Sborník vědeckých prací Vysoké školy báňské – Technické univerzity Ostrava
číslo 1, rok 2008, ročník LI, řada hutnická
článek č. 1379

EFFECT OF WORKING PROCESS AT CUTLERY PRODUCTION ON CHANGE STEEL STRUCTURE SEMI-FINAL PRODUCT

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ABSTRACT: Goal of this paper is presentation of microstructure steel 1.4301 behavior during cutlery spoon production. It explains problems witch comes from quality of used semi-finish product, required design of cutlery and are incident in production.

KEY WORDS: steel, microstructure

1. INTRODUCTION

Defonnation resistance is one of the most important material property. Integrity of material can not be damaged while material is changing its shape by influence external forces.
If forming is running according to optimal conditions (temperature and level of material deformation) metallic bond of atoms will stay intact. This fact is also reason of changes mentioned above. Measure of metal forming is deformation scale, which metal can take without any crack of it's coherence. Material will crack when forces at certain are get over ultimate strength Cold forming increases metal's stiffness, ultimate strength but at same time decreases toughness, tensibility and contraction. Previous metal's grains are getting soften and are extended in direction of forming. Further plastic deformation growth requires another increase of external force, metal is giving higher resistance and it's deformation reinforcement is increased. These changes are also observed in microstructure. Metal strusture has main effect on metal properties hereby; there is a need of equation investigation between structure and chosen properties. One of experimental method is light microscopy.

1.1 Material and it's properties

At present days steel class 17 is used in cutlery production. In general austenitic steel STN 41 7240 is the most used anticorrosive material, which is equal to material DIN 1.4301 by AISI material 304. Chemical composition of steel used is in tab. 1.

Tab.1: Chemical composition of steel used

C	Si	Mn	P	S	Cr	Ni	N
max.0,7	max.1	max.2	max.0,045	max.0,015	17-19,5	8-10,5	max.0,11

Austenitic chrome-nickel steel with 8 % Ni is characterized by especially advantages combination of treatability, mechanical properties and corrosion resistance. High corrosion resistance is the most important property of this steel group is increased by higher ratio of alloying elements. The most helpful are especially Cr and Mo in increasing corrosion resistance.
This steel has excellent corrosion resistance in a wide variety of environments and when in contact with different corrosive media. It is oxidation resistant at temperature degree 870-925 °C. At temperature over 60 °C can be cracked due to corrosive effect under pressure.

2. EXPERIMENTAL

In dependence on thickness of entry material is cutlery manufacturing examined in this report divided into two fundamental processing. First material 3 mm broad is used at annealing free cutlery production, second 5 mm broad material is used at annealing cutlery production (further presented as first and second production process). Production procedures for both materials are in table 2. Operating experiences shows need of semiproduct annealing at second cutlery production producere (market requirement is cost reduction, one of way how to reduce production's prices isannealing elimination which significantly affect final cost).

Tab.2: Production procedures

Production sequence of cutlery (thickness of material: 3 mm)	Production sequence of cutlery (thickness of material: 5 mm)
1x rolling	1x rolling
2x rolling	2x rolling
3x rolling	3x rolling
Cutting full shape	Clearing
Regring edge	Annealing
Clearing	4x rolling
Mark "brandle"	5x rolling
Form shape	Clearing
Grind edge to size	Annealing
Polish full shape	6x rolling
	7x rolling
	Clearing
	Annealing
	Cutting full shape
	Regring edge
	Ploish surfaces
	Form shape
	Mark "brandla"
	Grind edge to size
	Polish full shape

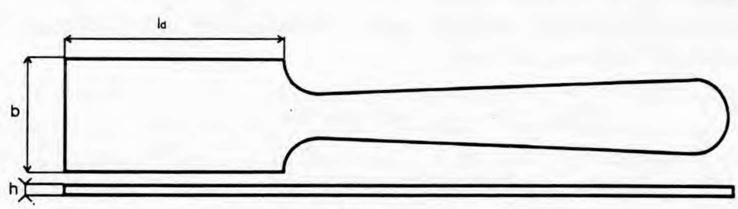


Fig. 1: "brandla"

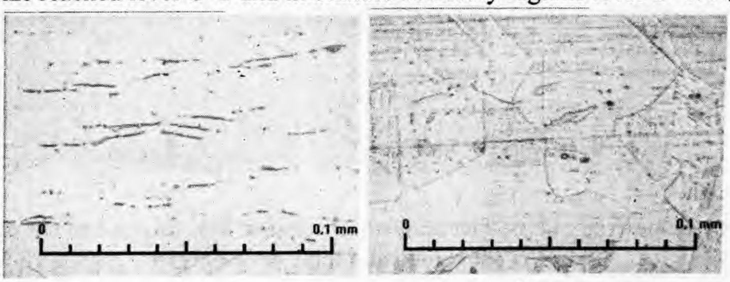
Microstructure of metallurgical scratch pattern samples prepared in longitudinal rolling direction from center and from boundary regions of semiproduct "brandla" ("brandla" is primary cutlery semiproduct fig.1.) was assessed by microscope.

2.1 Samples assess after δ-ferrite loading

To δ-ferrite evocation was a needed sample etching for cca 2 min. in above etching agent. Our target was δ-ferrite presence comparison in first and in second production procedure. Observed δ-ferrite in structure after first till the third rolling in both production procedures is unevently distributed, whereby there is no significant change in its distribution. In boundary regions was observed plastic deformation due to material rolling and cutting. Grow of material deformation in second producting procedure (fourth till the sixth) is causing increase of δ-ferrite alignment in forming direction.
Gradual increas of deformation level is plastic narrowing and elongating δ-ferrite. There was not observed any significant effect of annealing procedure on material presence and distribution in δ-ferrite structure compression at annealed condition and annealed condition (second production procedure, third till the sixth rolling).

2.2 Samples assess after microstructure etching

Metallurgical samples were again polished and etched (4 min) for total structure observation. After comparsion of two primary materialstructure (material 3 mm and 5 mm thick) was found, that source materials shows slight difference in austenite structure (fig.1). While in 3 mm thick primary material was relatively strong directed austenite observed, in primary material 5 mm thick we can see only small alignment of austenitic grains. With regard to partial alignment we can thereabouts asses at least austenitic grain size according to comperative method, standard 420462. In the middle of section austenitic grain size reached level G=5 and in brandla boundary regions level G=5/6 (20%).



a. b.

Fig. 1: Austenite structure of source material (a-material thick 3 mm, b-material thick 5 mm)

Following microstructure comparsion of every sample from three rolling of both production procedures we can say there is slightly stronger austenitic grains alignment at first production procedure. Shown data are related with plastic deformation dimension, which is bigger at first procedure, this we can also see on comparsion of relative reduction ε_h in table 3. For information we report also dimension of relative reduction ε_b and length of relative reduction ε_l. After third rolling in first production procedure we can see deformation reinforcement of austenite grain.

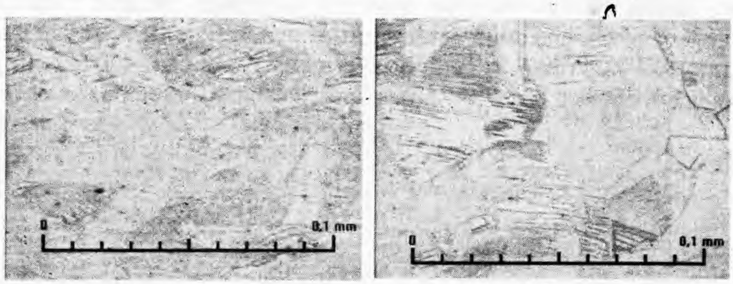
Tab.1: Relative reduction

	ε_h	ε_b	ε_l
1x-rolling, first working proces	0,3273	0,0419	0,3576
2x-rolling, first working proces	0,4400	0,0586	0,6417
3x-rolling, first working proces	0,4909	0,0614	0,8196
1x-rolling, second working proces	0,256	-	0,2687
2x-rolling, second working proces	0,426	-	0,5135
3x-rolling, second working proces	0,486	-	0,8338
4x-rolling, second working proces	0,612	-	1,0782
5x-rolling, second working proces	0,674	-	1,3793

6x-rolling, second working proces	0,7	-	1,7105
4x-rolling, second working proces, unannealed	0,582	-	1,0428
5x-rolling, second working proces, unannealed	0,644	-	1,0876
6x-rolling, second working proces, unannealed	0,686	-	1,6849

Stronger difference in material microstructure is appearing just in fourth and sixth rolling from annealed material in second production procedure (fig.2). There is steel appearing deforming material reinforcement in microstructure of particular rolling levels (after annealing) material grains become more polyedric with possibility to evaluate it's size according above mentioned norm. Austenite grain size after sixth rolling and annealing was G=5/6 (40%).

For comparsion and visualization difference in microstructure were done samples of annealing free material after third and sixth rolling. Strong deformation strips were observed in microstructure and at bigger enlarging we could saw unique appearance of deformation induced martensite (fig.3), which formation is connected with high local deformation degree. Shown data were not observed in annealing material.



a. b.

Fig. 2: Difference in material microstructure (a-material after four rolling and annealing, b-material after six rolling and three annealing)

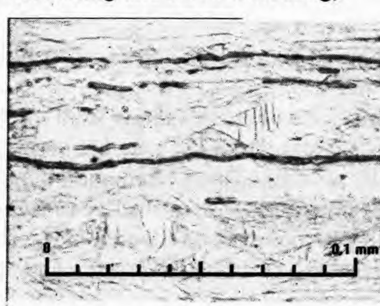


Fig. 3: Deformation induced martensite.

3. CONCLUSION

Source material structure is formatted of unevenly distributed δ-ferrite. According to experimental measurements we can say δ-ferrite is forming by gradual rising of deformation level, it is narrowed and elongated, but there is no significant influence of annealing on its occurrence and distribution.

Structure comparsion of both source materials shows slight difference in austenite grains occurrence. By increasing deformation level of material we can se deformation reinforcement of austenite grain.

Usage of annealing operation partly avoid generation of deformation reinforced austenite and so allowed further processing of material. At annealing free technology procedure is there creation of strong deformation strips and unique appearance of induced martensite what causes crack formation in material.

4. REFERENCES

[1] PETER SKOČOVSKÝ, OTAKAR BOKŮVKA, RADOMOLA KONEČNÁ, EVA TILOVÁ.: Náuka o materiály pre odbory strojnícke, Žilinská univerzita v Žiline 2001.

[2] PÍŠEK, F. et al.: Náuka o materiálu. Zv.1/4, Academia Phaha, 1975.

[3] IVAN LETKO, JOZEF MEŠKO, PETER VRÁBEL.: Priemyselné technológie 1, ZUSI v Žiline, 2001

[4] http://www.souszr.cz/U%ed%20texty/Stroj%edrensk%e1%20technologie/pages/text4.htm.

[5] PANTON PUŠKÁR, JÁN MICHEĽ VOJTECH PULC.: Náuka o materiály 1, Žilinská univerzita v Žiline 1998

[6] http://www.sppusa.com/reference/white_paper/wp_ss.html.

[7] Lexikon technických materiálov.

[8] www.outoKumpu.com/files/Group/HR/Documents/STAINLESS20.pdf.

[9] www.europert.org/v3.1/_pdf/Materiallist.pdf

[10] http://www.euro-inox.org/pdf/map/StainlessSteelProperties_CZ.pdf.