ARCHIVES
of
FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 9
Issue 4/2009

183 – 186

32/4

Effect of dispersion hardening process on machinability of EN AB-AlSi9Mg silumin

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Received 30.06.2009; accepted in revised form 06.07.2009

Abstract

Nowadays, aluminum and its alloys found their application in any type design structures, many's the time being an alternative for a ferrous alloys due to their technological properties like low density, ductility, high strength and good corrosion resistance. Among different fabrication processes the machining stage has a significant importance considering fabrication costs and processing time. Therefore, optimization of the process parameters that affect machining stages such as, tool wear, alloy machinability, machining effort and cutting speed becomes an area of constant development and study. To the most important factors having impact on machining properties belong: initial condition of machined material, which depends on a method and conditions of material preparation. In the paper are presented initial tests of machining properties of the EN AB-AlSi9Mg silumin subjected to heat treatment. Machinability measurements of the investigated alloy were performed with use of reboring method with constant force of feed. It enabled determination of an effect of heat treatment on machining properties of the investigated alloy. A further investigation shall be connected with determination of optimal parameters of solutionizing and ageing treatments in aspects of improvement of both mechanical properties and its machinability.

Key words: Silumins, Heat treatment, Machinability

1. Introduction

Application of the silumins expands together with nowadays tendency to reduction of a design structures mass. Proper and optimal usage of the Al-Si alloys is possible when their properties, which result directly from their structure and can be shaped through metallurgical treatment and heat treatment, are known [1]. Castings, besides rolled semi-products belong to the most widespread blanks used in low-volume, high-volume and mass production [2]. Machinability belongs to characteristic features of the material, having direct relation with methods and conditions of its preparation.

A factors which have an effect of the machinability are the factors which are present in stage of material preparation (chemical composition, structure, mechanical properties, plastic working and heat treatment). Aluminum alloys with copper, silicon, zinc, magnesium and manganese, i.e. with alloy-forming elements assuring reliable properties, find their applications in the machine-building industry. Among above specified chemical elements the copper has the most advantageous effect on the machinability, because the copper increases hardness of the alloy and facilitates separation of chips. Silicon, increasing abrasive capabilities of the material and reducing durability of cutting edge, distinctly deteriorates machining properties of these alloys.

With respect to it, contents of silicon was taken as base to classification of the machinability of such alloys. The alloys can be divided into three groups [3]:

- alloys with silicon contents up to 2% Si, featuring low grindability (having high susceptibility to sticking on cutting edge and requiring big tool rake angles),
- alloys with silicon contents of 2 – 12% Si, forgeable alloys (having smaller susceptibility to sticking on cutting edge),

- alloys with silicon contents above 12% Si; casting alloys with high contents of silicon (feature lower forces and temperature of machining, and high grindability).

Although machinability of aluminum alloys is considered as good, aluminum features its own specifics distinguishing it from machinability of ferrous alloys [4-6].

To improve efficiency of machining processes is advisable to have knowledge about methods and means of machinability improvement. Proper assessment of machinability of processed materials is of important meaning both for design and process engineers. Good machinability of a material considerably facilitates and simplifies technological process of machinery components production, and hence reduces manufacturing costs.

Equally important aspect connected with the machinability of material is a possibility of forecasting of cutting edge wear, what is especially important in case of modern, service-free elastic manufacturing processes full of processors and equipped with robots. Such systems are rather expensive, and therefore, it is important to make full use of their operating time, what is connected directly with their protection against damages resulted from not-correct process of machining. Moreover, growth of costs connected with reduction of feed rate, with respect to optimal one, is difficult to be accepted. Application of a higher parameters and more complete implementation of potential capabilities of a machining system enable reduction of fabrication costs of a component [7].

In such context, skill how to control technological feature of a material, like the machinability is, with simultaneous fulfillment of design requirements concerning a component takes a prime importance [8].

Actually, comprehensive research is carried out to produce Al-Si alloys with high properties, both mechanical and technological. [1, 9-14].

Methods to determination of machinability are based on measurements of cutting edge wear, machining speed, load of cutting edge [3,15].

Measurement of machinability – reboring with constant feed force is rated among accelerated methods. Approximation of machining conditions in test stand environment to real operating conditions during machining of material is the advantage of that method.

2. Methodology of the research

EN AB-AlSi9Mg alloy is rated among hypo-eutectoid silumins, features very good casting properties and is destined to castings with complicated shapes and high strength

In order to prepare test pieces the crude alloy was melted in resistance furnace in temperature of about 720°C. Refining of investigated alloy was the next stage of the treatment. Rafal 1 preparation in quantity of 0,4% of mass of the charge was used to the refining. Refined alloy after removal of oxides and slag from metal's surface was poured into metallic mould which was initially heated-up to temperature of 250°C.

Modification of investigated alloy was carried out after the refining. Modification with strontium was performed with use of AlSr10 master alloy in quantity of 0,6% of mass of the charge (0,06% Sr), and next after 30 minutes modified alloy was poured in metal mould.

Cast specimens underwent treatments of solutionizing and ageing. In the Table 1 are presented parameters of dispersion hardening process of the investigated alloy.

Table. 1.
Heat treatment parameters of the alloy

solutionizing temperature [°C]	solutionizing duration [h]	ageing temperature [°C]	ageing duration [h]
530; 545; 560	0,5; 1,5; 3	180; 235; 310	2; 5; 8

Machinability tests consisted in drilling in prepared specimens a hole 6 mm dia (with use of twist drill to aluminum alloys), and next determination of dependencies between length of path of the drill and time of its movement, assuming constant value of feed rate.

To determinate machinability of investigated alloy there was implemented the method of reboring with flat drill and with constant feed force [16, 8].

Test stand to measurement of the machinability, using method of reboring with constant force of feed is presented in the Fig. 1.

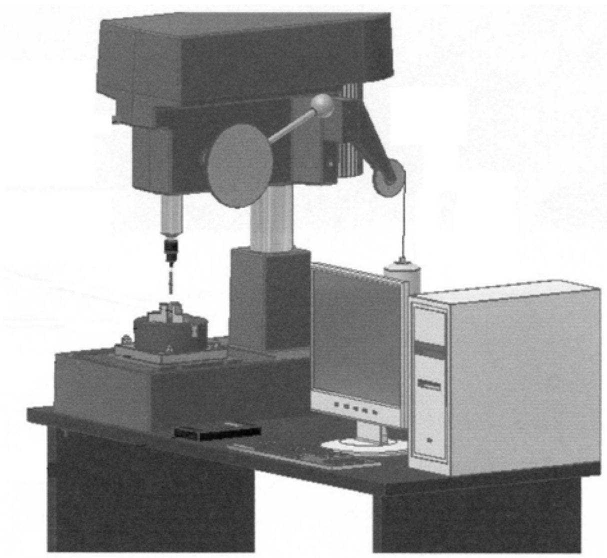

Fig. 1. Test stand [8]

During the test there were continuously measured duration of reboring operation and path traveled by the tool in this time. Implemented software enables processing and analysis of output signals and graphical visualization of obtained test results. Curve inclined to abscissa axis with angle of $\propto$ represents dependence between depth of reboring and time of sinking of the drill into investigated material. Inclination angle of the curve with respect to axis of abscissa is a measure of intensity of machining (reduction of the angle is tantamount to growth of intensity of machining).

Numerical index of absolute machinability “W_s” determines averaged growth of tool path in time, and is expressed in [mm/min].

Test of the machinability was performed for refined alloy, refined and modified alloy, and heat treated alloy.

3. Description of obtained results

The Fig. 2 shows machinability curves of refined EN AB-AlSi9Mg alloy.

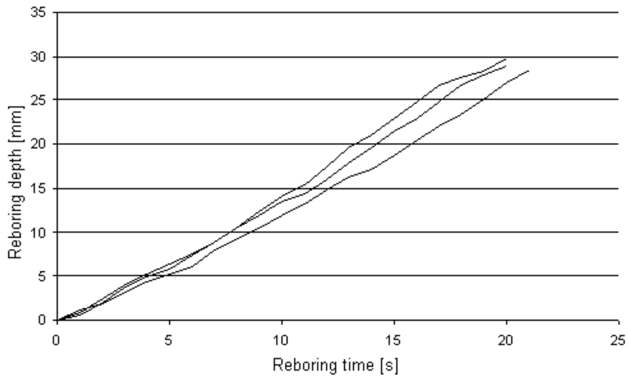

Fig. 2. Machinability curves of refined EN AB-AlSi9Mg alloy

Machinability index, W_s, for the alloy after refinement amounts to 85,7 mm/min.

The Fig. 3 shows machinability curves of refined and modified EN AB-AlSi9Mg alloy.

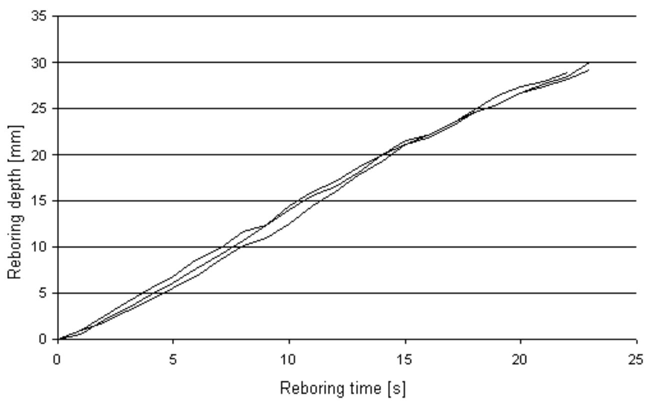

Fig. 3. Machinability curves of refined and modified EN AB-AlSi9Mg alloy

Machinability index, W_s, for the alloy after refinement and modification amounts to 80,7 mm/min.

To compare effect of implemented metallurgical processes and heat treatments on machinability of the investigated alloy, in the Fig. 4 are shown selected curves of the machinability. Machinability curves were registered for the refined alloy, modified alloy and the alloy after heat treatment.

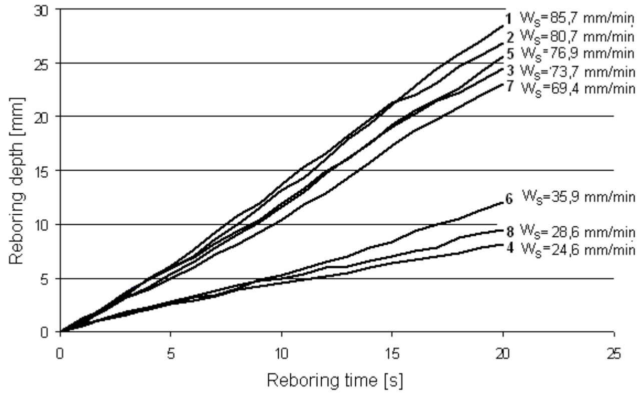

Fig. 4. Machinability curves of EN AB-AlSi9Mg alloy: 1) refined alloy, 2) modified alloy, 3÷8) heat treated alloy

Parameters of the heat treatment process for the selected curves (Fig. 4) are shown in the Table 2.

Table 2.
Selected parameters of the heat treatment process

Number curves	solutionizing temperature [°C]	solutionizing duration [h]	ageing temperature [°C]	ageing duration [h]
3	530	0,5	180	2
4	530	3	180	5
5	545	3	235	8
6	545	0,5	180	8
7	560	3	235	5
8	560	3	180	8

Making analysis of the curves from the Fig. 4 one can determine an effect of refinement, modification and heat treatments on machinability of investigated alloy, assuming slope of machinability curve with respect to X-axis as a measure of intensity of machining, as well as absolute index of machinability, W_s.

The best machinability is seen in case of refined alloy. Machinability index for this alloy is higher than the index for the alloy after modification and the alloy after heat treatment.

Maximal obtained index of absolute machinability, W_S, for the alloy after heat treatment which amounted to 76,9 mm/min was obtained for the alloy solutionizing treated in temperature of 545°C during 3 hours, and next ageing treated in temperature of 235°C during 8 hours.

Minimal obtained index of absolute machinability, W_S, for the alloy after heat treatment which amounted to 24,6 mm/min was obtained for the alloy solutionizing treated in temperature of 530°C during 3 hours, and next ageing treated in temperature of 180°C during 5 hours.

4. Conclusions

Performed initial test have enabled determination of en effect of heat treatment on machinability of the EN AB-AlSi9Mg alloy.

Implemented method of machinability measurement features short time of the measurement and small consumption of material.

The best machinability was recorded for the refined alloy (W_s=85,7 m/min). After modification, machinability of the alloy was slightly deteriorated.

Machinability of the alloy heat treated, comparing with the machinability of refined and modified alloy was changed.

Depending on heat treatment parameters of the investigated alloy, obtained machinability index W_s, amounted from 24,6 m/min to 76,9 mm/min.

Acknowledgements

This paper has been written as a result of the research work conducted under Research Project No. 16/I/GW/2008 financed by University of Bielsko-Biała.

References

[1] S. Pietrowski, Silumins, Wydawnictwo Politechniki Łódzkiej, Łódź, 2001 (in Polish)

[2] M. Feld, Fundamentals of designing of technological processes of typical machinery parts, WNT Warszawa 2003

[3] M. Miernik, Machinability of steels – methods of determination and forcasting, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław 2000

[4] M. Feld, Machining of aluminum alloys, WNT Warszawa 1984

[5] J. R. Kaufman, E.L. Rooy, Aluminium Alloy Castings: Properties, Processes & Applications, ASM International 2004

[6] T. Tanaka, T. Akasawa, Machinability of Hypereutectic Silicon-Aluminium Alloys, Journal of Materials Engineering and Performace, vol. 8 (1999) 463-468

[7] K. Jemielak, Automatyczna diagnostyka stanu narzędzia i procesu skrawania, Oficyna Wydawnicza Politechniki Warszawskiej, Warszawa 2003

[8] J. Pezda, Effect of modification with strontium on machinability of AK9 silumin, Archives of Foundry Engineering, vol. 8, Iss. 1 (2008) 273-276

[9] P. Wasilewski, Silumins – Modification and its impact on structure and properties, PAN Solidification of metals and alloys, Zeszyt 21, Monografia, Katowice 1993 r. (in Polish)

[10] J. Pezda, Effect of dispersion hardening on impact resistance of EN AC-AlSi12Cu2Fe silumin, , Archives of Foundry Engineering, vol. 9, Iss. 2 (2009) 21-24

[11] S. Pietrowski, T. Szymczak, Silumins alloy crystallization, Archives of Foundry engineering, vol. 9, Iss. 3 (2009) 143-158

[12] J. Piatkowski, F. Bińczyk, Analysis of solidification and microstructure of Al-Si alloys, Archives of Foundry, vol. 6, No. 19 (2006) 227-232 (in Polish)

[13] S. Rzadkosz, L. Staszczak, Effect of selected microadditives on mechanical properties of aluminum alloys, Archives of Foundry Engineering, vol. 7, Iss. 1 (2007) 85-88

[14] J. Piątkowski, J. Szymszal, Thermal analysis and microstructure of master alloys used for modification of silumins, Archives of Foundry engineering, vol. 9, Iss. 3 (2009) 129-132

[15] C. Zimerman, S P. Boppana, K. Kafbi, Machinability test methods, Metals Handbook, vol. 16, Machining, ASM International 1989, s. 639-647

[16] J. Matuszek, J. Wojtyła Stand to machinability test of free-cutting steels, using reboring with constant feed force, Mechanik 5/1977