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BUILT UP LAYER FORMATION IN THE SUPER DUPLEX STAINLESS STEEL TURNING

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Abstract. Industries from oil and gas segment, which operate in exploration in offshore and deepwater, find in the super duplex stainless steel, a material that present high performance in highly corrosive environments, enabling its use in equipments subjected to critical operating conditions, such as, high pressures, high temperatures and in contact with harsh chemicals. The combination of alloying various elements in these steels provides high corrosion resistance, high strain-hardening coefficient and low thermal conductivity, which reduces machinability and causes the formation of built up layer (BUL) on the tools used to cut these steels. The goal of this work is to develop the best combination of different cutting speeds with other cutting data already defined, such as tool geometry, cutting feed using high pressure coolant jet (70 bar), aiming long tool life with reduction in the formation of built up edge, allied to the lowest surface roughness values possible, in the longitudinal turning of super duplex stainless steel.

Keywords: Super Duplex Stainless Steel, Built-up layer

1. INTRODUCTION

The growing demand from the oil exploration industry for materials that have excellent performance in corrosive environments requires from the market new solutions. In cases of equipments subjected to critical operating conditions it is necessary to use alloys that have high mechanical associated with high corrosion resistance.

In addition, the companies that manufacture equipment for this segment also seek to improve their processes, due to the requirements of the new oil fields that operate in the seabed with 3,000 meters of depth or more and with pressures up to 700 bar.

One of the modern materials for these purposes is the super duplex stainless steel (SDSS). This steel grade allows the equipment to be lighter, with greater mechanical resistance and with a longer life, favored by its excellent resistance to pitting corrosion. It presents high mechanical strength, high ductility, high hardening rate and low thermal conductivity, making it difficult to remove heat from cutting region, causing most of the heat generated in the machining to be absorbed by the tool. All these properties make the machinability of these alloys relatively lower when compared to conventional stainless steels (Paro, *et al.*, 2001).

These properties also encourage diverse mechanisms of tool wear such as diffusion, abrasion, adhesion/"attrition" and mainly a phenomenon known as BUL, leading to shorter tool life compared to the machining of ordinary stainless steels (Korkut, *et al.*, 2004).

2. EXPERIMENTAL PROCEDURE

The experiments were performed on CNC lathe. The materials used in the trials were rolled SDSS bars (UNS S32750) with diameter of 120mm and cutting length of 90mm.

Interchangeable carbide inserts with ISO geometry CNMG 120408 MM – M15 were used in the experiments, using tool holder PCLNR 2525 M12HP with high pressure cooling (70 bar) (Sandvik Coromant, 2015). It was used an aqueous fluid with miscible vegetable-based oil, with concentration of 8 to 10%.

The cutting speeds used in the trials were: $v_c=120/150/200/240\text{m/min}$.

The feed and the depth of cut used were $f=0.1\text{mm/rot}$ and $a_p=0.5\text{mm}$.

3. RESULTS AND DISCUSSION

Analyzing the results, it can be concluded:

a) $v_c=120\text{m/min}$: Experiment that presented the shortest life in machined volume ($147,4\text{cm}^3$), as well as the lowest chip removal rate ($5,99\text{cm}^3/\text{min}$) and short machining time ($24,6\text{min}$), that is, it was the trial that presented the lowest productivity among all tests performed. The BUL formation was quite intense and as the literature predicts, stimulated the growth and instability of the roughness (starting: $1,18 / 1,22 \mu\text{m}$ / ending: $0,82 / 0,68 \mu\text{m}$), also causing inadequate chip formation.

b) $v_c=150\text{m/min}$: Experiment that in terms of life in machined volume ($237,9\text{cm}^3$), machining cut time ($31,7\text{min}$) and chip removal rate ($7,50\text{cm}^3/\text{min}$), it was close to the best result obtained in these experiments. The BUL formation was intense but lower than with $v_c=120 \text{ m/min}$, which harmed the chip formation during machining (chip morphology: long ribbons tangled) with high but stable roughness (starting: $0,91\mu\text{m}$ / ending: $0,93\mu\text{m}$).

c) $v_c=200\text{m/min}$: Experiment that presented the longest life in machined volume ($259,9\text{cm}^3$) with high chip removal rate ($10,03\text{cm}^3/\text{min}$) and short machining time ($25,9\text{min}$). In other words, the experiment with the highest productivity and with the best chip control performance. This was the trial with the lowest BUL formation and with slow growth of wear over the tool life followed by strong chipping, which caused a sudden increase in the wear. The surface roughness (Ra) obtained were low and stable during tool life (starting: $0,77\mu\text{m}$ / ending: $0,69\mu\text{m}$).

d) $v_c=240\text{m/min}$: Experiment that was the second to present lower life in machined volume ($165,6\text{cm}^3$), and a short machining time ($13,8\text{min}$) with the highest chip removal rate ($12,0\text{cm}^3/\text{min}$), with the highest productivity among all the trials, but with rapid deterioration of the edge resulting in total impairment of the tool edge, in addition to the poor chip formation. The BUL formation was small but the wear growth was quite fast due to the high thermal and mechanical loads generated in this test and presented severe chipping. The roughness were high and unstable (starting: $1,11\mu\text{m}$ / ending: $0,85\mu\text{m}$).

4. CONCLUSIONS

It can be concluded that in turning operation of SDSS it is fundamental to control the formation of built up layer, because it determines the tool life, at least until $v_c=200\text{m/min}$. So, when the cutting speed has been increased from 120 to 200m/min, tool life increased, because BUL formation decreased. With $v_c=240\text{m/min}$, BUL was not longer predominant and tool life was short due to other wear phenomena.

5. ACKNOWLEDGEMENTS

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7. RESPONSIBILITY NOTICE

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