INDIRECT METHODS OF AUSTENITIC STAINLESS STEELS WORKABILITY EVALUATION

[1]**Prof. Phd. Eng. Daniela Florentina TĂRÂŢĂ,** University of Craiova, Faculty of Mechanics, Department of Vehicles, Transports and Industrial Engineering, Calea Bucuresti Street, no. 107, Craiova,Code 200512, Romania, danielatarata@yahoo.com

Abstract. *The paper presents the results of a complex study of the workability behaviour in cutting of certain austenitic steels , with little nickel , also allied with manganese. The paper shows the correlation between physical properties of these steels and workability behaviour. The experimental researches on thermal characteristics influence on Mn-alloyed austenitic inoxidable steels workability confirm the correlation between thermal conductibility properties, thermal absorption and dispersion properties and chipping process parameters (cutting speed, feeding), that determine a certain cutting tool wearing and a manufactured surface roughness.*

Keywords: austenitic steels, workability, thermal conductibility, cutting, roughness

1. INTRODUCTION

The workability is an important properties of austenitic stainless steels , a complex function of more variables [1], which partially characterizes the process of cutting. Austenitic inoxidable steels are characterized through some specific particularities that separate them from the rest of steels, as respects to cutting workability [1], [2], [4]. In the case of steels in which the nickel was replaced with manganese, there has to be taken into account the physical properties of these elements [3], respectively the different value and the expansion coefficient of thermal conductibility, that determine a lower workability for manganese-alloyed steels.

2. EXPERIMENTAL WORKS

2.1 The analytical determination of studied steels thermal conductibility

The thermal conductibility is different depending on steels structure and chemical composition [2], as shown in fig. 1. In table 1 or fig. 2 there are presented the thermal conductibility (λ) values , at 20˚C , for some steels categories

Table 1 Thermal conductibility values

		λ [W/m˚C]
A	Ordinary carbon steels	58
B	Martensitic inoxidable steels	27
C	Ferrite inoxidable steels	25
D	Austenitic inoxidable steels	14

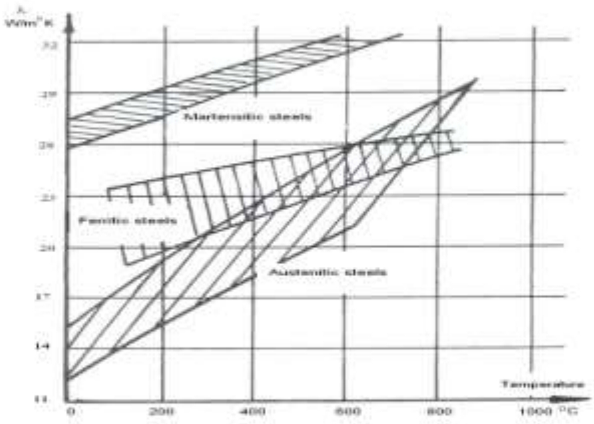

Fig. 1. Experimental apparatus used for recordings

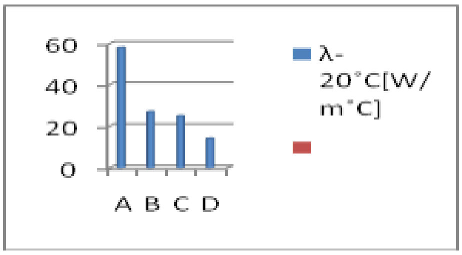

Fig. 2. Thermal conductibility values

It is observed that austenitic inoxidable steels have a thermal conductibility of almost 3-4 times smaller than unalloyed ordinary carbon steels, and of 1,5-2 times smaller than martensitic and ferrite inoxidable steels. The low value of thermal conductibility determine material and tool heat concentration during manufacturing. In this way, a very slow chip expulsion is produced and much higher temperatures are recorded than the ones produced at ordinary carbon steels chipping. On the other side, austenitic inoxidable steels also have a higher thermal expansion coefficient. Under these properties combined action and their growth along with temperature, at austenitic inoxidable steels chipping, there are recorded dimensional unsteadiness effects, friction forces between tool and material with effects of adhesive wearing and material coatings on tool. Austenitic inoxidable steels thermal conductibility can be also calculated on E. I. Kazantev relation [3]:

$$\lambda = 15{,}5 - a + (1{,}28 + b) \times 10^{-2} \times t\ [W/m \circ C] \qquad (1.1)$$

$$a = 11{,}6(\sigma - 0{,}5)\ ;\ \ b = 1{,}34 \times (\sigma - 0{,}5)\ , \quad (1.2), (1.3)$$

$$\sigma = \frac{C}{12} + \frac{Si}{28} + \frac{Mn}{55} + \frac{Cr}{52} + \frac{Ni}{59} + \frac{W}{84} + \frac{Nb}{93} + \frac{Mo}{96} + \frac{V}{51}\ , \qquad (1.4)$$

where: σ is the ratios sum between chemical elements concentration and their atomic masses. The studied austenitic inoxidable steels groups chemical composition is presented in table 2. The thermal conductibility computed at 20°C and 100°C, for studied austenitic inoxidable and CrNi-standard steels, 304L brand (X2CrNi18-10) and 301(CrNi18-8), is given in table 3 and figure 3.

Table 2 Chemical composition values

Steel group	Chemical composition %									
	C	Mn	Cr	Si	Ni	N	V	Nb	S	P
II-AMnNi	0,08	11,45	16,3	0,6	4,3	0,28	-	-	0,009	0,019
III-AMnNiV	0,10	12,52	20,46	0,9	4,3	0,33	0,3	-	0,009	0,019
V-AMnNiNbV	0,08	12,38	20,68	1	3,8	0,28	0,28	0,9	0,01	0,026

Table 3 Thermal conductibility

Steel group	σ	a	b	Thermal conductibility W/m˚C	
				20°C	100°C
AMnNi S7	0,62	1,39	0,16	14,39	15,55
AMnNiV	0,74	2,78	0,32	13,03	14,31
AMnNiNbV	0,74	2,83	0,32	12,99	14,27
304L	0,67	1,97	0,22	13,83	15,03
301	0,57	0,85	0,099	14,92	16,02

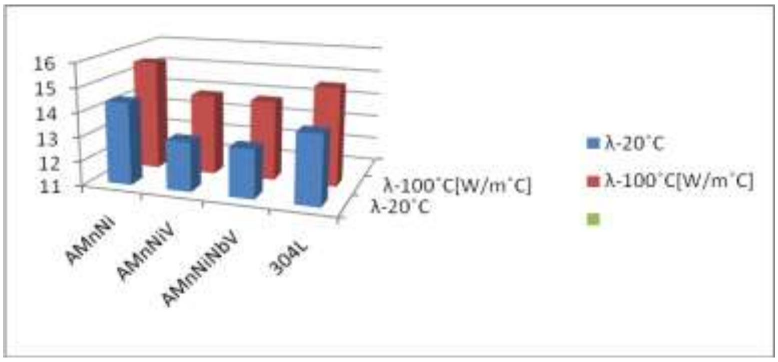

Fig. 3. Thermal conductibility of austenitic inoxidable steels

2.2 Experimental work on the surface roughness

The quality of the surfaces roughness was studies in cutting for three steels , as follows : austenitic stainless steel allied with 11,45% manganese AMnNi , and etalons steels, the 301 steels on AISI (CrNi18-8) and 304L steels (CrNi 20-12).The cutting tools were knives with interchangeable metallic carbides plates of the TPGN 22.04.12 , STAS 9130/1-80, in group P10[4], and used the data acquisition system, fig. 4.

The machineability function on the roughness Ra has been determined based on experimental program with 15 tests[2], where for each variable the levels -2,-1,0,+1,+2 were considered. The functions which resulted through the multiple exponential regression were represented in the domains : v=0-200m/min; f=0-0,5mm/rot;a_p= 0-3mm, having fixed in each case one of the parameters (v=92,63m/min; f=0,292mm/rot; a_p =1,5mm).

Fig. 4. Data acquisition system

The parameters of the machineability - roughness function Ra were determined by multiple exponential regression:

$$Ra = Ct \times x_1^a \times x_2^b \times x_3^c \quad (2) \qquad x_1 = \frac{59 \times n}{1000}\ ;\ x_2 = f\ ;\ x_3 = a_p \qquad (3)$$

Table 4 The machineability - roughness Ra function coefficients

Ra	Ct	a	b	c	s_d	s_{dp}%
AMnNi	14,0610	0,0995	1,3789	-0,2205	0,8130	9,25
301	9,6593	0,1550	1,8134	0,3352	0,6533	6,69
304L	6,5823	0,0985	1,0232	0,3507	0,6755	12,64

Keeping constant one of the independent variable (speed v, advance f, cutting depth a_p) , the roughness evolution for austenitic stainless steel allied with manganese , AMnNi , show that the advance has a more important influence than the cutting speed, fig.5. The maximum values of Ra correspond to the cutting regime where the cutting tool wear was maximum.It notice also for 304L austenitic steel , an increase of Ra with advance, fig. 6.

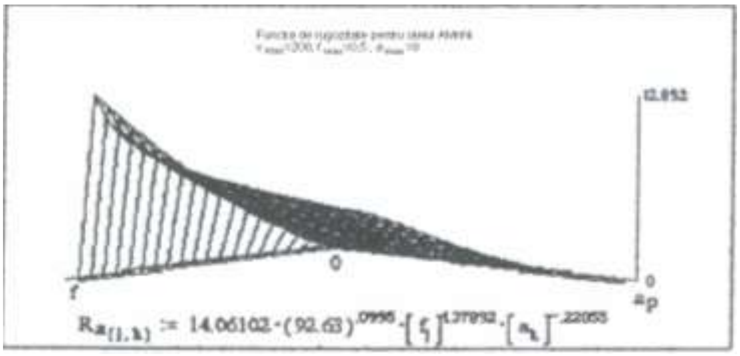

Fig. 5. Roughness Ra(f, a_p) evolution for the austenitic stainless steel AmnNi

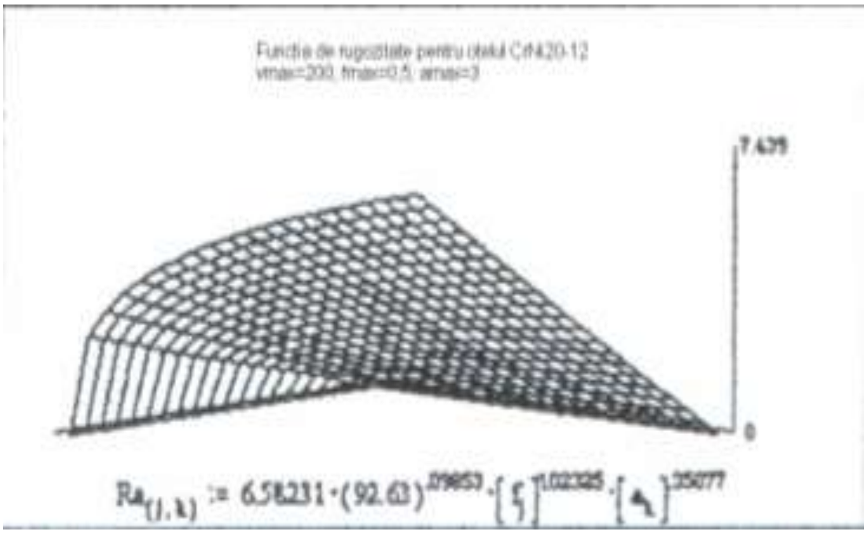

Fig. 6. Roughness Ra(f, a_p) evolution for the 304L austenitic steel

3. CONCLUSIONS

After these researches, the next conclusions are found:

- The obtained results demonstrate the thermal conductibility influence on manufacturing, being close-correlated with chemical composition, structure and grain, mechanical properties, and with these steels cutting behaviour, through tools wearing and roughness evolution.
- The Mn and Ni various physical properties, respectively thermal conductibility (50W/m˚C for manganese and 92W/m˚C for nickel) and expansion coefficient ($22 \cdot 10^{-6} \cdot 1/^{o}C$ for manganese and $13.3 \cdot 10^{-6} \cdot 1/^{o}C$ for nickel), determine a decrease of manganese-alloyed steels workability towards nickel-alloyed ones.
- Alloying agents, manganese and carbon concentration increase determine a thermal conductibility decrease.

- The roughness evolution for austenitic stainless steel allied with manganese , AMnNi is correlate with a low thermal conductivity ,which determines a slow thermal dispersion in cutting areas, higher friction forces between tool and material, with effects of adhesive wearing and material coating on tool.

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