Transactions of the VŠB – Technical University of Ostrava, Mechanical Series
No. 2, 2011, vol. LVII
article No. 1880

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CONTRIBUTION TO TURNING OF ALLOY ON NI BASE BY CERAMIC TOOL

PŘÍSPĚVEK K SOUSTRUŽENÍ SLITINY NA BÁZI NI NÁSTROJEM Z ŘEZNÉ KERAMIKY

Abstract

This article deals with dry turning of nickel superalloy - Inconel 718. The different ceramic inserts were applied for cutting process. These inserts were produced by Greenleaf Corporation company. This paper discusses durability of cutting inserts, the different intensity of tool wear at various cutting parameters. The most suitable cutting conditions are chosen in the scope of applied tools.

Abstrakt

Příspěvek se zabývá suchým soustružením niklové slitiny – Inconel 718, při němž byly aplikovány vyměnitelné destičky Z řezné keramiky Z produkce firmy Greenleaf Corporation. V článku je provedena diskuse trvanlivosti těchto destiček, související S rozdílným opotřebením nástroje při různých řezných podmínkách. Jsou vyhodnoceny nejlepší řezné podmínky a doporučeny pro praktickou aplikaci.

1 INTRODUCTION

Nowadays, requirements considering reliability and life time of parts are increasing. Load of machine parts increases, design of machined part is very sophisticated technology operation associated with the technological process are connected with many problem especially when application difficult – to - machine materials. Eliminations of some difficulties during machining is connected with the specific machining strategies, tool and cutting conditions choice.

Many components are made of materials, which are named as super-alloys or exotic materials. Inconel, Hastelloy, Waspaloy, Nimonic or titanium material belongs to these materials. While in the nineties the portion of these super-alloys was below 1 %, nowadays this portion is from 2 to 3 %. Many of these materials are applied for production turbine engines, transmission systems in energetic, aeronautics, cosmonautics, mining industry and medical engineering [1, 2, 3].

On the other hand, the unique and advisable characteristics of super-alloys will rise difficulties considering their machinability. These difficulties are caused by very high temperatures in the cutting zone (because of low thermal conductivity) together with the high mechanical load of cutting edge. The high load of cutting edge could leads to deformation of cutting tool and acceleration of abrasion processes during cutting, especially at higher cutting rates.

2 CONDITIONS OF EXPERIMENT

The Inconel 718 was chosen for experimental study. The main goal was to find the suitable cutting conditions, grade and shape of cutting inserts for dry machining nickel alloys. Inconel 718 is a precipitation hardened nickel/chromium alloy with significant contents of iron, niobium,

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molybdenum and other elements such as aluminum and titanium. Inconel 718 combines high strength and corrosion resistance with excellent weldability. This alloy can be used in temperatures range from -250°C to 700°C [4, 5, 6].

Inconel 718 is a complex metal structure material with high surface hardening of machined surface during the machining operations. Hardness of surface layers can be 2 times higher that hardness of the material in the deeper layers under the surface. This factor significantly affects machining strategies. Repeating passes of hardened layers should be minimized [4, 6, 7, 8, 9, 10]. Intensive mechanical and thermal load of cutting inserts causes the high intensity of tool wear despite application of low cutting speeds. Because of high mechanical load of surfaces, high cutting forces it is recommended to carry out machining operations on machines of high toughness.

Therefore, the experiment was carried out on a lathe SE 820 NUMERIC. This lathe is equipped a control system SIEMENS 810 D MANUAL TURN [11].

The ceramic inserts (WNGA 080408 and CNGA 120408) produced by Greenleaf Corporation company were applied, Fig. 1.. Both types of inserts were made of WG-300 materials, which is recommended for machining nickel based alloys. Inserts were clamped into tool holder from Pramet Tools Ltd. company - PWLNR 2525 M08 and PCLNR 2525 M12. Both types of tool holders have square section 25×25 mm and length 125 mm. Tool holders have a same negative geometry: γ_o = -6°, λ_o = -6°, κ_r = 95° [12, 13].

Fig. 1 Used cutting inserts.

Table 1 shows the cutting parameters used in experiment. The experiment was carried out under the all combinations of feeds and cutting speeds. All experiments were performed without coolants.

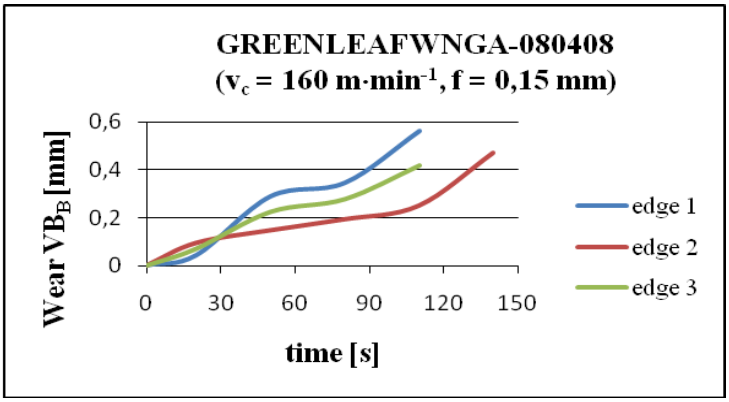
Tab. 1 Used cutting conditions.

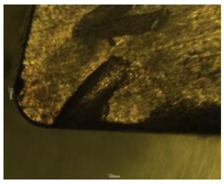
a_p [mm]	f_1 [mm]	f_2 [mm]	v_{c1} [m·min^{-1}]	v_{c2} [m·min^{-1}]	v_{c3} [m·min^{-1}]	v_{c4} [m·min^{-1}]
1	0.15	0.25	160	240	320	400

3 RESULTS OF EXPERIMENTS

The choice of the most appropriate cutting parameters for each cutting inserts was performed through measurement of cutting time during turning and cutting length which can be easily derived on the base of workpiece diameter and cutting speed (when cutting insert durability is known). The critical value of VB was chosen VB_B = 0.4 mm.

Tab. 2 Tool wear in dependence on cutting time for WNGA 080408.





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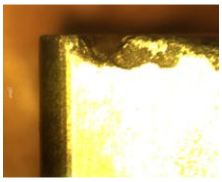

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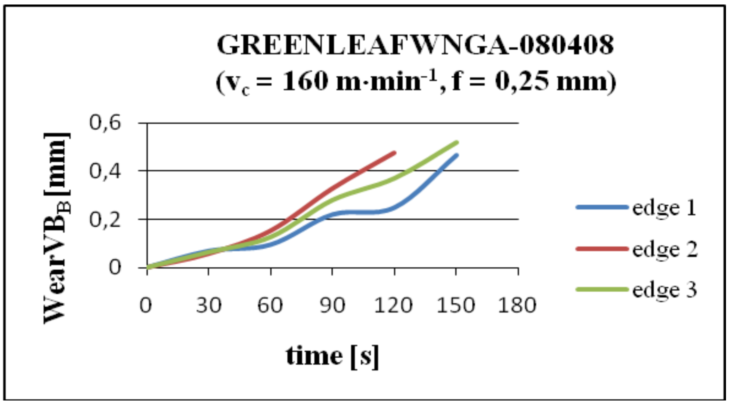

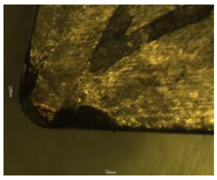

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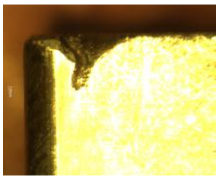

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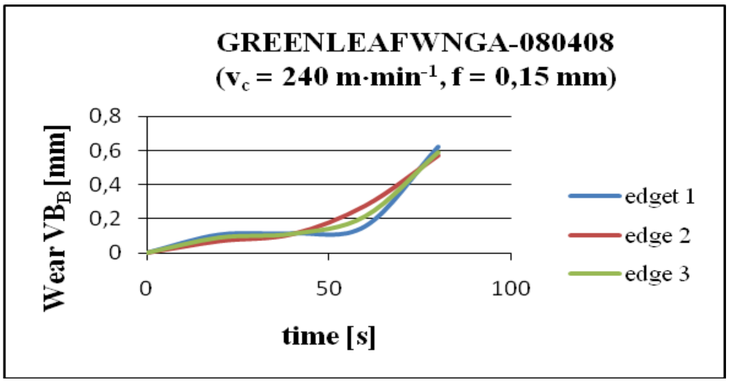

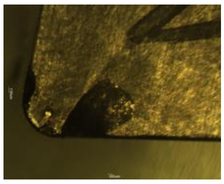

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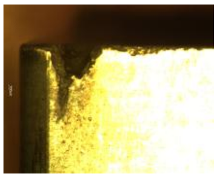

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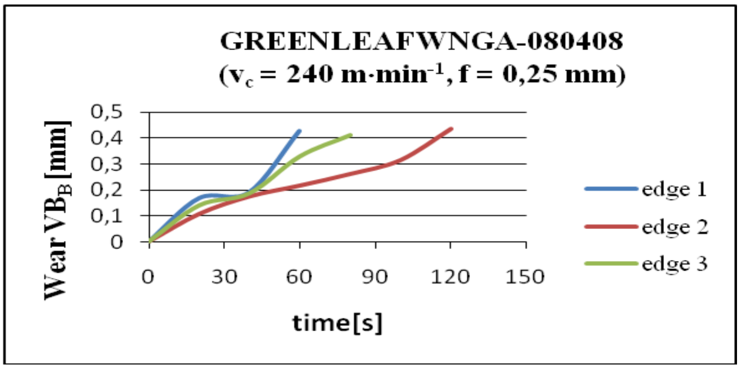

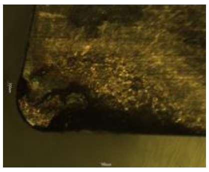

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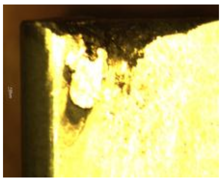

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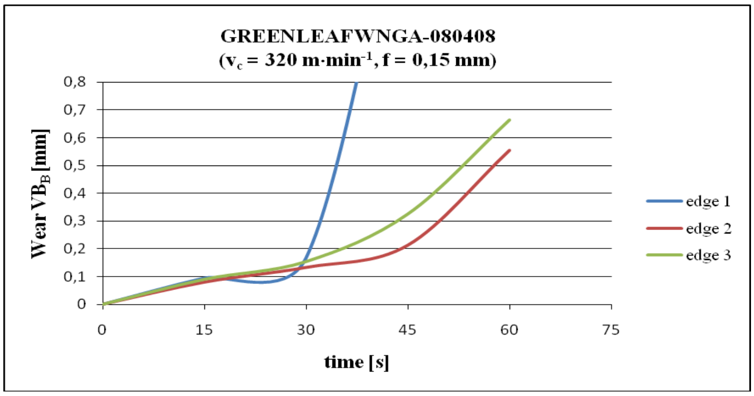

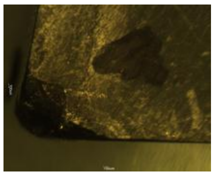

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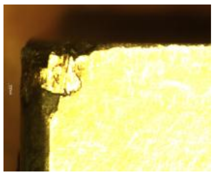

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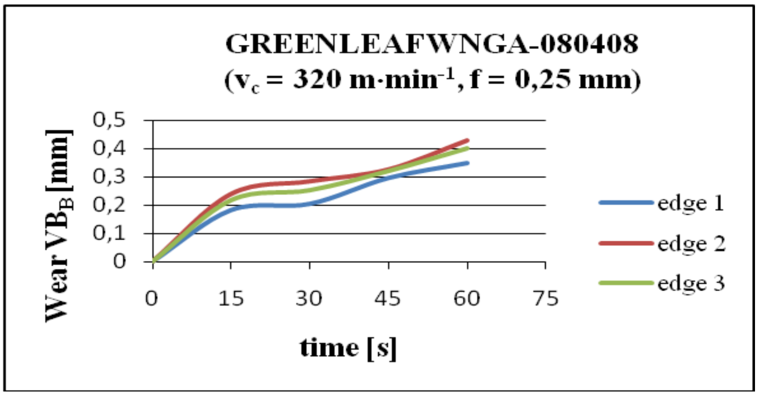

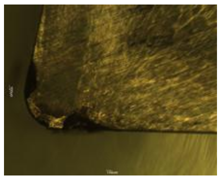

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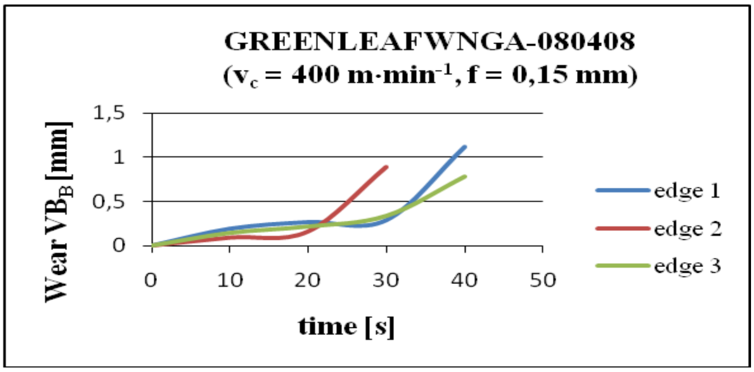

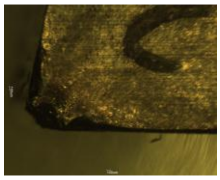

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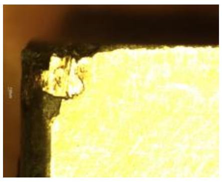

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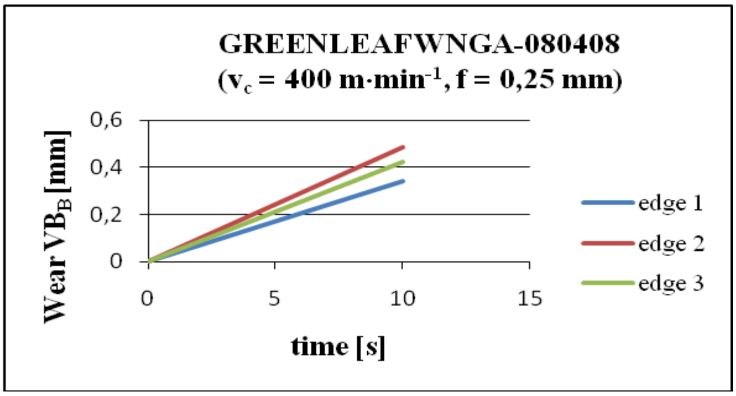

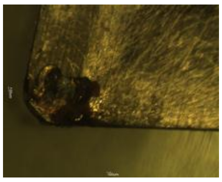

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The experiment was carried out with two different inserts. Each inserts was applied under the 4 cutting speeds and 2 feeds. Each experimental condition was repeated 3 times (so 48 experiments were carried out). Tool wear was measured by a laboratory microscope and each cutting test was stopped when tool wear (chosen parameter) reached the critical value (VB_B = 0.4 mm). The results of these measurements are illustrated in the next figures.

On the base of this experiment, durability of each cutting insert was obtained, Table 3. On the base of measured values the most suitable cutting conditions could be found for dry machining of Inconel 718 with cutting insert - WNGA 120408.

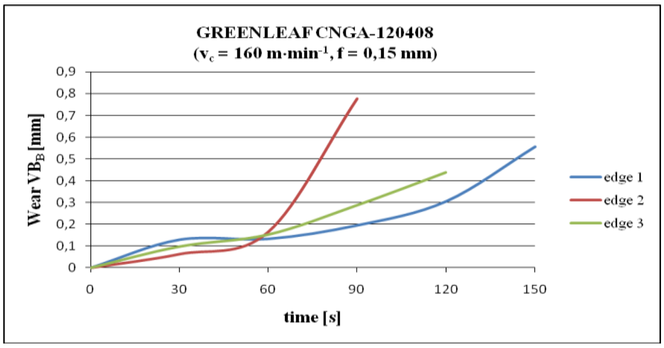
Tab. 3 Durability of cutting insert [s] for each cutting condition (WNGA 080408)

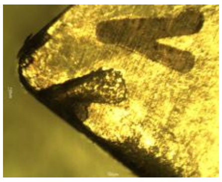
	f [mm]	
v_c [m·min^{-1}]	0.15	0.25
160	110.83±11.49	124.17±10.83
240	75.00±0.00	84.17±18.84
320	46.00±6.66	61.67±4.41
400	29.33±2.67	9.00±0.58

Table 3 shows that the most suitable cutting conditions for cutting insert WNGA 080408 can be set up as the following: cutting speed v_c = 160 m·min^{-1} and feed f = 0,25 mm. Application of the higher cutting speed dramatically reduce durability of cutting insert. Application of cutting speed (more than 160 m·min^{-1}) is unacceptable for dry machining of this type of nickel base alloy.

On the base of the next experiment, durability of each cutting insert was also obtained, Table 5. On the base of measured values the most suitable cutting conditions could be also found for dry machining of Inconel 718 with cutting insert - CNGA 120408.

Tab. 4 Tool wear in dependence on cutting time for CNGA 120408.





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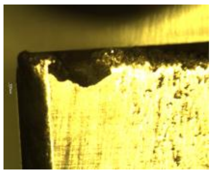

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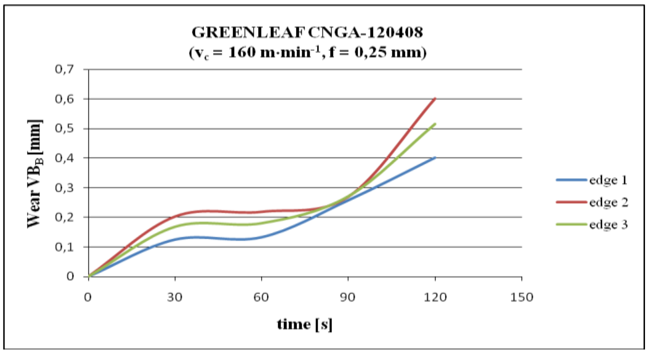

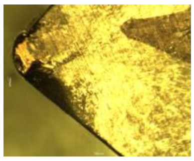

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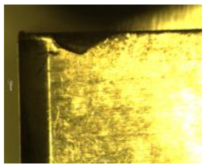

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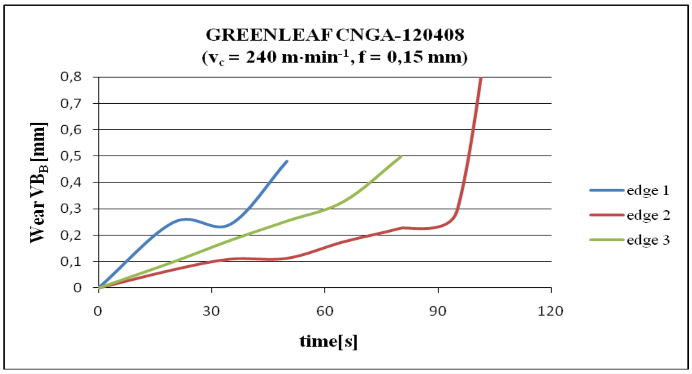

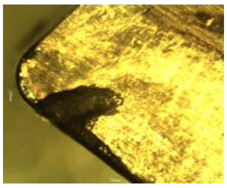

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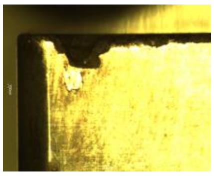

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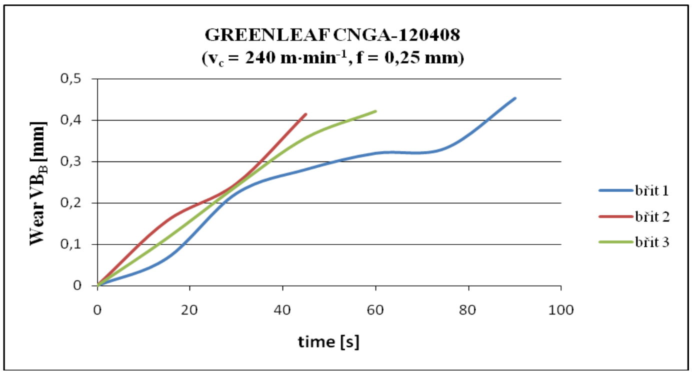

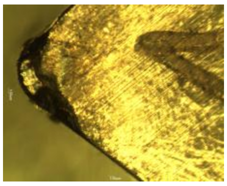

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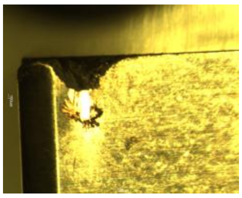

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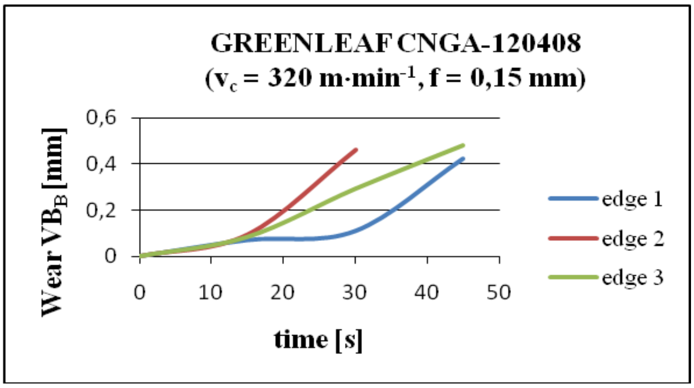

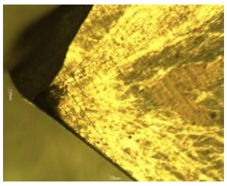

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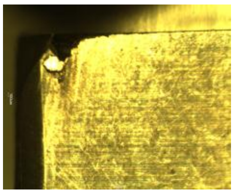

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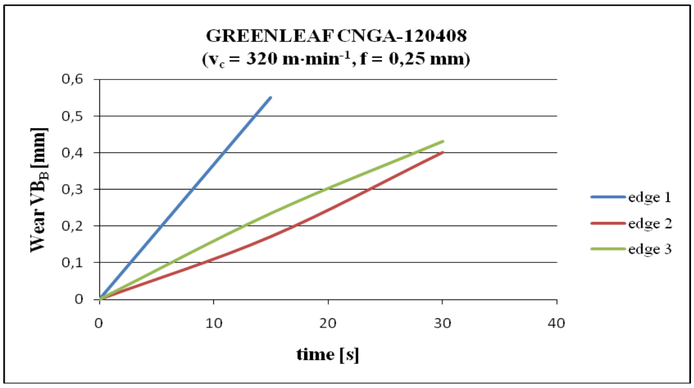

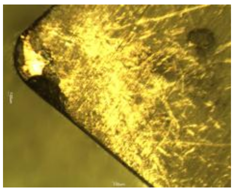

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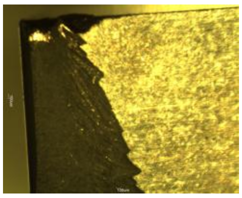

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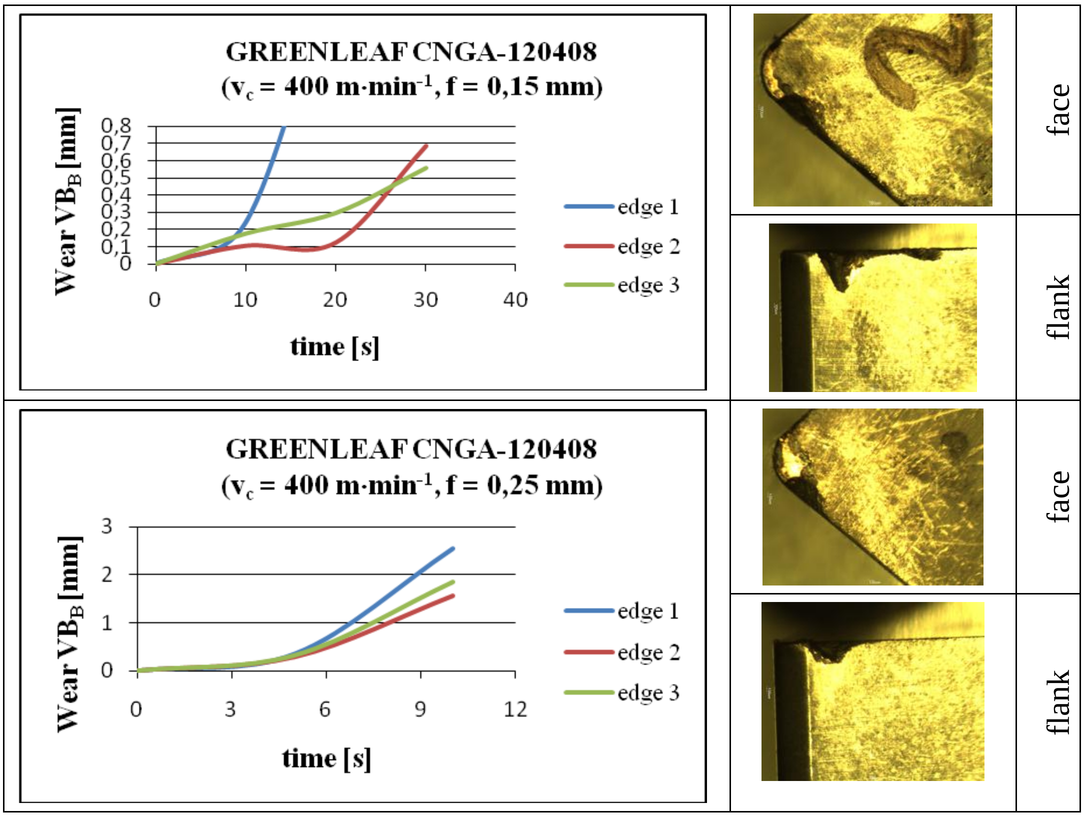

Tab. 5 Durability of cutting insert [s] for each cutting condition (CNGA 120408).

	f [mm]	
v_c [m·min^{-1}]	0.15	0.25
160	102.50±17.32	116.17±2.17
240	71.33±15.01	61.33±12.25
320	36.33±4.98	23.00±6.03
400	20.33±4.18	5.37±0.12

Table 5 shows that the insert CNGA 120408 also reach the highest life time for cutting speed v_c = 160 m·min^{-1} and feed f_{ot} = 0.25 mm. Application of the higher cutting speed dramatically reduce durability of cutting insert. Application of higher cutting speeds (more than 160 m.min^{-1}) is unacceptable for dry machining of this type of nickel base alloy.

Measurements of tool life verify the literature knowledge about low cutting speeds. Moreover, despite application of low cutting speeds tool life is usually very low, much lower than that for machining conventional steels.

On the base of measured tool life *t* (cutting time for VB_B = 0.4 mm), derived number of revolutions, known diameter of workpiece the cutting length was calculated through the equation 1.

$$L = \frac{n \cdot t \cdot \pi \cdot D}{1000} \qquad (1)$$

where: *L* - cutting length [m]

n - number of revolution [ot·min^{-1}]

t - cutting time for VB_B = 0.4 mm [min]
D - machined diameter [mm]

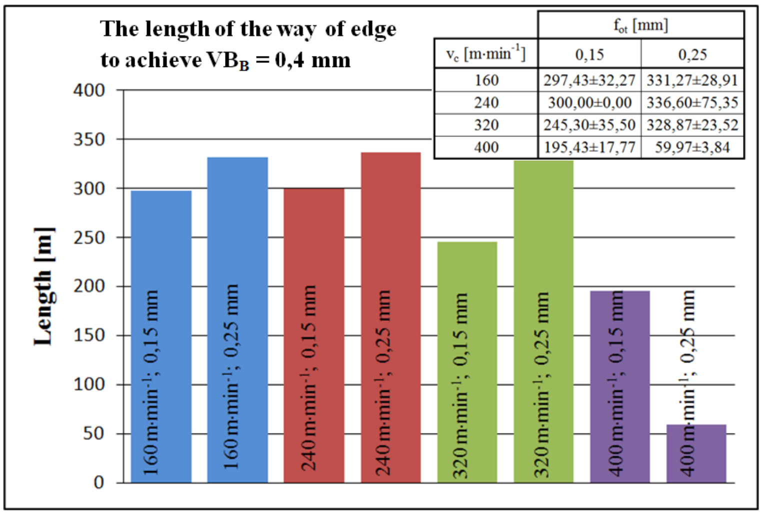

Fig. 2 Comparison length of cutting length (WNGA 080408).

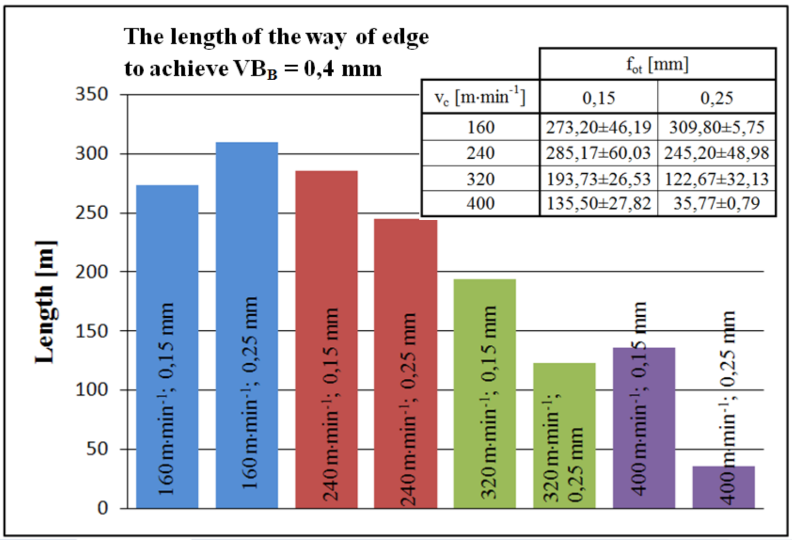

Fig. 3 Comparison length cutting length (CNGA 120408).

Comparison of cutting lengths indicates that the highest tool life and so the derived cutting length can be obtained for the lowest cutting speeds v_c = 160 m·min^{-1} and feed f = 0.25 mm for both type of cutting inserts (WNGA and CNGA). The cutting insert WNGA enable to reach longer cutting length and so the cutting times than that for CNGA.

4 CONCLUSIONS

This paper deals with turning nickel based alloy Inconel 718 by ceramic inserts produced by Greenleaf Corporation company, without the cutting fluid. The turning process was carried out under the various cutting conditions. On the other hand the optimal cutting conditions, cutting speed v_c = 160 m·min^{-1} and feed f = 0.25 mm were found as optimal condition for cutting insert WNGA 080408. Tool life were measured and also the derived cutting length was calculated through the time and applied cutting speed. The maximum cutting length were reached 331 meters (2.1 minutes). On the other hand the suitable cutting conditions for CNGA 120408 cutting insert was also found as the following: v_c = 160 m·min^{-1} and feed f = 0.25 mm. The obtained tool cutting length is 310 meters (1.9 minutes). This inserts have small value of cutting life, but this inserts withstand in cut twice more meters than inserts from cemented carbide. After summarized all obtained results we have got conclude, that if correct cutting parameters, cutting tool geometry and cutting material were choice, it is possible economically machining alloys such as Inconel 718 without cutting fluid.

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