ACTA TECHNICA CORVINIENSIS – Bulletin of Engineering
Tome V (Year 2012). FASCICULE 2 [April–June]. ISSN 2067-3809

[1.] Michal SPORKA, [2.] Tatiana CZÁNOVÁ

NEW KNOWLEDGES AT MACHINING OF IMPROVING HIGHSTRENGTH GRAPHITE CAST IRON BY DRILLING

[1.] DEPARTMENT OF MACHINING AND ANUFACTURING TECHNOLOGY, FACULTY OF MECHANICAL ENGINEERING, UNIVERSITY OF ZILINA, SLOVAKIA

ABSTRACT: High fortification of the machined surface of ADI (Austempered Ductile Iron) cast iron can significantly affect its functional properties. This article deals with problems of selected ADI samples, their production and use. On the basis of experimental tests has been identified its machinability, the cutting process during drilling, and also mutual comparison of nodular and grey cast iron, which will further intensify and extend current knowledge of this problems.
KEYWORDS: ADI cast iron, drilling, machinability

INTRODUCTION

The relatively new construct material ADI alloy (ADI – Austempered ductile iron) have a special properties It is a bainite cast iron which we have from heat treatment (isothermal improving) of graphite cast iron with spherical graphite (nodular cast iron). ADI cast iron offers combination of simple properties like steel have. If conditions are fulfilling the ADI cast iron seems like steel for improving for example 42 CrMo4 (15 142), with its properties.

USING OF ADI CAST IRON

ADI cast irons are more low density like steel at same strength, have good wear resistance, elasticity, good sliding conditions and run into good characteristics of internal damping. This is why ADI is rivalrous to steel for forging, improving and steel cast iron.

Figure 1. Single-throw crank-shaft of Volkswagen engine 1,8T material EN-GJS-600-3 (www.lam.mw.tum.de)

Substitute of steel with casting from ADI is still the most frequent mood of application to reduce the manufacturing costs that means saving money or increasing life of workpieces (fig.1).

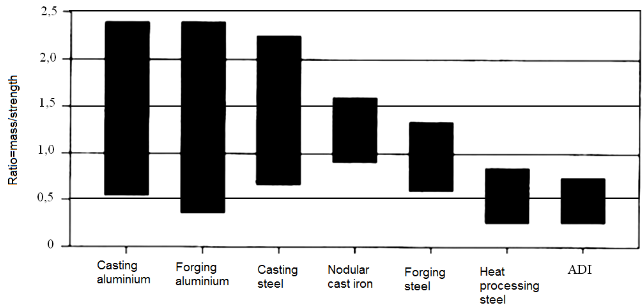


Figure 2. Comparison of material´s conditions

If we know ratio between relative mass and slip line of ADI cast iron as against aluminium, steel and nodular cast iron are advantages at using ADI cast iron (fig.2). ADI cast iron are manufactured by isothermal improving, what is process of thermal treatment and it significantly impacts their mechanical properties (tab.1).

Table 1. Mechanical properties of ADI materials according to DIN EN 1564 (BECHNÝ, 2003)

Mark	Number	Rm (MPa)	$Rp_{0,2}$ (MPa)	A5 (%)	HB
EN-GJS-800-8	EN-JS1100	800	500	8	260 to 320
EN-GJS-1000-5	EN-JS1110	1000	700	5	300 to 360
EN-GJS-1200-2	EN-JS1120	1200	750	2	340 to 440
EN-GJS-1400-1	EN-JS1130	1400	1100	1	380 to 480

The properties of ADI are appointed for conditions of higher and high working strains (BECHNÝ, 2003).

EXPERIMENTALLY MEASUREMENT

It was drilled fifteen not continuous holes to prepared samples (fig.4) (drilling to full material) at five cutting conditions. The diameter of drilled holes was D = 6,8 mm and deep was h = 2xD. For experiment was used machine CNC – tripleaxle milling machine STAMA 325 and a tool GÜHRING 5518 DIN 6537 L91x6,8 mm – PVD TiAlN (fig.3).

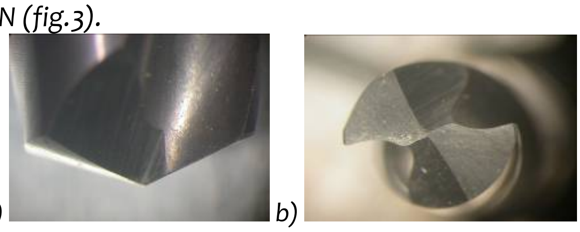
a) b)


Figure 3. Photos of drilling tool a) back plane P_p, b) working reference plane P_r

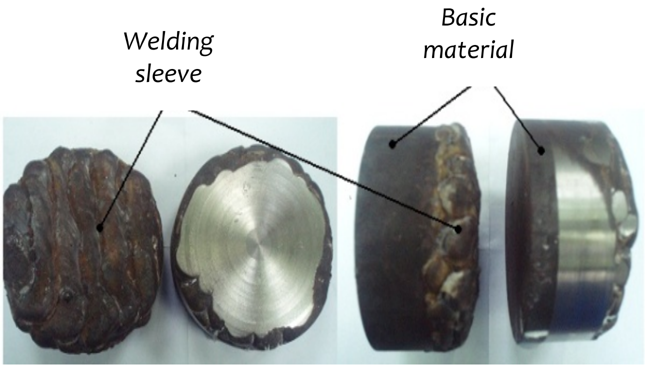


Figure 4. Used samples and their modification to experimentally measurements

Characteristic of used samples and their treatment:

<u>LLG</u> – <u>gray iron</u>:

SRE – without thermal treatment,

SNI – without thermal treatment, on the one side we were surfacing by welding nickel electrode - E-S 723: chemical composition C-0,9%, Si-0,9%, Mn-0,6%,Fe 3,5%, Ni->92%,

<u>LGG</u> – <u>nodular cast iron</u>:

GRE – without thermal treatment,

GPL - sample without thermal treatment on the one side we were surfacing by welding stuffed electrode - RD 592/L13: chemical composition; C-3,98%, Si-3,65%, Mn-0,79%, Cr-0,08%, Ni-0,95%, Cu-0,79%, Mg-0,087%, P-0,06%, S-0,018%,

GTS 1 – sample with thermal treatment at electric furnace with 910℃ temperature, time 30 min. and cooling at salt bath to 410℃ during 90 min., on the one side we were surfacing by welding stuffed electrode - RD 592/L13: chemical composition; C-3,98%, Si-3,65%, Mn-0,79%, Cr-0,08%, Ni-0,95%, Cu-0,79%, Mg-0,087%, P-0,06%, S-0,018%,

GTS 2 – sample with thermal treatment at electric furnace with 850℃ temperature, time 30 min. and cooling at salt bath to 410℃ during 90 min., on the one side we were surfacing by welding stuffed electrode - RD 592/L13: chemical composition; C- 3,98%, Si- 3,65%, Mn-0,79%, Cr-0,08%, Ni-0,95%, Cu-0,79%, Mg-0,087%, P-0,06%, S-0,018%,

<u>ADI cast iron</u>:

ADI TS1 – sample with thermal treatment at electric furnace with 910℃ temperature, time 30 min. and cooling at salt bath to 410℃ during 90 min., on the one side we were surfacing by welding stuffed electrode - RD 592/L13: chemical composition; C-3,98%, Si-3,65%, Mn-0,79%, Cr-0,08%, Ni-0,95%, Cu-0,79%, Mg-0,087%, P-0,06%, S-0,018%,

ADI TS2 – sample with thermal treatment at electric furnace with 850℃ temperature, time 30 min. and cooling at salt bath to 410℃ during 90 min., on the one side we were surfacing by welding stuffed electrode - RD 592/L13: chemical composition; C-3,98%, Si-3,65%, Mn-0,79%, Cr-0,08%, Ni-0,95%, Cu-0,79%, Mg-0,087%, P-0,06%, S-0,018%.

EXPERIMENTALLY MEASUREMENT OF TANGENTIAL COMPONENT OF F_O AND M_K (T)

Experiments were completed on eight samples, where we measured influence of cutting conditions to tangential component of cutting force F_o and torque M_k (T) (fig.5). Measured values were paced to graphs (fig.6, 7).

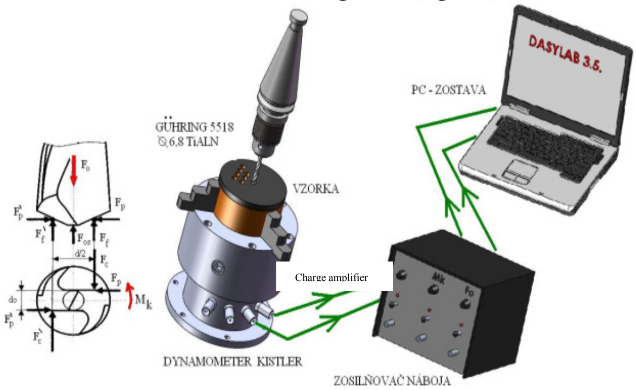


Figure 5. Model of cutting forces measurement at drilling

The result from graphic files is that maximum values of F_O and M_k were measured at sample GPL. Minimum values were measured at samples SNI and SRE (fig.6 and 7). We find out at comparison of F_O and M_k ADI TS1 and ADI TS2 samples that sample ADI TS1 had lower F_O, in some cases by up to 37.8% and less torque Mk up to 27.8% compared with the ADI TS2.

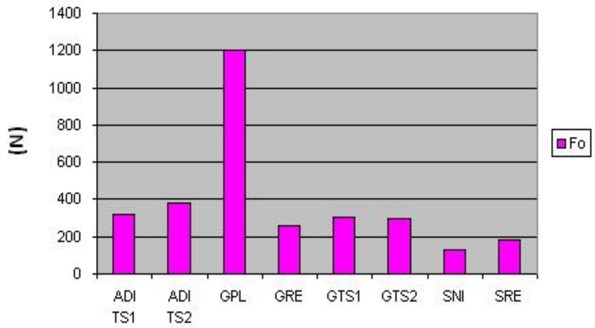


Figure 6. Example comparison of F_O [N] at each sample

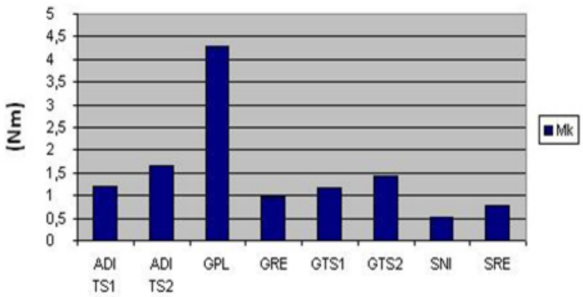


Figure 7. Example comparison of Mk [N.m] at each sample

EXPERIMENTALLY MEASUREMENT OF THE INSTANTANEOUS DEPLETED POWER

The measurement consists in two sections. In first one was measured instantaneous depleted power at idle, that means it was pasted path of machined area without material removal. In second one was measured instantaneous depleted power at load during of machining sample surface (fig. 6, 7).

The graphical results show that the maximum instantaneous value of received power was measured for a sample of the GPL, where the average value in *conditions vc = 150 (m/min), vf = 491 (mm/min), n = 7021 (r/min) = 653. Minimum values were measured at SRE, where the average value of received power in conditions vc = 100 (m/min), vf = 140 (mm/min), n = 4681 (r/min) = 510.8 W.*

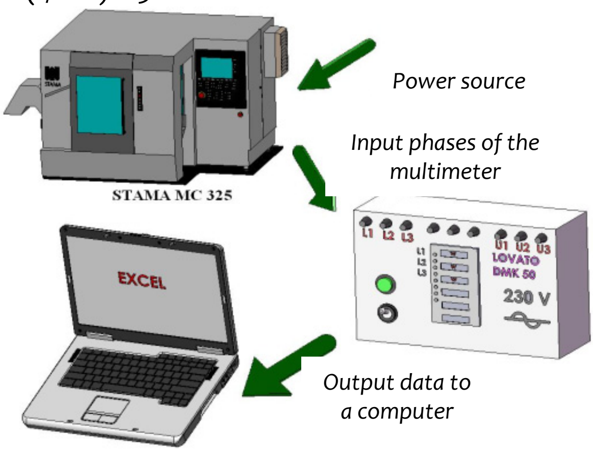


Figure 8. Scheme of measurement of the instantaneous depleted power

Figure 9. Comparison of power active components at idle and at load in drilling one hole

When compared to the reciprocal waveforms of samples ADI TS1 and ADI TS2 (Fig. 10), we found that the sample TS1 ADI had a lower value of received power at the cutting conditions vc = 70 (m/min), vf = 229 (mm/min) n = 3276 (r/min) of 7,4%; vc = 100 (m/min), vf = 140 (mm/min), n = 4681 (r/min) of 4,5% and vc = 150 (m/min), vf = 491 (mm/min), n = 7021 (r/min) of 8,9% compared with the ADI TS2.

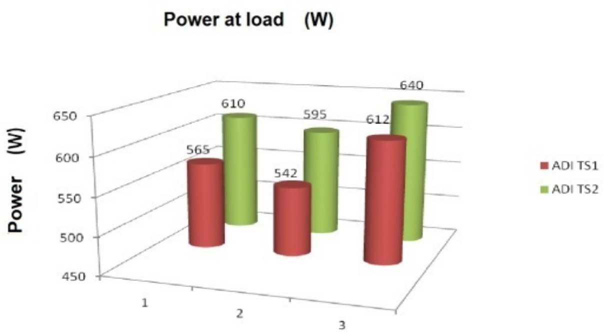


*Figure 10. Total comparison of the instantaneous depleted active power at load in conditions: **1-** v_c=70(m/min), v_f =229(mm/min), n=3276(r/min); **2-** v_c=100(m/min), v_f =140(mm/min), n=4681(r/min), **3-** v_c=150(m/min), v_f =491(mm/min), n=7021(r/min)*

From economic view is measurement of instanteous depleted active power very important. It is factor, which impacts the choice of technological process, cutting material and also choice of machined material. Since finances are nowadays an important factor in production, we must not forget indicators, such as the instantaneous depleted power.

CONCLUSIONS

Machinability of these cast irons significantly worse particularly high hardness and a higher percentage of silicon, which acts abrasive on the tool. Based on this knowledge and material characteristics were carried out experiments which allow to more identify machinability and cutting process for drilling in ADI cast iron.

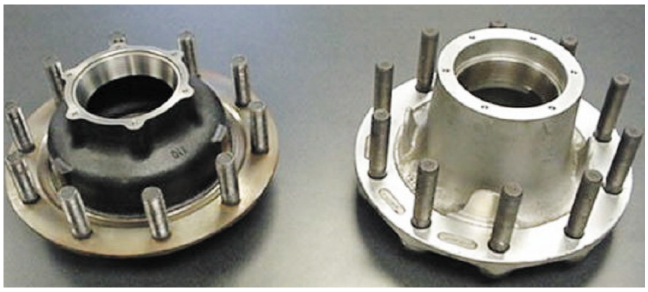


Figure 11. Comparison of the hub of a motor vehicle on the right side ADI design, on the left side solution of aluminium alloy (www.claasguss.de)

Research ADI cast iron contributes to continuous improvement of the manufacturing process and reduce production costs by using these cast irons as a compensation of steel forged parts and also as a compensation of aluminium alloys (fig.11), and casting from the ADI cast iron is about 2% lighter and 20% cheaper.

REFERENCES

[1.] ALBRECHT, E. – VĚCHET, S. – KOHOUT, J.: Liatina s kuličkovým grafitom a její vysokopevná varianta – ADI

[2.] BECHNÝ, L. – SLÁDEK, A. – FABIAN, P.: Bainitická tvárna liatina v škrupinovej forme, IX. medzinárodná konferencia SPOLUPRÁCA ´03, Krakow, 28. – 30.5.2003,

[3.] CZÁN, A. – NOVÁK, S.: Katalóg materiálové inžinierstvo, roč. 10, 2003, č.2, str. 45-47.

[4.] JURKO, J. – ZAJAC, J. – ČEP, R.: Top trendy v obrábaní, 2. časť – Nástrojové materiály, Žilina: MEDIA/ST, 2006, str. 4, 97, 141-142.

[5.] KIRGIN, K. E.: Modern Casting 81, 1992, č.1, str. 32-34.

[6.] www.claasguss.de

[7.] www.darwin.bht.rwth-aachen.de

[8.] www.lam.mw.tum.de

[9.] www.SHM-cz.cz

[10.] www.files.sssbb.meu.zoznam.sk

ACTA TECHNICA CORVINIENSIS – BULLETIN of ENGINEERING

ISSN: 2067-3809 [CD-Rom, online]