

CHIP FORMS AND THEIR CORRELATION WITH TEMPERATURE AND CUTTING FORCES IN INCONEL 625 AND 718 TURNING

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ABSTRACT

The paper concerns chip formation problem in difficult to cut materials machining. Selected tests results including temperature distribution in cutting zone and force measurement in longitudinal turning of Inconel 625 and 718 have been presented and related to chip forms. It has been proved that there is no clear correlation between chip shapes and tested factors.

INTRODUCTION

In machining difficult to cut materials like nickel based alloys a great attention should be paid to chip formation. It has been proved that tool manufacturers recommendations do not prove to be correct in some local operating conditions [5]. Although it is possible to test recommended chipformer application areas, it is not on line procedure. The paper tries to answer the question if it is possible to monitor cutting forces or temperature distribution in cutting zone and correlate them with chip form.

Tests were performed in longitudinal turning of Inconel 625 and 718. The machinability of HRSA strongly depends on the prior treatment of the material so it is useful to compare these two materials [2].

RESEARCH AIM, OBJECT AND STAND

The aim of research was to analyze chip breakage sequence, forces and temperature measurement in longitudinal turning of Inconel 625 and 718 alloy with Sandvik Coromant insert WNMG 080404-23, grade 1105 and toolholder PWLNR 2020K 08, entering angle 95° [2]. Fig.1 shows the tool and cross section of -23 chipformer. Recommended application area included depth of cut $a_p = 0,5 - 4,0$ mm, feed $f_n = 0,1 - 0,3$ mm/rev.

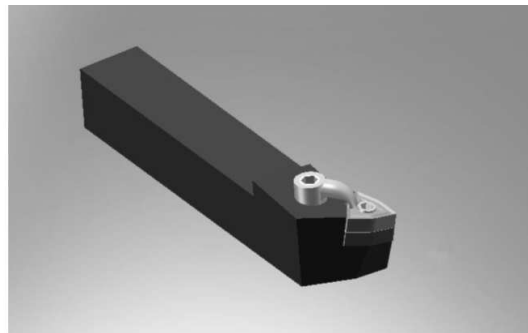
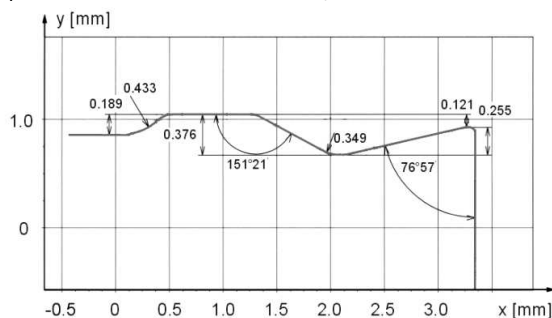


Fig.1

3-D model of Sandvik Coromant tool and -23 chipformer cross section

All tests have been performed on a specially prepared test stand. The research stand has combined high speed camera stand for recording high speed phenomena in cutting zone [3], the stand for force measurement and the stand for temperature measurement.

The stand has consisted of:

1. High speed camera made by Vision Research - Phantom V5.2
2. Various point and scattered lighting systems
3. Force measurement set based on Kistler 9257B dynamometer and Kistler 5070A amplifier (Fig. 3) with DynoWare computer program
4. Temperature measurement set based on FLIR SC620 infrared camera (Fig.4) Therma CAM Researcher Pro 2.9 computer program
5. Precision lathe for testing tools and work materials Masterturn 400

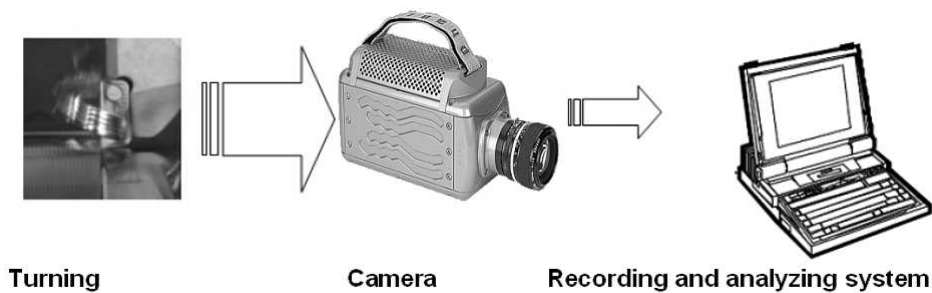


Fig.2
Chip form recording system

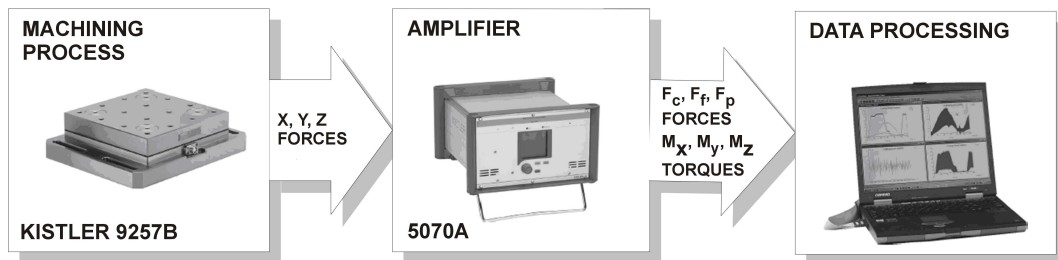


Fig.3
Force measurement system components



Fig. 4
Components of temperature measurement stand

Tests were conveyed according to Hartley plan, consisted of eleven configurations of cutting data repeated three times [1]. Next chapter presents selected examples.

SELECTED RESULTS OF TESTS

The authors have decided to present selected results for the depth of cut $a_p = 2,0$ mm and the cutting speed $v_c = 75$ m/min for two feeds $f_n = 0,105$ mm/rev and $f_n = 0,211$ mm/rev. Its obvious that the latter value of feed gives better filling of chip groove and as a result better chip form.

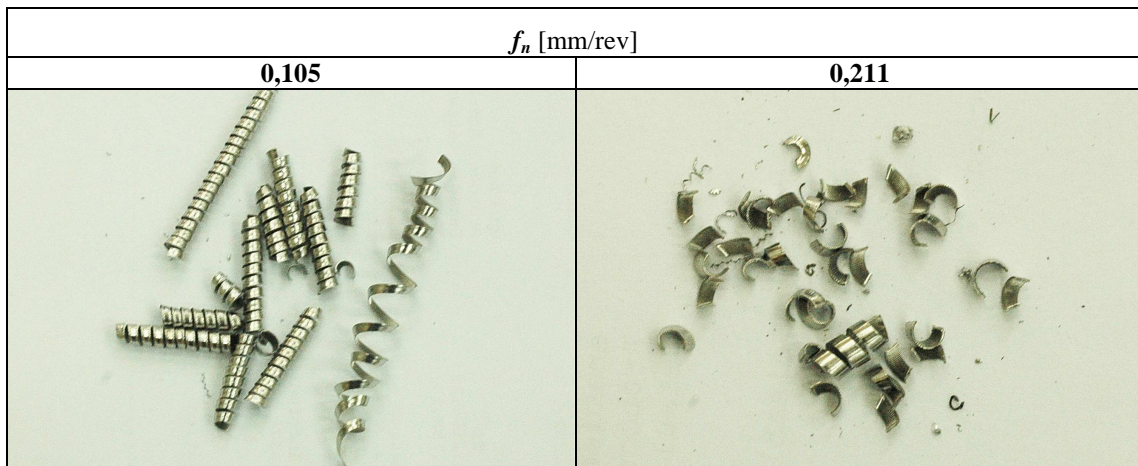


Fig.5

Chips achieved in Inconel 625 turning for chipformer -23, $v_c = 75$ m/min, depth of cut $a_p = 2,0$ mm

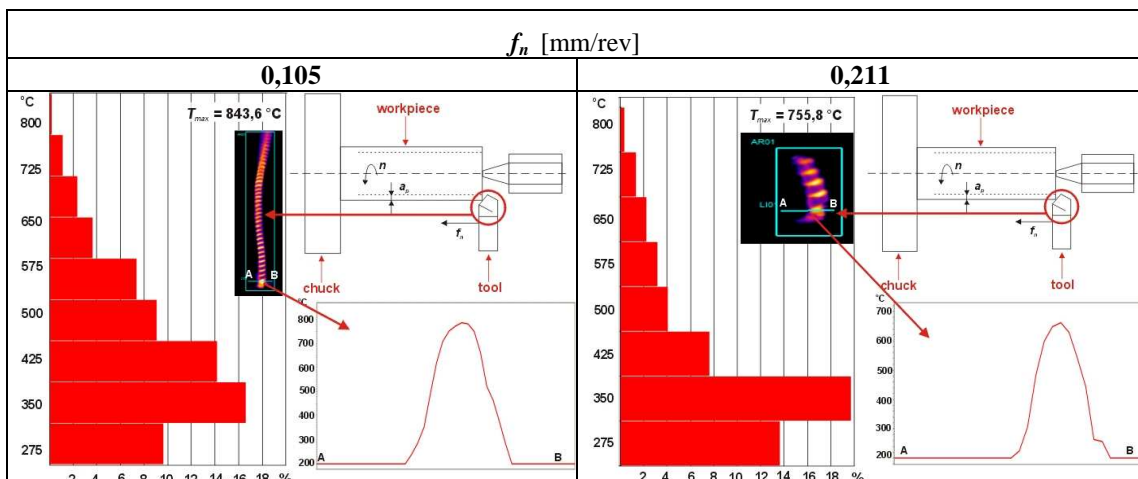


Fig. 6

Temperature distribution in cutting zone in Inconel 625 turning for chipformer -23, $v_c = 75$ m/min, depth of cut $a_p = 2,0$ mm

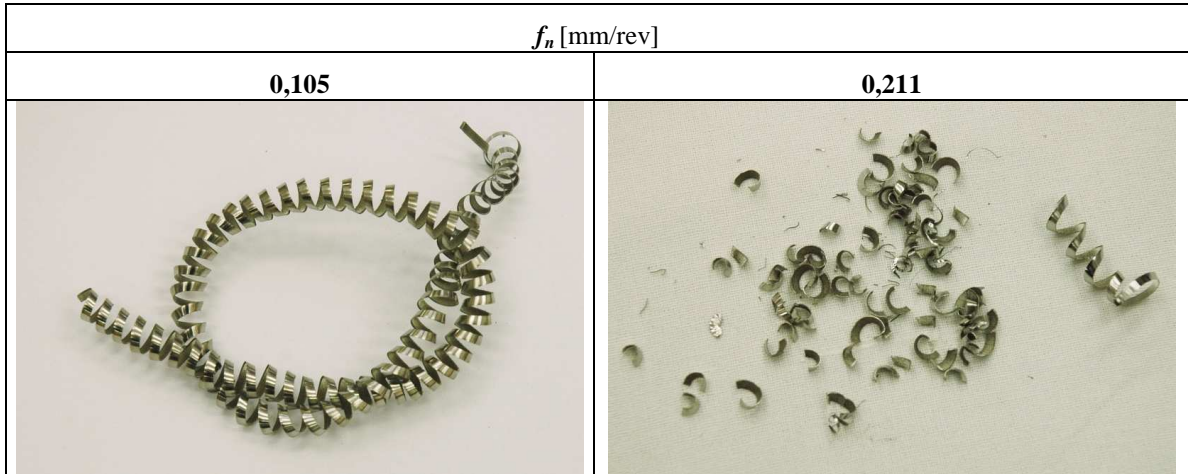


Fig.7

Chips achieved in Inconel 718 turning for chipformer -23, $v_c = 75$ m/min, depth of cut $a_p = 2,0$ mm

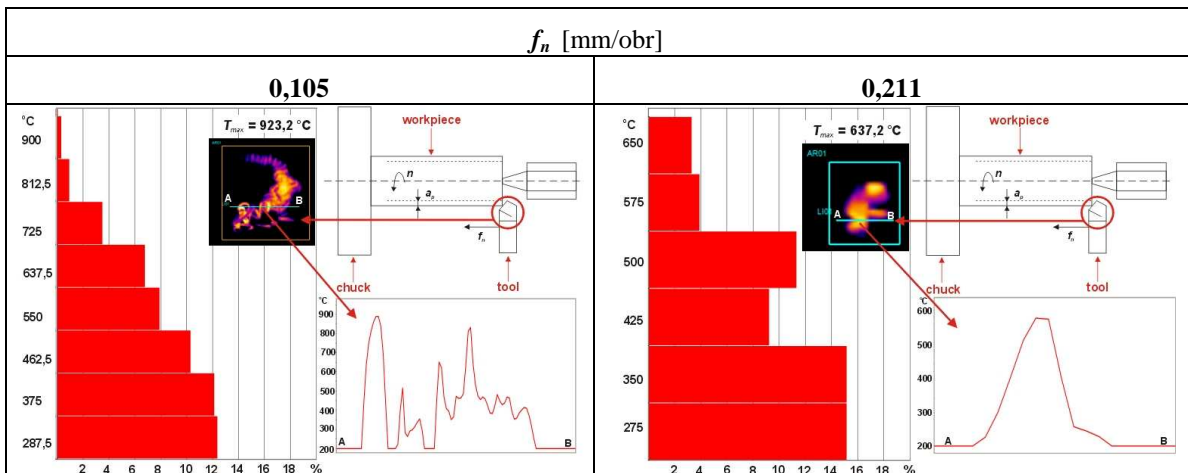


Fig. 8

Temperature distribution in cutting zone in Inconel 718 turning for chipformer -23, $v_c = 75$ m/min, depth of cut $a_p = 2,0$ mm

Fig.6 and Fig.8 present distribution of temperature in cutting zone as well as its maximum value. The bar chart shows percentage participation of particular selected temperature values in rectangle area shown on the right. Temperature below 200 °C has been neglected. On the lower right-hand corner of the figures the temperature distribution along AB line is shown. General tendency is shown in Fig. 9. It is visible that there are not any temperature phenomena showing different chips forms for tested sets of cutting data. There was temperature $T_{max} = 923,2$ °C in turning Inconel 718 for $f_n = 0,105$ mm/rev and $T_{max} = 843,6$ °C in turning Inconel 625 also for $f_n = 0,105$ mm/rev.

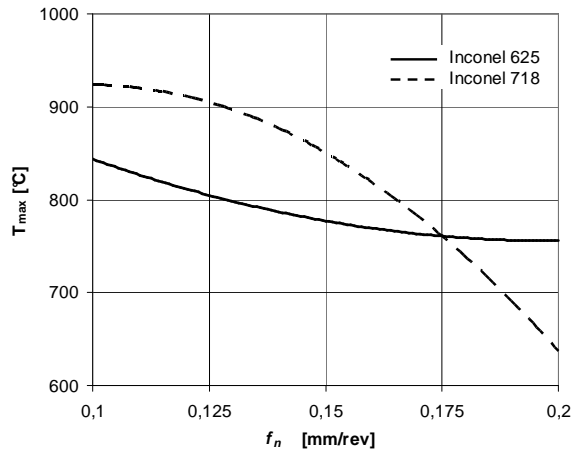


Fig. 9

Influence of feed value on max. temperature in cutting zone in turning Inconel 625 and 718, $v_c = 75$ m/min, depth of cut $a_p = 2,0$ mm

In the matter of forces, the influence of feed value on the main cutting force F_c and feed force F_f has been typical of majority of work materials. In turning Inconel 718 with $v_c = 75$ m/min, max. $F_c = 858,8$ N and $F_f = 600,3$ N values have been achieved for feed $f_n = 0,211$ mm/rev and $a_p = 2,0$ mm. In turning Inconel 625 with $v_c = 75$ m/min, max. $F_c = 964,4$ N and $F_f = 520,9$ N values have also been achieved for feed $f_n = 0,211$ mm/rev and $a_p = 2,0$ mm.

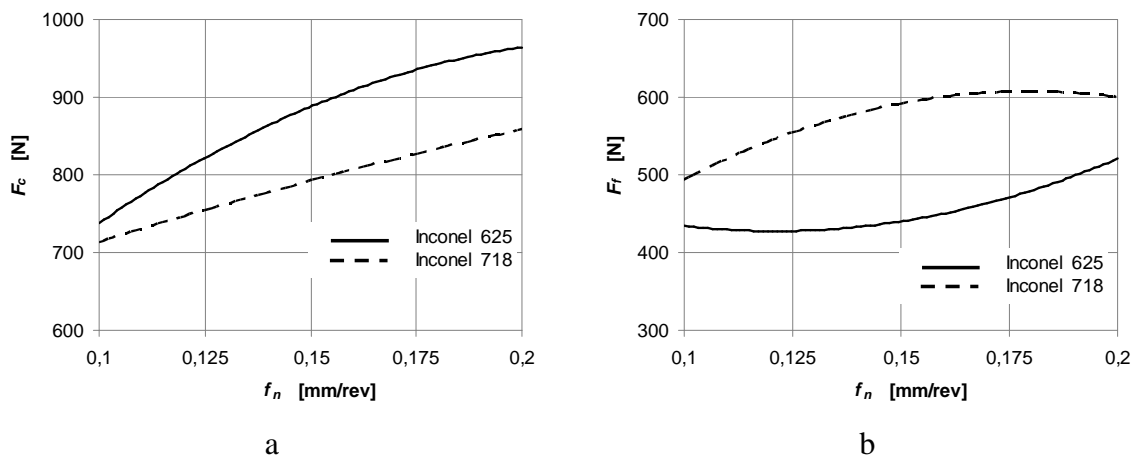


Fig.10

Influence of feed value on the main cutting force F_c (a) and feed force F_f (b) in turning Inconel 625 and 718, $v_c = 75$ m/min, $a_p = 2,0$ mm

CONCLUSIONS

In the paper, selected tests concerning measurement of cutting forces, temperature in cutting zone and chip formation process in turning Inconel 625 and 718 have been presented. Tests showed that various forms of chips could be observed although there were not any significant rapid changes in forces values and temperature distribution. Thus the conclusion is that it is not possible to monitor changes in chips formation by means of force and temperature measurement applied in presented way. Chip form is generally very important for the quality of

machining process, especially on CNC lathes. Since tool manufacturers recommend areas of chipformers application it is important to test them under local operating features. It has been proved that they often, as was mentioned earlier, differ from manufacturer's recommendations [4] [5] [6]. So it is necessary to perform a set of machining tests to specify usable chipformer area in local machining condition, often with the help of simulation procedures [7] [8] and modern methods concerning recording high speed phenomena, i.e. chip formation process in this case.

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