EVALUATION OF FINISHING MACHINING OF STAINLESS STEEL 1.4307

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Abstract

Modern applications of pneumatic and hydraulic systems in extreme subsea production increased emphasis on long life and minimum maintenance cycles. For this reason, are constantly developed new sealing elements. These sealing elements require very low surface roughness at the contact surfaces. High geometrical and dimensional accuracy is not required because the inaccuracies are compensated by sealing elements. The aim of this paper is to propose a production technology that can achieve the surface roughness Ra = (0.1 ÷ 0,4) μm and geometric accuracy H11. Machined material is chrome-nickel austenitic stabilized steel F304L according to EN 10088-3 marked 1.4307. This article includes applications of ball diamond finishing machining to turning surface. Appropriate technological conditions have been established. These conditions correspond to the specified surface roughness criterion.

Keywords: Roughness, surface finish, machining, stainless steel

1. INTRODUCTION

Very low surface roughness of the machined surface is common in industry. Grinding technology is most often used for these requirements. By grinding we can achieve low surface roughness, high dimensional and geometric accuracy. The disadvantage of this technology is high operating costs, non-ecological operation and we need special machines and tools. [1,2,3]

New technologies are available to achieve the desired surface roughness. These technologies allow use on conventional machines. The machined/turned surface has a typical structure caused by tool geometry and feed. High quality machined surface has a smooth profile and the surface roughness is constant. Feature this new technology use surface-forming technology at turning machine by flexible diamond ball. The principle and scheme shown in **Figure 1** and **Figure 2**. [1,3,4,5,6]

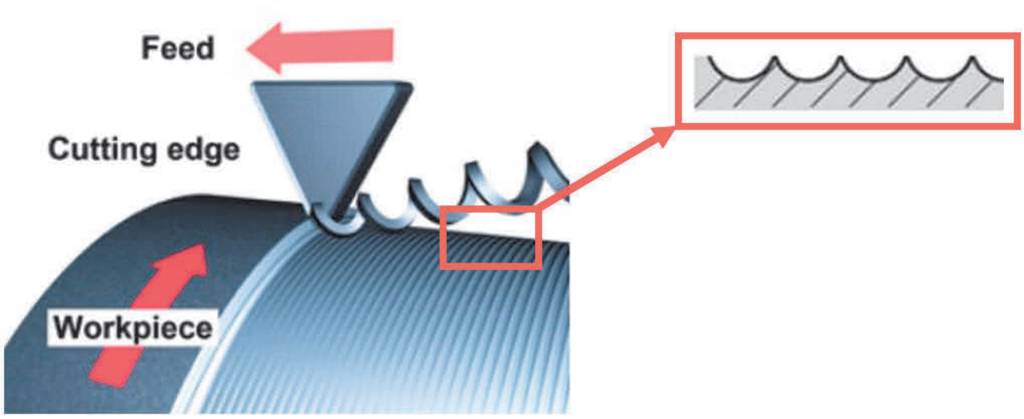


Figure 1 Turning surface definition (right - general definition, left - detail of machined surface) [4,5]

During forming, pressure is created at the point of contact of the diamond tip and the workpiece. This cause very high load in the interface. There is plastic deformation that leveling of the surface profile. The volume of material in the raised areas of the profile projections is pressed into the depression. This significantly reduces surface roughness. The resulting accuracy depends on previous manufacturing technology and surface roughness after machining. [2,4,5,6,7]

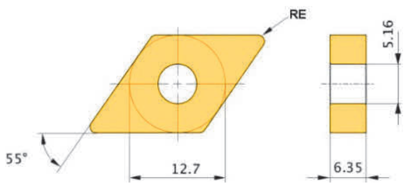
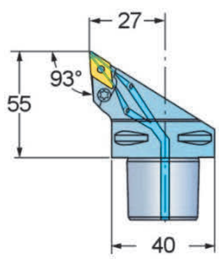
Figure 2 Finishing tool in the machining process [8]

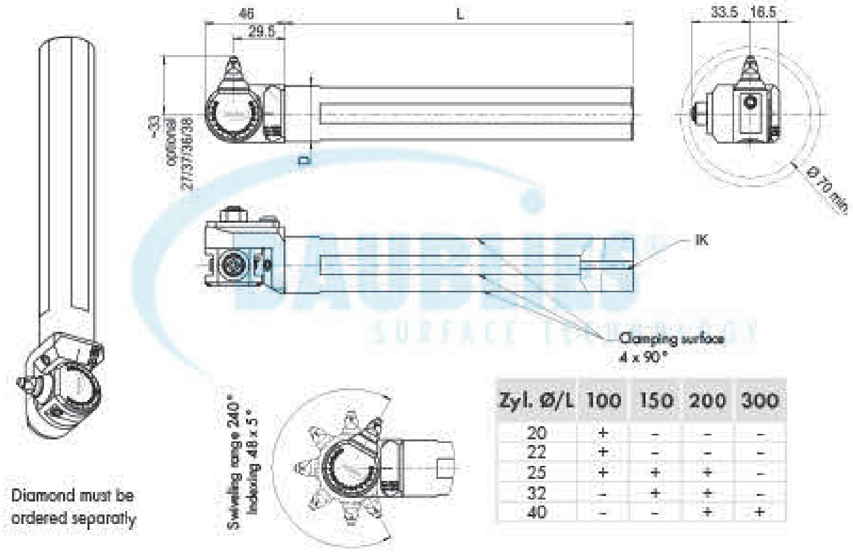
The research presented in this article focuses on the study of finishing machining - ball diamond finishing. We follow the right choice of technological conditions. Then we will evaluate the final surface roughness. Finally, we will make a qualified estimate of the next process behavior.

2. EXPERIMENT DESCRIPTION

The experiment was designed for a DMG MORI NLX2500MC / 700 machine. Detailed information about the machine is given in **Table 1**. The machined material is chromium-nickel austenitic steel F304L marked 1.4307 according to EN 10088-3. The detailed proposed experimental conditions are shown in **Table 2**.

Table 1 Experiment conditions - machine, machining tools, finishing tools [5,6,7,8]

Machine	DMG MORI NLX2500MC/700	
Control system	Mitsubishi M730BM	
Material of workpiece	F 304L (EN 10088-3: 1.4307); Ø100/Ø80 - 300	
Clamping	Three-jaw chuck Kitagawa 10”	
TURNING Tool holder / inserts	Producer: Mitsubishi Materials DNMG1506-08 (RE = 0,8 mm)	
	Producer: Sandvik C4-PDJNR-27055-15HP 	

<table>
<tr><td rowspan="2">FINISHING
Tool</td><td>Variable diamond burnishing tool for internal use - Baublies AG
Ø 25 / L150
</td><td>Application parameters:
Speed up to 150 m/min
Feed rate 0.05 - 0.2 mm/rev
Spring compression up to 1 mm</td></tr>
<tr><td colspan="2">
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The experiment was divided into two parts. First, turning was performed using the C4-PDJNR-27055-15HP and the DNMG1506-08 insert. Technological conditions were determined according to the manufacturer's recommendations. The aim was to achieve a different surface roughness at each experiment.

The second part was finishing the surface with the Baublies AG forming tool. Technical data are in **Table 2**. Technological conditions were gradually adjusted during finishing. The aim was to achieve the lowest roughness after finishing.

Table 2 Technological conditions of the experiment [2,3,6,7,8,9,10,11]

Exp. no.	Technology	Cutting speed	Feed per revolution	Axial cutting depth / Spring compression
		v_c	fn	a_p
		[m·min^{-1}]	[mm]	[mm]
1	Turning	100	0.10	0.5
	Finishing	100	0.05	0.15
2	Turning	120	0.10	0.5
	Finishing	140	0.05	0.3
3	Turning	120	0.10	0.5
	Finishing	120	0.05	0.15
4	Turning	120	0.08	0.5
	Finishing	120	0.05	0.2
5	Turning	120	0.20	0.5
	Finishing	120	0.05	0.2

Exp. no.	Technology	Cutting speed	Feed per revolution	Axial cutting depth / Spring compression
		v_c	fn	a_p
		[m·min^{-1}]	[mm]	[mm]
6	Turning	145	0.10	0.5
	Finishing	120	0.05	0.2
7	Turning	120	0.08	0.5
	Finishing	120	0.05	0.2
8	Turning	145	0.11	0.6
	Finishing	120	0.05	0.2
9	Turning	140	0.10	0.5
	Finishing	150	0.04	0.1

3. RESULTS AND DISCUSSION

The experiments, are based on our experience and other articles on the subject. The data below is a brief summary of the complete measurement range. Includes a full range of results. Similar results were achieved when the experiments were repeated. For this reason, we consider them realistic.

The surface roughness Ra was measured during experiments. The surface roughness of each surface was measured five times and the results were averaged. The surfaces were measured with machine HOMMEL ETAMIC W5. The measurement parameters are shown in **Table 3**.

Table 3 Roughness measurement parameters by machine HOMEL [10,11]

Device name	Wavelength limit lc [mm]	Base length lt [mm]	Feed speed vt [mm·s^{-1}]	Alignment L [mm]
HOMEL ETAMIC W5	0.8	4.8	0.5	175

Surface roughness was measured before and after finishing. All measured data are shown in **Table 4**.

Table 4 Surface roughness measurement results and accuracy

Exp. no.	Roughness Ra [µm]		Geometric accuracy	
	Turning	Finishing	Turning	Finishing
1	0.40	0.40	H11	H11
2	0.70	0.50	H11	H11
3	0.60	0.40	H11	H11
4	0.60	0.27	H11	H11
5	1.80	0.40	H11	H11
6	0.36	0.34	H11	H11
7	0.50	0.62	H11	H11
8	0.59	0.62	H11	H11
9	0.56	0.47	H11	H11

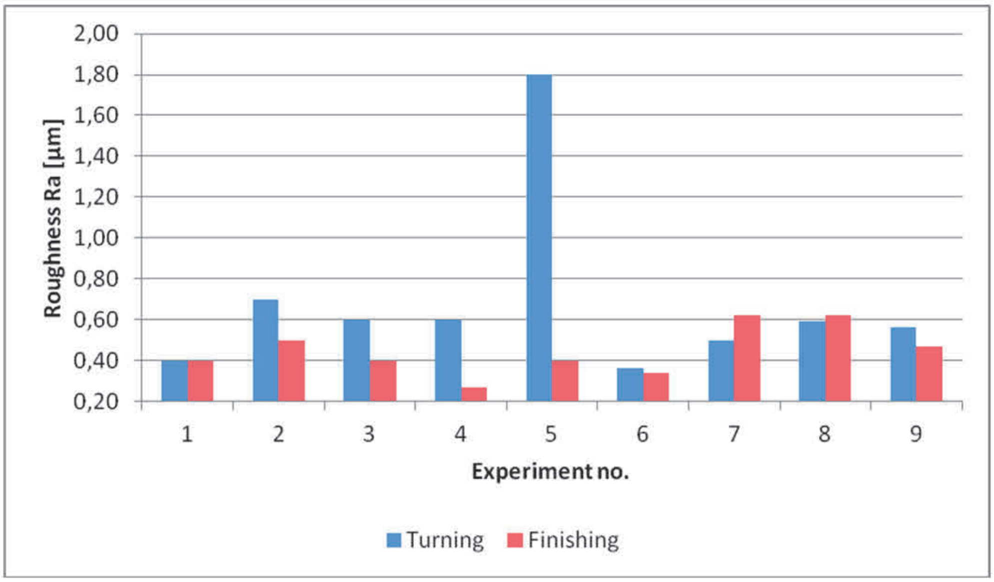

Figure 3 Surface roughness comparison before and after finishing

4. CONCLUSION

Surface roughness criteria Ra = (0.1 ÷ 0.4) µm and accuracy in class H11 were specified for the experiment. First, turning was performed using by the DNMG1506-08 tool. This turning was performed in H11 accuracy. Each experiment was designed to always achieve a different surface roughness after turning for each experiment. After turning, the surface was finished with a diamond ball finishing tool. The tool was manufacturer is Baublies AG. In all experiments, the diameter of the finished surface was reduced by (0.015 ÷ 0.02) mm. This reduction is very small. For this reason, an accuracy class of H11 was achieved for all experiments after turning a finishing. This confirmed that the accuracy is transferred with very little departure between the turning and finishing technology. The deviation is caused by plastic deformation of the machining material. The required accuracy and roughness was achieved in experiments number 1, 3, 4, 5, 6. The comparison of experiments is shown in **Table 3**.

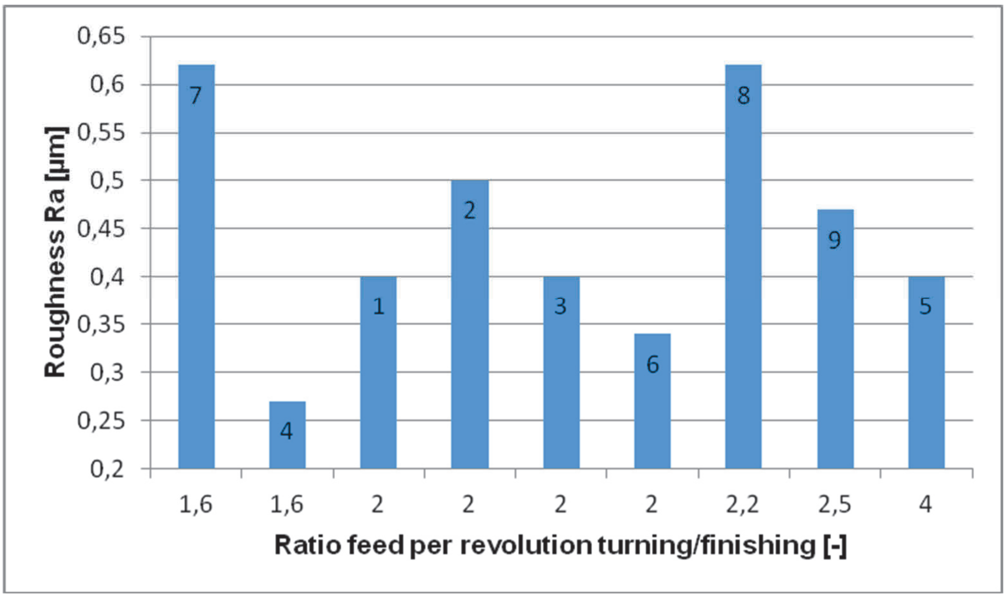

Figure 4 Roughness Ra after completion - feed rate comparison

Another part of the experiment was to compare the surface roughness before and after finishing. **Figure 1** shows that the finishing process is not consistent and is not dependent on surface roughness in turning. Nine experiments were carried out and only six had a surface roughness reduction.

According to the theoretical assumption finished surface roughness was determined at tool feed during finishing and turning. According to previous experiments, we know that finishing feed must be lower several times than the turning feed. In the experiments, the rate of turning feed / finishing feed was 1,6 ÷ 4. **Figure 4** and **Table 5** shows that it is not possible to predict surface roughness versus feed ratio.

Table 5 Finishing operations comparison, ratio feed per revolution turning/finishing

Exp. no.	Technology	Cutting speed	Feed per revolution	Axial cutting depth	Roughness	Ratio feed per revolution turning/finishing
		v_c	fn	a_p	Ra	
		[m·min^{-1}]	[mm]	[mm]	[μm]	[-]
7	Finishing	120	0.05	0.2	0.62	1.6
4	Finishing	120	0.05	0.2	0.27	1.6
1	Finishing	100	0.05	0.15	0.40	2
2	Finishing	140	0.05	0.3	0.50	2
3	Finishing	120	0.05	0.15	0.40	2
6	Finishing	120	0.05	0.2	0.34	2
8	Finishing	120	0.05	0.2	0.62	2.2
9	Finishing	150	0.04	0.1	0.47	2.5
5	Finishing	120	0.05	0,2	0.40	4

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