MM Science Journal | www.mmscience.eu
ISSN 1803-1269 (Print) | ISSN 1805-0476 (On-line)
Special Issue | HSM 2025
18th International Conference on High Speed Machining
October 15-16, 2025, Metz, France
DOI: 10.17973/MMSJ.2025_12_2025161

HSM2025-44873

RESIDUAL STRESS EVOLUTION IN DRY SINGLE CUTTING-EDGE BROACHING OF INCONEL 718: IMPACT OF FILLET RADIUS AND UNDERLYING MECHANISMS

Cristian Pérez-Salinas[1]*, José Perez-Ruiz[2], L. Norberto López de Lacalle[3,4], Pablo Fernández-Lucio[3,4]

[1]Universidad Técnica de Ambato, Faculty of Civil and Mechanical Engineering, Ambato, Ecuador

[2]Universidad industrial de Santander, School of mechanical engineering, Bucaramanga, Colombia

[3]Department of Mechanical engineering, ESI Bilbao, University of the Basque Country, Bilbao, Spain

[2]Aeronautics Advanced Manufacturing Centre (CFAA), University of the Basque Country (UPV/EHU), 480170, Zamudio, Spain

*Corresponding author; cperez072@ikasle.ehu.eus

Abstract

This study investigates the effect of cutting-edge radius on surface integrity during dry broaching of Inconel 718 at 20 m/min. Experiments and simulations were used to analyse the effect of cutting radius and rise per tooth (RPT) on residual stresses using X-ray diffraction (EDX) and hole drilling, supplemented by Vickers microhardness and SEM. The results show that radii greater than 15μm produce a critical transition: while they increase microstructural deformation and surface tensile stresses, they also produce subsurface compressive stresses that improve component integrity. These findings provide important guidelines for optimizing tooling and extending the service life of critical components broached in nickel alloys.

Keywords:

Surface integrity, Residual stress, Nickel based superalloys, Broaching process, Cutting-edge radius

1 INTRODUCTION

Nickel alloys are a material that stands out for its high performance and usefulness in critical and thermo-mechanically demanding applications [Arunachalam and Mannan, 2000]. However, its counterpart is evidenced by its difficulty in machining due to strain hardening, low thermal conductivity, and sensitivity to surface damage reported in the literature [Klocke et al., 2013]. Broaching is a traditional process, but its high capacity allows for the creation of slots of different geometries and with superior quality. [Schulze, 2014]. In broaching, it is a traditional process, but its high capacity allows the production of grooves of different geometry and superior quality [Schulze, 2014]. Despite this, there is limited literature on its impact on surface integrity compared to other processes (milling, turning) [Chamanfar et al., 2017].

There are standards that require strict control of surface integrity (AMS 5662/5663 API 6A, NACE MR0175/ISO 15156) and residual stresses are useful because of their direct relationship to surface integrity. Residual stresses are internal forces that remain in a material after external forces that caused deformation are removed, in this case forces generated during tool passage [Sharman et al., 2006]. These stresses can significantly influence the surface integrity of a component, affecting its strength and durability. Residual stresses can increase or decrease fatigue strength depending on their nature (compressive or tensile). Compressive stresses are often beneficial as they reduce the risk of surface cracking. Tensile residual stresses can accelerate stress corrosion cracking, especially in aggressive environments, as well as reduce fatigue and creep resistance [Sridhar et al., 2011].

Machining anomalies can affect the surface integrity of components by creating defects such as surface tears, inclusion cracks, cavity formation, carbide cracks or grain extraction [M'Saoubi; et al., 2008; Chamanfar et al., 2017]. [Sadat and Reddy, 1992, 1993] found that a low cutting speed (6 m/min) causes surface damage to the workpiece and evidence of residual stress tends to be compressive. In the work of [Sharman et al., 2006] reports that cutting Inconel 718 with a worn tool resulted in increased microstructural deformation, microhardness changes and high surface tensile stresses. [Telesman et al., 2021] also reports that decreased broaching speed resulted in higher magnitude of compressive stresses for both sharp and dull tools.

Despite advances in the study of tool life during the machining of superalloys, there is little work specifically analysing the role of cutting-edge microgeometry, particularly cutting-edge radius, in broaching processes. Furthermore, studies investigating the combined effects of RPT and cutting-edge radius on surface residual stresses are limited, and even less information is available on the subsurface stresses induced by this type of machining. [Yang et al., 2019].

Existing literature has extensively documented the effects of tool wear and cutting speeds, both low (below 60 m/min) [Sadat and Reddy, 1993, 1992] and high (above 120 m/min) in conventional processes such as turning and milling [Tan et al., 2021; Peng et al., 2013]. However, in the case of broaching, the speed ranges differ significantly. In this context, a cutting speed of 20 m/min can be considered high, which underlines the need to re-evaluate the effects of cutting parameters according to the particularities of the process.

To deepen the understanding of the impact of broaching on surface integrity, the present study focuses on quantifying the effect of cutting-edge radius (0-30 μm) on residual stresses and microstructural deformation in the machining of Inconel 718. A correlation between RPT and cutting-edge radius and subsurface hardness profiles is established, showing that radii larger than 15 μm can induce beneficial compressive stresses in the subsurface zone.

To achieve this objective, a multi-scale analysis strategy is employed, combining energy dispersive X-ray (EDX) and hole drilling for the characterisation of residual stresses. Additionally, a Vickers microhardness analysis is performed to determine the thickness of the layer affected by the tool passage, complemented with scanning electron microscopy (SEM) to inspect the depth of the induced deformation.

2 METHODOLOGY

For the development of this study the following methods and techniques were used.

2.1 Cutting-edge preparation and characterization

The method proposed by [Denkena et al., 2010]was used to characterise the rounding of the cutting edge. To this end, an Alicona InfiniteFocus device was employed as the measuring instrument. The cutting-edges were prepared with a radius between 5 and 35 μm. The edges were rounded using a brushing process with a ceramic bristle brush [Pérez-Salinas et al., 2025]. This process was employed to both round and polish the cutting edge, thereby uniforming the surface texture.

2.2 Experimental procedures

The broaching experiments were implemented in dry conditions as shown in Fig. 1. An aged Inconel 718 (Hardness of 45 HRc) shaft of diameter 100 mm (Fig. 2) was mounted on a CMZ-TC25 turning center capable of withstanding 5000 N in its three axes, to allow a cutting length of 30 mm. The excellent rigidity properties of the machine due to its robustness allowed vibrations to be minimized. The machine's feeding movements (0-30 m/min) limit the cutting speeds for the application of the broaching process.

The tool was an uncoated Carbide rectangular roughing broach segment (1 tooth) with 6%Co with a cutting width of 8 mm. Tab. 1 summaries the tool geometry and cutting parameters used in the cutting tests. The cutting forces were measured with the Kistler force dynamometer under orthogonal cutting conditions (measuring range ±10 kN in the z-axis and ±5 kN in the x and y directions). Two repetitions were performed for each broaching condition. Further details are presented in Tab. 1. Note that the shear rate remains constant for all experiments.

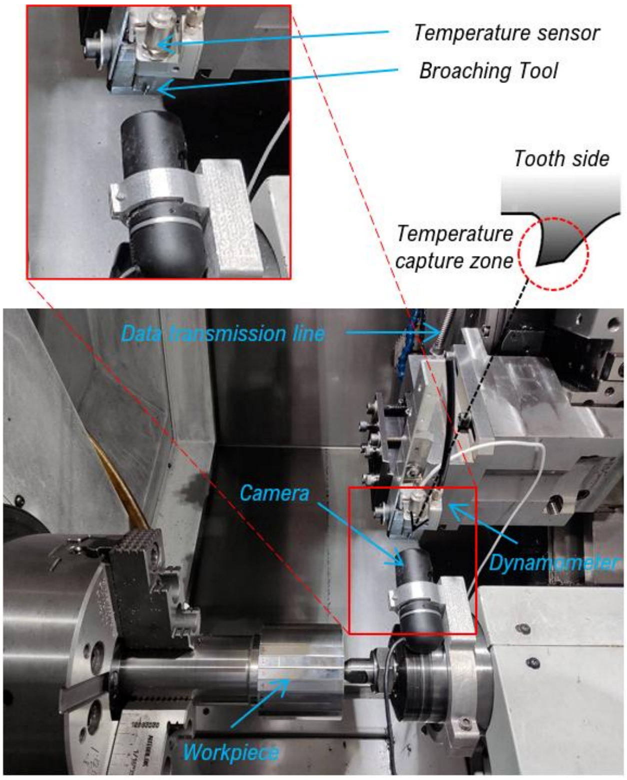

Fig. 1: Experimental set-up for orthogonal cutting tests by broaching with one cutting-edge

Tab. 1: Cutting parameters and tool geometries

Parameter	Unit	Value
Cutting speed, *Vc*	(m/min)	20
Rise per tooth, *RPT*	(μm)	25, 50, 75
Radius edge, *re*	(μm)	5, 12, 25, 35

2.3 Inspection of surface integrity

To inspect residual stresses on the surface, an X-ray technique was employed at two points within a 1 mm² area in the central region of the machined surface. A 1 mm diameter round collimator, chromium (Cr) X-ray target material, and Kα radiation with Ψ angles of 125° and 131° were utilized [Noyan and Cohen, 1987]. To examine surface stress beneath the machined surface, a hole drilling technique was applied. Due to the destructive nature of this technique and the spatial constraints imposed by the inspection setup, only one sample per cutting edge radius was analyzed. According to ASTM E837-13, the residual stresses in the subsurface of the slot were evaluated using a hand drill with the RS-200 milling guide. The specialized Vishay H-DRILL software was utilized to calculate residual stress from the measurements [Schajer, 2006].

Vickers' hardness testing under a 10-gr load is used to determine the hardness of the surface and the sub-layers below the machined surface. Additionally, SEM images of the cross-section are captured to analyze the deformations caused by the broaching tool passing through the surface and to assess the extent of the surface damage.

The output variables that were evaluated on the surface and subsurface that were addressed in dry conditions were taken at corresponding points, as shown in Fig. 2.

3 RESULTS AND DISCUSSION

This section presents and discusses the results in relation to cutting forces, surface and subsurface residual stresses, and the depth of material damage caused by the tool during broaching.

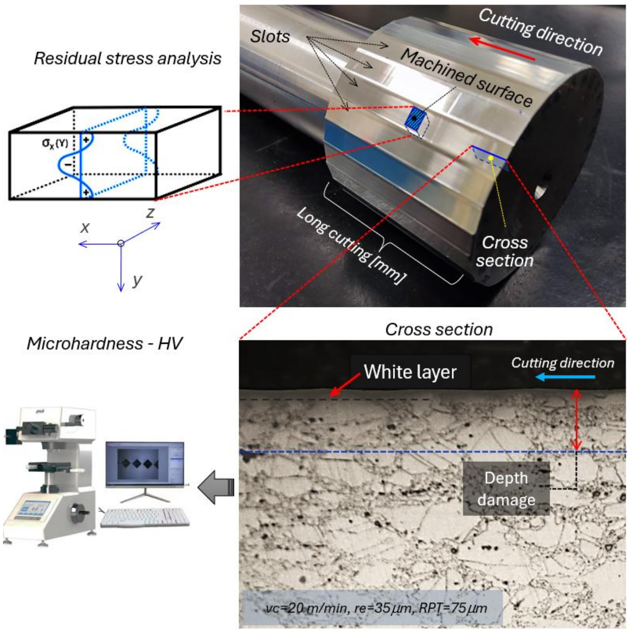

Fig. 2: Assessment of the workpiece and the variables.

3.1 Cutting forces and residual stresses.

The cutting forces exhibit a range of 1500-3700 N in the cutting direction (X-axis) and 1490-4000 N in the thrust direction (y-axis) when the tool is in operation. Notably, the radius and RPT have a direct impact on these forces, with increases in these variables leading to corresponding increases in the forces (See Fig. 3).

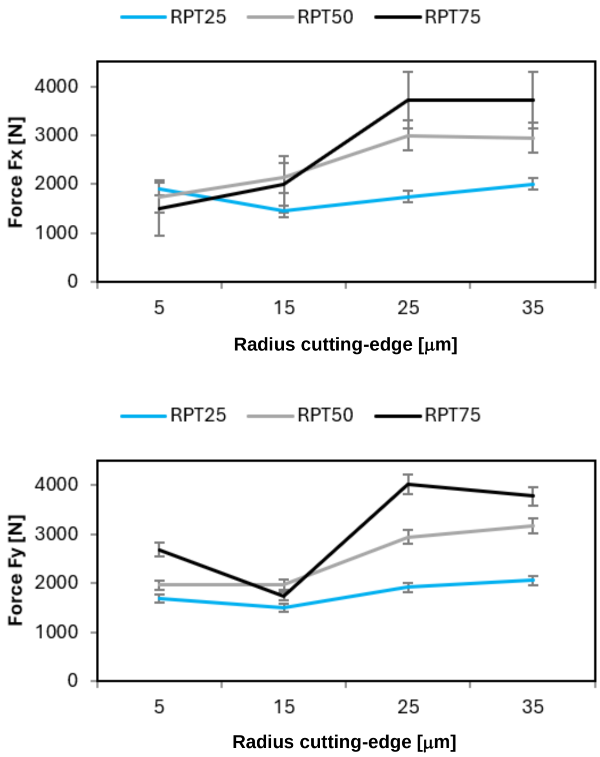

Fig. 3: Effect of cutting-edge radius and RPT on cutting force components

Figure 4 shows the results of the surface residual stresses induced after the broaching process. The curves represent the stresses in the shear direction (σ_1) and in the perpendicular direction (σ_2). Although no clear linear trend is identified in the behaviour of the residual stresses, it is observed that residual stresses tend to decrease as the shear edge radius approaches 12 µm. This behaviour is consistent with the simultaneous decrease of the cutting force components for radii close to that value.

The literature suggests that the relationship between cutting forces and residual stresses is highly complex, given the interaction of multiple factors during chip formation. These interactions are governed by intense thermomechanical phenomena in the cutting zone, where temperatures can exceed 70 % of the melting point of alloys [Ezugwu et al., 2003]. According to Arunachalam [Arunachalam et al., 2004], in nickel-based superalloys, shear forces (near to ~1200 N/mm²) correlate with tensile residual stresses due to the predominance of thermal effects, The effect is similar to that of residual stresses occurring in the material around the weld, which is due to a combination of solidification shrinkage and local deformation [Korsunsky and James, 2004]. Complementarily, [Denkena et al., 2015] indicate that larger edge radii tend to increase shear forces but may favour the generation of compressive stresses by enhancing plastic deformation over thermal effects. in addition to the generation of large thicknesses of white layer (see Fig.2). Moreover, [Jiang et al., 2023] demonstrated that increasing the feed rate raises shear forces while promoting a transition from tensile to compressive residual stresses. However, this behaviour can vary depending on the material, tool geometry, and cutting conditions. Similarly, [Dahlman et al., 2004] reported that higher feed rates induce compressive stresses both at the surface and in the subsurface of high-carbon, high-chromium steel (AISI 52100) during turning operations. These findings reinforce the notion that both an increase in cutting-edge radius and feed rate can contribute to the development of compressive residual stresses in the broaching of Inconel 718.

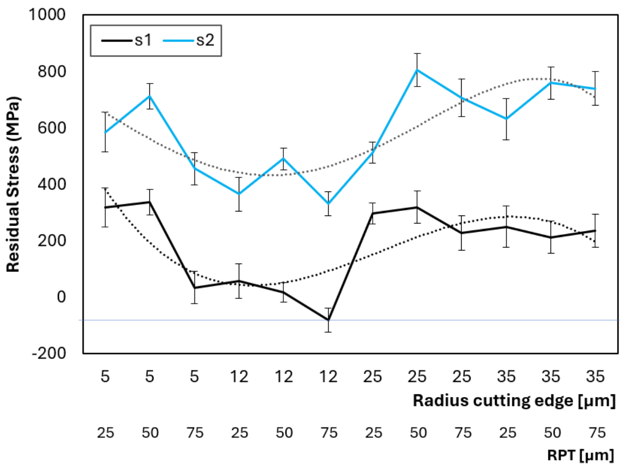

Fig. 4: Residual stresses induced by different cutting-edge radius and RPTs

On the other hand, the subsurface behaviour of the residual stresses is presented in Figure 5. It is observed that, in general, the subsurface stresses tend to be compressive. These compressive stresses are located below 0.2 mm depth in most cases, except for the 5 µm shear radius, where the zone of compressive stresses extends to about 0.3 mm depth. Compression is more pronounced in the shear direction (σ_1), which agrees with that reported by [Ulutan and Ozel, 2011], who argue that high shear forces intensify subsurface plastic deformation, thus promoting compressive stresses. [Jawahir et al., 2011] complement this view by pointing out that in difficult-to-machine materials, low shear angles increase the shear plane area, increasing shear forces and extending the depth of compressive stresses (up to 150-200 µm in Ti-6Al-4V alloys). In the present study, although the depths measured in Inconel 718 are similar, further investigations are required to confirm this more precisely. However, the present results do show that, under the conditions analysed, single-cutting-edge broaching tends to induce subsurface compressive residual stresses.

These findings underline the importance of broaching tool design, particularly the microgeometry of the cutting edge. As stated by [Jawahir et al., 2011], optimisation of cutting-edge radius and RPT would allow to control the cutting forces and thus to adapt the induced residual stresses to improve fatigue resistance and extend the lifetime of the manufactured parts.

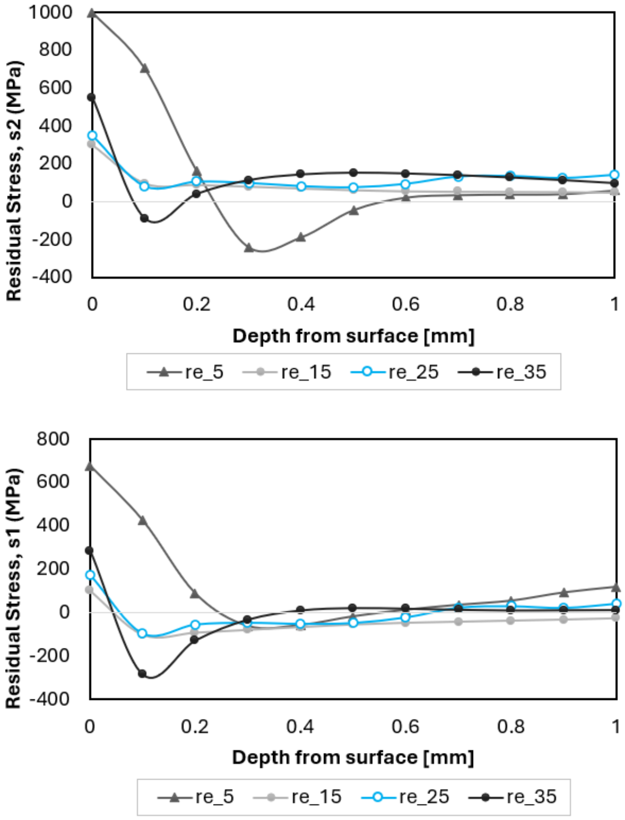

Fig. 5: Subsurface residual stress for 5, 15, 25 and 35 µm cutting-edge radius.

3.2 Surface hardness and sub-surface hardness

In heat-resistant materials, hardness can either increase due to strain hardening or decrease if excessive overheating occurs during machining. Significant variations in subsurface hardness may indicate changes in residual stresses, potentially affecting the mechanical strength and service life of the component.

Fig. 6 presents the surface and subsurface microhardness profiles measured after the passage of the broaching tool. Subsurface microhardness was consistently evaluated at a depth of 10 µm. Overall, no significant differences were observed with changes in cutting-edge radius or RPT (ratio of penetration thickness). However, a noticeable increase in surface microhardness was recorded for all broaching conditions compared to the initial hardness of the material prior to machining (500 HV).

Regarding the subsurface, the microhardness decreased at a depth of 10 µm but progressively recovered toward the base material hardness beyond 30 µm depth. An exception to this trend was found for the condition with a 15 µm cutting-edge radius and an RPT of 25, where an intermittent microhardness profile persisted up to 60 µm deep, as illustrated in Fig. 7.

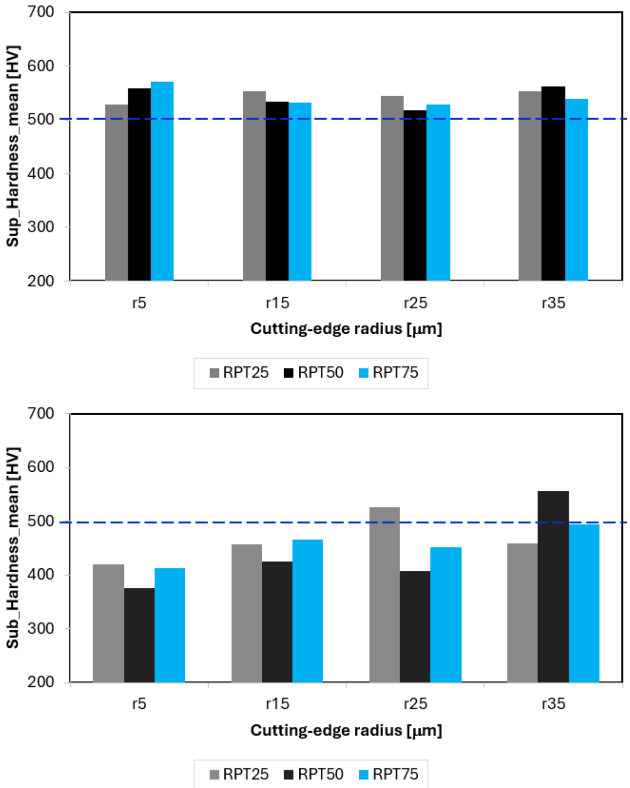

Fig. 6: Surface and sub-surface hardness achieved in dry broaching of Inconel 718 at different cutting-edge radii and RPT

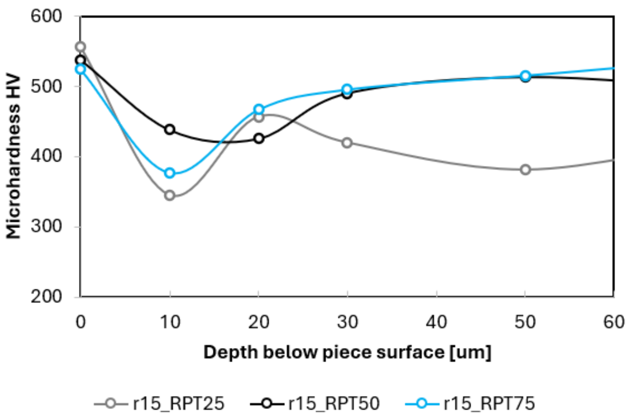

Fig. 7: The subsurface hardness achieved by dry broaching Inconel 718 with a 15 µm cutting edge radius at different RPTs and depths.

Changes in surface and subsurface hardness can serve as indicators of modifications in the residual stresses generated during machining. Residual stresses arise from factors such as thermal input, plastic deformation, and the interaction between the cutting tool and the material. In the study by [Sharman et al., 2006], machining Inconel 718 at cutting speeds of 40, 80, and 120 m/min revealed notable changes in subsurface hardness compared to surface microhardness. When using a new tool at a feed rate (*vf*) of 0.15 mm/rev, a significant reduction in subsurface hardness was observed at depths ranging from 30 to 70 µm. In contrast, at a higher feed rate of 0.25 mm/rev under similar cutting conditions, the maximum hardness reduction extended from 50 to 100 µm. Additionally, the results indicated that higher feed rates led to a broader depth range of hardness reduction compared to lower feed rates.

Similarly to the results presented in Fig. 6 of the present study, Sharman's findings showed that the microhardness profile closely followed the behaviour of residual stresses: high tensile stresses were present near the surface, gradually decreasing with depth, before stabilizing at values typical of the bulk material. This correlation suggests a direct relationship between hardness variation and residual stress distribution in the subsurface layers.

[Chou, 2002] considered that the primary hardening mechanism in the machining of AISI 4340 steel was the rapid heating and cooling cycle. This hardened layer is less than 30 µm thick and shows phase transformation with the presence of 7 vol.% austenite. Instead [Sharman et al., 2006] commented that elevated temperatures near the machined surface of Inconel 718 could cause over-aging, resulting in a reduction in microhardness. Additional studies, such as those by [Arunachalam et al., 2004] and [M'Saoubi; et al., 2008], propose that subsurface softening may result from recrystallization processes, which promote material recovery by reducing dislocation density, thereby leading to lower hardness values.

3.3 The depth of the effect on the material in the subsurface layer.

From images taken in cross-section of the machined surface after cutting. The surfaces were polished and etched to reveal deformations in the microstructure Fig. 8. This also facilitated the location of indentations for Vickers microhardness measurement.

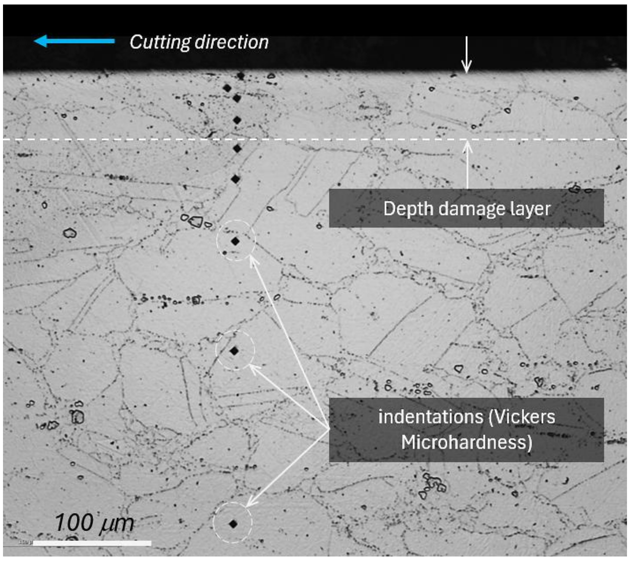

Fig. 8: The depth of damage and indentation were measured using single-line dry broaching of Inconel 718, with cutting conditions of vc = 20 m/min, re = 35 µm, and RPT = 50 µm

Figure 9 illustrates the damage depth induced in the material during dry broaching across all tested cutting conditions. The results clearly show that the cutting-edge radius has a significant influence on the extent of subsurface damage generated during machining. An incremental and direct relationship is observed: as the cutting-edge radius increases, the depth of material damage also increases. In contrast, variations in the RPT (ratio of penetration thickness) do not exhibit a significant or consistent effect on the depth of damage. When transitioning from a 5 µm to a 15 µm cutting-edge radius, the increase in damage depth remains relatively modest. However, a noticeable and progressive increase in damage depth occurs when the radius is further increased to 25 µm and 35 µm.

These results suggest that the cutting-edge radius is a dominant factor in determining subsurface damage during broaching operations. Larger cutting radii promote a greater mechanical interaction with the material, likely enhancing plastic deformation and heat generation at the contact zone, which in turn deepens the affected layer. Therefore, careful optimization of the cutting-edge microgeometry is essential to minimize damage depth and preserve the mechanical integrity of the machined component.

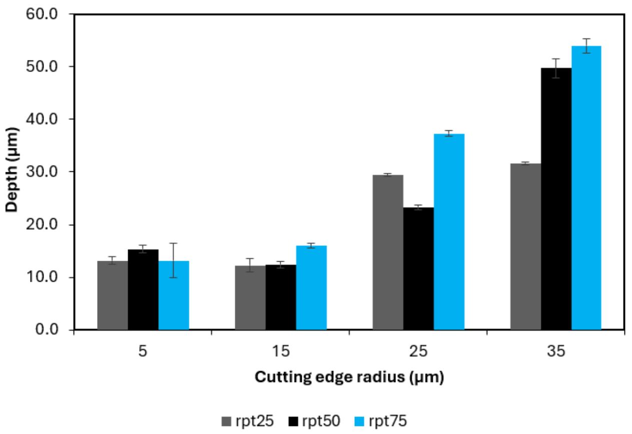

Fig. 9: The depth of damage to the material caused by dry broaching of Inconel 718 under all the tested cutting conditions.

The material damage depth is closely linked to subsurface hardness and shows a direct relationship with the residual stress distribution. Subsurface hardness generally decreases with increasing damage depth, primarily due to partial recrystallization and microstructural changes induced by the combined effects of heat and pressure during machining [Zhang et al., 2025]. As highlighted in the works of [Ren et al., 2022] and [Sharman et al., 2006], the layers closest to the machined surface often exhibit higher hardness values because of deformation-induced work hardening. In contrast, subsurface layers tend to show a reduction in hardness, driven by thermal softening and mechanical relaxation processes occurring during and after cutting.

In parallel, the relationship between the depth of plastic deformation and residual stresses is well-established. According to [Ren et al., 2022], compressive residual stresses typically concentrate in the subsurface regions, while tensile residual stresses are more prevalent at the immediate surface. This stress distribution pattern arises from the competing effects of mechanical deformation, which promotes compressive stresses, and thermal input, which tends to induce tensile stresses at the surface.

Moreover, as the depth of material damage increases, the magnitude of residual stresses tends to diminish. This behaviour is due to the fact that deeper layers are subjected to lower levels of plastic deformation and reduced thermal exposure during machining, as described by [Wöste et al., 2021]. Consequently, the gradient of mechanical and thermal influence weakens with depth, leading to a progressive relaxation of both compressive and tensile residual stresses.

These interrelations underline the importance of controlling both the cutting conditions and the cutting-edge microgeometry to manage subsurface integrity. Minimizing excessive damage depth is essential not only to preserve surface and subsurface mechanical properties, but also to optimize the component's fatigue performance and service life.

4 CONCLUTIONS

This study investigates the effect of cutting-edge radius and RPT variation on surface integrity during the dry broaching of Inconel 718 at a cutting speed of 20 m/min. The following conclusions are drawn from the results obtained:

- Increasing the radius of the cutting edge significantly increases the depth of damage in single-cutting-edge broaching of Inconel 718.
- Broaching induces surface hardening through plastic deformation, followed by a reduction in microhardness in the subsurface layers due to thermal effects.
- This generates a residual stress profile characterised by surface tension and subsurface compression, decreasing in magnitude with depth.
- Controlling the cutting-edge radius and RPT is essential for minimising subsurface damage and promoting compressive stress states that enhance component durability.

5 ACKNOWLEDGMENTS

This work was supported by the Department of Economic Development and Competitiveness of the Basque Government through the ELKARTEK 2024 project, ORLEGI (KK-2024/00005), and HAZITEK 2023 project, HATASU (ZL-2023/00594). This paper in aspects of data analysis in the fog is part of the research project PLEC2024-011247 funded by MICIU/AEI /10.13039/501100011033 and by FEDER, EU.

Special thanks to the Universidad Técnica de Ambato for their collaboration and research support financed by resolution 0371-CU-P-2021

6 REFERENCES

[Arunachalam 2000] Arunachalam, R. and Mannan, M.A. Machinability of Nickel-based high temperature alloys. Machining Science and Technology, 2000, Vol.4, No.1, pp 127–168.

[Arunachalam 2004] Arunachalam, R.M., Mannan, M.A. and Spowage, A.C. Residual stress and surface roughness when facing age hardened Inconel 718 with CBN and ceramic cutting tools. International Journal of Machine Tools and Manufacture, 2004, Vol.44, No.9, pp 879–887.

[Chamanfar 2017] Chamanfar, A., et al. Microstructure and mechanical properties of surface and subsurface layers in broached and shot-peened Inconel-718 gas turbine disc fir-trees. Materials Characterization, 2017, Vol.132, pp 53–68.

[Chou 2002] Chou, Y.K. Surface hardening of AISI 4340 steel by machining: a preliminary investigation. Journal of Materials Processing Technology, 2002, Vol.124, pp 171–177.

[Dahlman 2004] Dahlman, P., Gunnberg, F. and Jacobson, M. The influence of rake angle, cutting feed and cutting depth on residual stresses in hard turning. Journal of Materials Processing Technology, 2004, Vol.147, pp 181–184.

[Denkena 2010] Denkena, B., de León, L., Bassett, E. and Rehe, M. Cutting Edge Preparation by Means of Abrasive Brushing. Key Engineering Materials, 2010, Vol.438, pp 1–7.

[Denkena 2015] Denkena, B., Grove, T. and Maiss, O. Influence of the cutting-edge radius on surface integrity in hard turning of roller bearing inner rings. Production Engineering, 2015, Vol.9, pp 299–305.

[Ezugwu 2003] Ezugwu, E.O., Bonney, J. and Yamane, Y. An overview of the machinability of aeroengine alloys. Journal of Materials Processing Technology, 2003, Vol.134, pp 233–253.

[Jawahir 2011] Jawahir, I.S., et al. Surface integrity in material removal processes: Recent advances. CIRP Annals, 2011, Vol.60, pp 603–626.

[Jiang 2023] Jiang, X., et al. Residual compressive stress prediction determined by cutting-edge radius and feed rate during milling of thin-walled parts. The International Journal of Advanced Manufacturing Technology, 2023, Vol.124, pp 773–788.

[Klocke 2013] Klocke, F., Vogtel, P., Gierlings, S., Lung, D. and Veselovac, D. Broaching of Inconel 718 with cemented carbide. Production Engineering, 2013, Vol.7, pp 593–600.

[Korsunsky 2004] Korsunsky, A.M. and James, K.E. Residual Stresses Around Welds in Nickel-based Superalloys. Journal of Neutron Research, 2004, Vol.12, pp 153–158.

[M'Saoubi 2008] M'Saoubi, R., et al. A review of surface integrity in machining and its impact on functional performance and life of machined products. International Journal of Sustainable Manufacturing, 2008, Vol.1, pp 203–236.

[Noyan 1987] Noyan, I.C. and Cohen, J.B. Residual Stress. New York, NY: Springer, 1987.

[Peng 2013] Peng, R., et al. Surface Integrity and the Influence of Tool Wear in High-Speed Machining of Inconel 718. (Falta información de revista/libro/proceedings).

[Pérez-Salinas 2025] Pérez-Salinas, C., et al. Preparation of the cutting edge on broaching tools by brushing-polishing with ceramic brushes: Analysis and prediction of effects. Proceedings of the Institution of Mechanical Engineers, Part C: Journal of Mechanical Engineering Science, 2025, ISSN 09544062.

[Ren 2022] Ren, Z., Li, B. and Zhou, Q. Subsurface residual stress and damaged layer in high-speed grinding considering thermo-mechanical coupling influence. The International Journal of Advanced Manufacturing Technology, 2022, Vol.122, pp 835–847.

[Sadat 1992] Sadat, A.B. and Reddy, M.Y. Surface integrity of inconel-718 nickel-base superalloy using controlled and natural contact length tools. Part I: Lubricated. Experimental Mechanics, 1992, Vol.32, pp 282–288.

[Sadat 1993] Sadat, A.B. and Reddy, M.Y. Surface integrity of inconel-718 nickel-base superalloy using controlled and natural contact length tools. Part II: Unlubricated. Experimental Mechanics, 1993, Vol.33, pp 343–348.

[Schajer 2006] Schajer, G.S. Hole-drilling residual stress calculation program Version 3.01, Vishay, User guide, 2006.

[Schulze 2014] Schulze, V. Broaching. In: CIRP Encyclopedia of Production Engineering. Berlin, Heidelberg: Springer, 2014, pp 109–118.

[Sharman 2006] Sharman, A.R.C., Hughes, J.I. and Ridgway, K. An analysis of the residual stresses generated in Inconel 718™ when turning. Journal of Materials Processing Technology, 2006, Vol.173, pp 359–367.

[Sridhar 2011] Sridhar, B.R., Ramachandra, S. and Chandrasekar, U. Residual stress in nickel base super alloy Udimet 720 for different surface conditions. International Journal of Engineering Science and Technology, 2011, Vol.3, pp 36–43.

[Tan 2021] Tan, L., et al. Effects of tool wear on machined surface integrity during milling of Inconel 718. The International Journal of Advanced Manufacturing Technology, 2021, Vol.116, pp 2497–2509.

[Telesman 2021] Telesman, J., Gabb, T.P., Kantzos, P.T. and Ghosn, L.J. Effect of broaching machining parameters, residual stresses and cold work on fatigue life of Ni-based turbine disk P/M alloy at 650 °C. International Journal of Fatigue, 2021, Vol.150, pp 106328.

[Ulutan 2011] Ulutan, D. and Özel, T. Machining induced surface integrity in titanium and nickel alloys: A review. International Journal of Machine Tools and Manufacture, 2011, Vol.51, pp 250–280.

[Wöste 2021] Wöste, F., et al. Investigation of the effect of residual stresses in the subsurface on process forces for consecutive orthogonal cuts. Production Engineering, 2021, Vol.15, pp 873–883.

[Yang 2019] Yang, D., Xiao, X. and Liang, X. Analytical modeling of residual stress in orthogonal cutting considering tool edge radius effect. The International Journal of Advanced Manufacturing Technology, 2019, Vol.103, pp 2965–2976.

[Zhang 2025] Zhang, G., Xiao, H. and Yang, S. Measurement and Control of Subsurface Damages. 2025, pp 1–21.