consider a rigid cutter on the spindle. The cutter was mounted in a HSK 50A thermal holder. The workpiece was made of 6082 aluminium alloy. The machining of the thin wall starts from a solid plate of the dimension 100x80x10 mm. Deformations of the part were measured in the *x* direction, the perpendicular feed direction, by TRITOP, a non-contact optical measuring system. In addition to parts deformation, average surface roughness Ra was measured. As the coolant, 5% emulsion Blasocut BC25 was first used and then air. Cutting conditions were as follows: depth of cut – 5 mm, width of cut – 2 mm, cutting speed – 301.44 m/min, milling method - down milling.

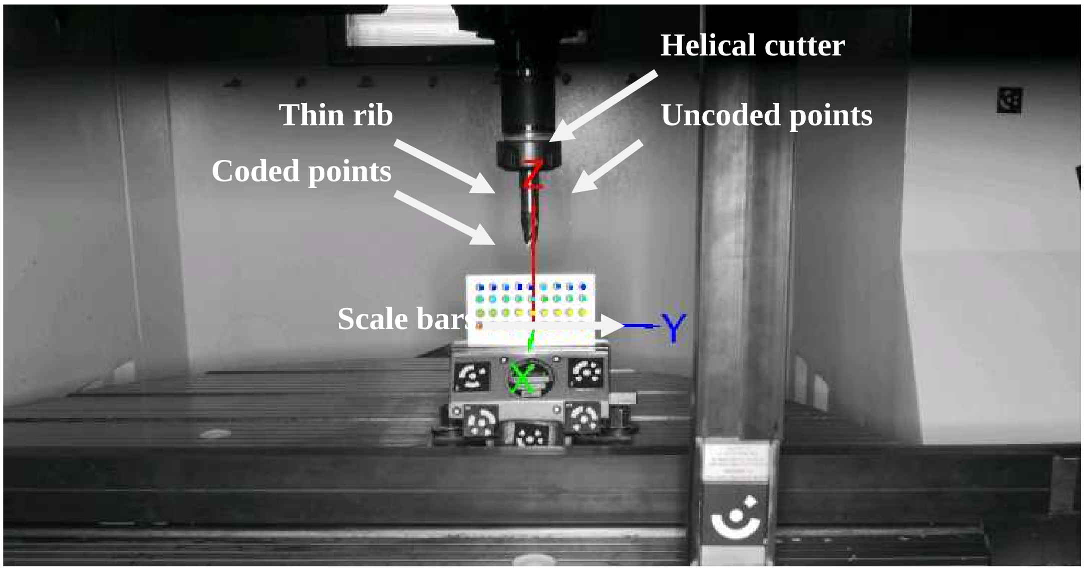

Fig. 3 *Machining set-up*

Results

The deformation of thin ribs is shown in a deviation colour map. The results of deformation at different cutting medium are shown in Figures 4-5. The difference in deformation was minimal. The deformation components occurred mainly at the top of the wall in both cutting media, about the same as can be seen in Fig.4 and Fig.5. We can say that cutting medium (air, emulsion) has a significant impact on the deformation of thin wall milling. Cutting medium is reflected more on the quality of the surface.

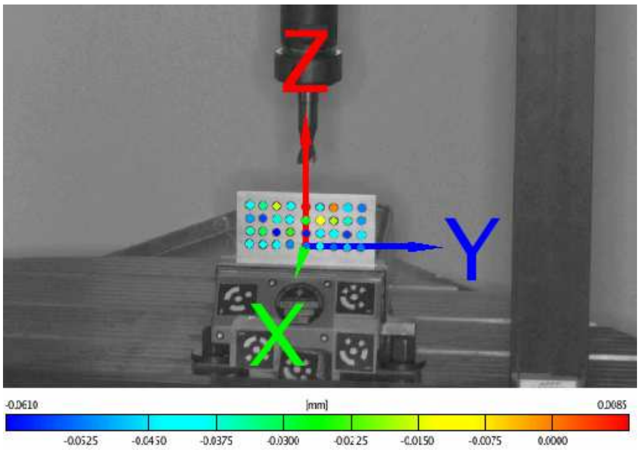

Fig. 4 *Colour deviation map of thin rib using air*

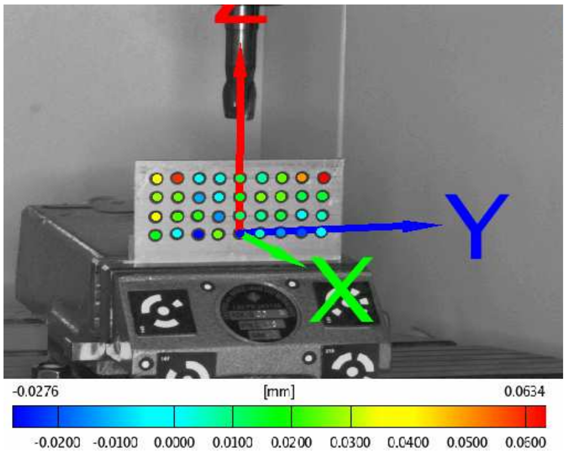

Fig. 5 *Colour deviation map of thin rib using emulsion*

Roughness was measured by using Surtronic 3 +. The measuring positions are shown in Figure 6. Surface roughness of thin ribs is given in Table 1.

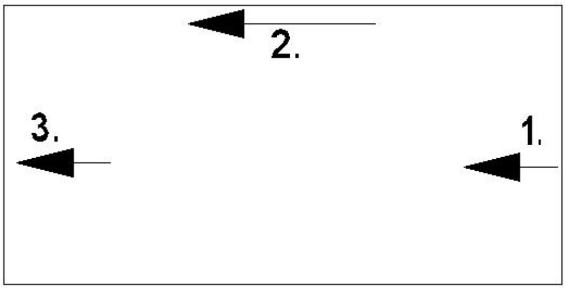

Fig. 6 *Measuring position*

ROUGHNESS OF THIN RIBS SURFACE Table 1

Measuring position	**Roughness Ra [μm]**	
	Air	**5% emulsion Blasocut BC 25**
1.	0.46	0.32
2.	1.22	0.34
3.	1.26	0.58

Scientific asset

Asset of this paper is pointing out the importance of cutting medium in milling the thin ribs. Contribution is a summary of basic cutting fluid characteristics; it describes problems with thin ribs and noncontact measuring method of deformation by TRITOP optical measuring system. Experimental results proved the influence of cutting medium on deformation and surface quality of thin ribs.

Conclusion

Cutting medium plays an important role in machining operations and has impact on productivity, tool life and quality of work. The high-speed machining of aluminium and its alloys does not use emulsion, but only air. However, at the speed of 10,000 min^{-1}, it is recommended to use emulsion, since, in addition to better lubrication, cooling and removing chips and metal fines from the tool/workpiece interface, which has no significant effect on the deformation of thin-walled parts, it leads to higher surface quality. Cutting conditions (particularly the depth of cut) remain the most important parameters influencing the deformation of thin ribs.

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