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CONSTRUCTION AND TECHNOLOGY OF PRODUCTION OF CASTED SHARES FOR ROTATING AND FIELD PLOUGHS

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Summary. In the paper, among other things, there were formulated requirements for shares of rotating and field ploughs in terms of casting material and construction of cast itself. Austempered ductile iron (ADI) was selected as casting material for testing shares of casts. Trial model of a share was created for computer simulation purposes. On its basis there were prepared concepts of construction models of right and left share for a rotating plough of Polish production as well as welts for the shares. The next step was developing technology and producing prototype lot of casts, which were analysed in terms of durability.

Key words: agricultural machines and tools, casted tools, shares, life of tools, trybologic wear.

INTRODUCTION

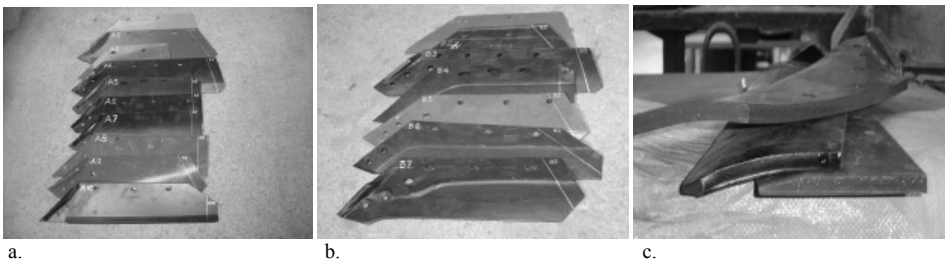
The paper is a part of structural project WKP_1/1.4.1/1/2005/12/12/229/2006/U entitled „Development of innovative construction and technology of manufacturing casted elements of agricultural machines". A Consortium has been formed to carry out the project. The Consortium Leader was Foundry and Research Institute in Krakow and the Partners were: Industrial Institute of Agricultural Engineering in Poznan and The Metal-Chemical Works MET-CHEM in Pilzno. The purpose of the work was the creation of new, innovative construction of a casted share, selection of casting material, production of prototype lot and conducting tests.

The aim of the project was to replace beaten and welded elements of agriculture machines used to cut through soil by austempered ductile cast-iron.

Such material and technological conversion should enable a longer life of these elements without an increase of production costs, and as a result it should increase competitiveness of the produced elements.

MATERIAL SELECTION

Life of tools depends, inter alia, on the selection of material and production technology. Currently, the most common in the market are welded shares, beaten shares and bended beaten-welded constructions. Examples of such shares are presented in Figure 1.



a. b. c.

Fig. 1. Examples of shares available in the market: a. welded, b. beaten, c. bended beaten-welded

Analysing properties of steels of which „top level" shares are produced currently, we can find out that:

- tensile strength of such steel exceeds 1500 MPa,
- hardness over 40 HRC,
- extension over 6%,
- impact strength KCU over 20 J/cm^2.

Properties of casting material for shares casts should be therefore similar to properties of currently applied plastic-formed, heat-treated steel for shares.

Among casting materials, properties similar to workable alloy steel characterize only ductile cast iron after heat treatment consisting in austempering.

This cast iron is wear resistant in various conditions. Its mechanical properties depend on the sort and quantity of introduced alloy additions and, above all, depend on the parameters of the applied heat treatment.

After isothermal hardening it gains tensile strength 800 – 1500 MPa, and elongation to 18%, depending on the applied technological process. In Table 1 there are standardized sorts of ADI cast iron. Although this cast iron is not commonly applied in the country, abroad it is becoming widely used in many industry branches. Inter alia it is applied in such economy branches as [1-5]:

- auto industry (gears, wheelworks, camshafts, crankshafts, suspension, break pad),
- railway (locomotive wheels, clutch, break pad, train suspension),
- agriculture (plough shares, road vehicles, parts of chassis of agriculture machines, gears),
- mining (corpus and shell pumps, rotators, crankshafts, drills)
- machines construction (road wheels and chain wheel, sideway, chapping, jackshaft, vane, shredders, rolls, teeth to digger, chain caterpillar, gearing, hypoing gear, worm-gear, helical bevel gear pair).

Applying ADI cast iron instead of steel has many economical and practical advantages for manufacturers and users, such as:

- lower power consumption during production process even by 50%,
- better workability (before heat treatment), and thereby lower wear of cutting tools,
- smaller mass of casts,
- considerable fatigue strength,
- better abrasion hardness,
- noise reduction of cooperation parts,
- longer service life in many cases.

Table 1. ADI spheroid cast iron – grades according to EN and ASTM standards

Grade	Mechanical properties				
	Tensile strength R_m [MPa]	Yield point $R_{p0,2}$ [MPa]	Elongation A_5 [%]	Hardness HB [-]	Impact resistance [J]
EN-GJS-800-8	800	500	8	260-320	
ASTM 897 Grade 1	850	550	10	269-321	100
EN-GJS-1000-5	1000	700	5	300-360	
ASTM 897 Grade 2	1050	700	7	302-363	80
EN-GJS-1200-2	1200	850	2	340-440	
ASTM 897 Grade 3	1200	850	4	341-444	60
EN-GJS-1400-1	1400	1100	1	380-480	
ASTM 897 Grade 4	1400	1100	1	388-487	35
ASTM 897 Grade 5	1600	1300	-	444-555	

CASTING

Before performing actual casts, a series of construction solutions were prepared, and then paper models of shares were prepared in the so called LOM technology (Fig. 2). They enabled a selection of variant for further tests and introduction of necessary construction corrections. Afterwards, experimental casts were produced (Fig. 3) in five material groups of various chemical contents and the applied heat treatment parameters.

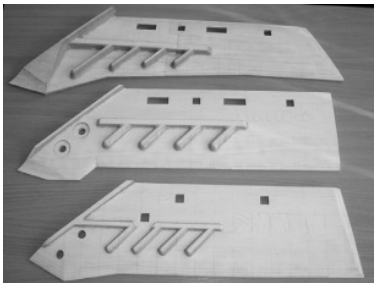


Fig. 2. Paper models of shares made in LOM technology

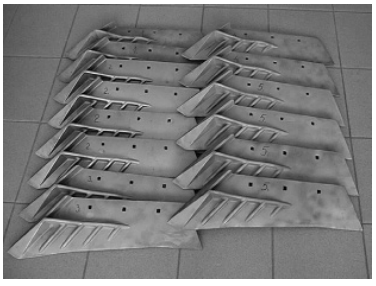


Fig. 3. Produced lots of experimental casts

Purified and heat treated casts were put to preliminary performance tests. Tests results showed that casted shares produced from ductile cast iron and austempering have a longer service life then the beaten shares of German production, available on domestic market and considered as some of the best quality. A graphic picture of the obtained tests results of the produced shares is presented in Figure 4.

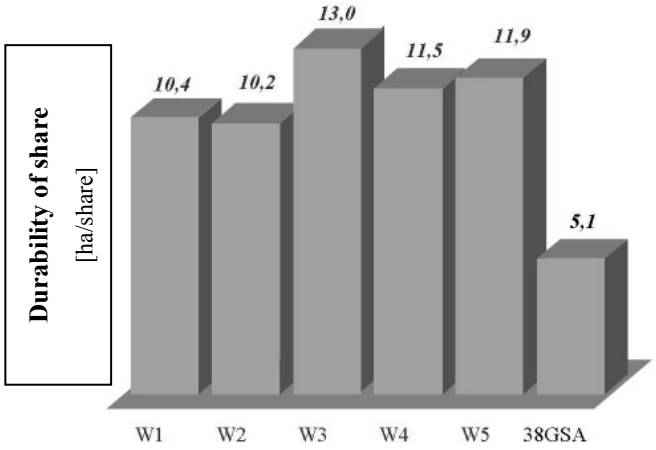


Fig. 4. Durability of shares from melts W1 to W5 and shares from steel 38GSA

A crucial influence on the obtained properties is exerted by quality of spheroid cast iron (mainly form, size, and number of graphite releases) and heat treatment parameters as well as chemical content of the produced cast iron. It can be variable in quite a wide range, however some (appropriate to the thickness of the cast wall) quantity of elements fostering hardenability (e.g. Ni, Cu) is necessary

It was assumed, that the chemical content of laboratory melts will be in the following ranges:

- carbon: 3,3 – 3,8%;
- silicon: 2,3 – 3,1 %;
- phosphorus: do 0,09%;
- sulphur: do 0,03%
- manganese: 0,1 – 0,5%;
- nickel: 1,3 – 1,8 %;
- copper: 0,5 – 0,9%;
- magnesium: 0,05 – 0,09%.

Keeping this chemical content will allow, by applying appropriate heat treatment parametres, to obtain ADI cast iron in a wide range of mechanical properties. Microstructure of such cast iron is presented in Figure 5.

The obtained initial results and observations during performance tests allowed, with the help of computer simulation (Fig. 6 – 12), to make some construction and technological corrections, and then to start works on the production of cast shares of rotating and field ploughs (Fig. 13).

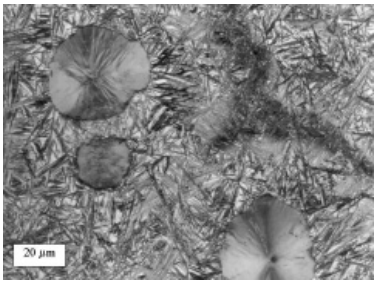


Fig. 5. Microstructure of ductile cast iron with austempering (ADI)

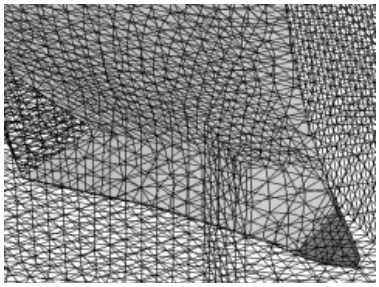


Fig. 6. Pressure distribution on the surface of sharp share

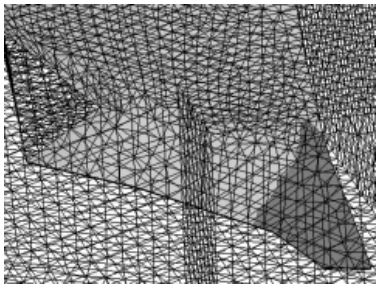


Fig. 7. Pressure distribution on the surface of blunt share

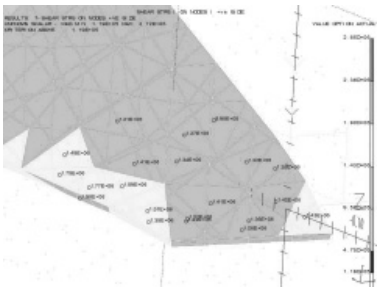


Fig. 8. Tangential stress distribution on the top of sharp share

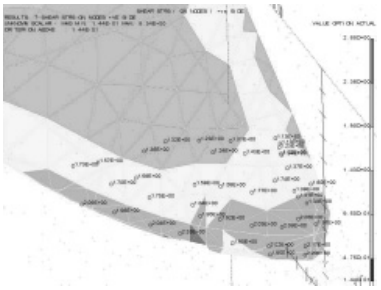


Fig. 9. Tangential stress distribution on the top of blunt share

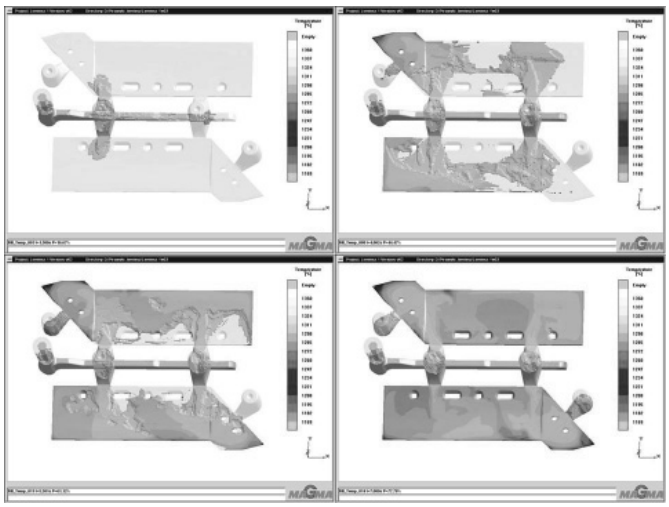


Fig. 10. Simulation of casting process

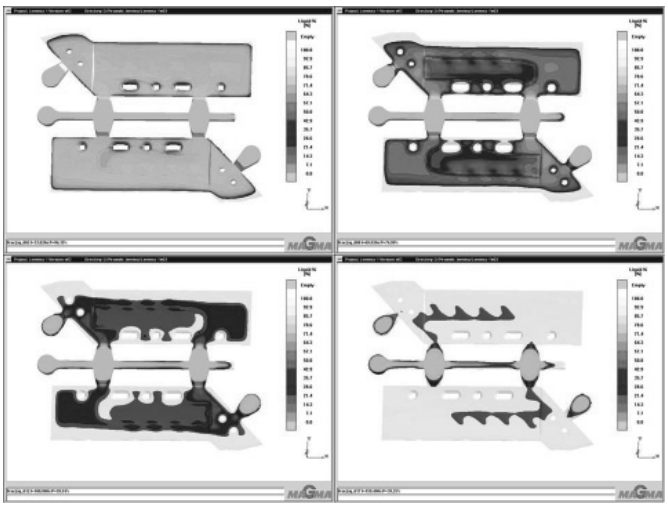


Fig. 11. Simulation of solidifying process

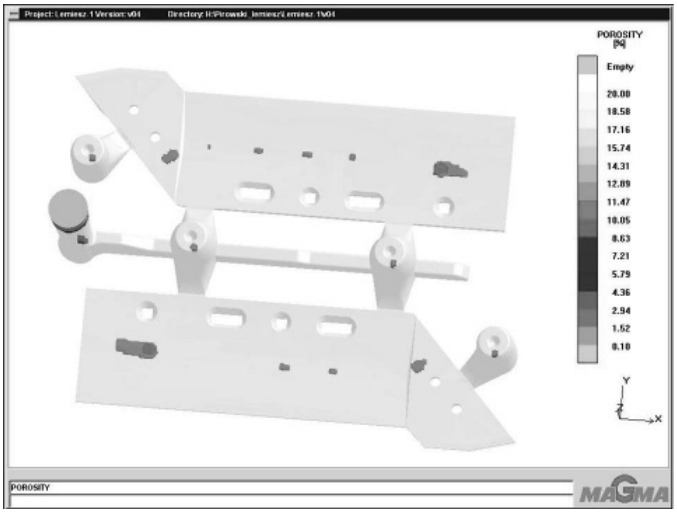


Fig. 12. Simulation of creating shrinkages porosity

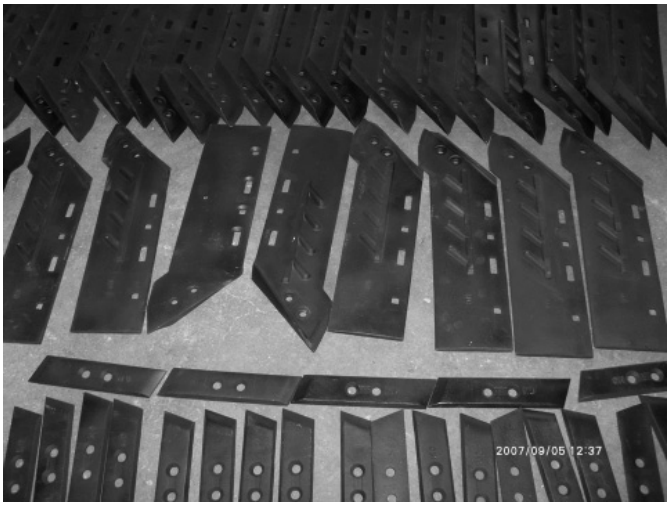


Fig. 13. The first produced lot of commercial casts

CONCLUSION

An analysis of the carried out observations allowed to confirm that after an appropriate technological process of cast shares they have considerably better properties then the beaten and welded steel shares avilable on the market. Their service life is c.a. 30% longer. Production cost of cast

shares does not exceed the market price of good quality shares on offer and is considerably lower than the price of top quality shares (40-50% compared to the most expensive ones).

Innovative cast share produced from ductile cast iron with isothermal transformation (Fig.14) was presented during a number of foundry exhibitions and events. The share obtained inter alia Diploma-Medal during XIII International Technology Exhibition for Foundry – Kielce 2007 and Silver Medal during International Invention, Science Research and New Techniques Exhibition - Brussels Innowa (Brussels Eureka) in Brussels in 2008. This share is passing a patent application.

TVP was interested with the new fabrication and produced a series of science films, which presented inter alia our works on the share creation.

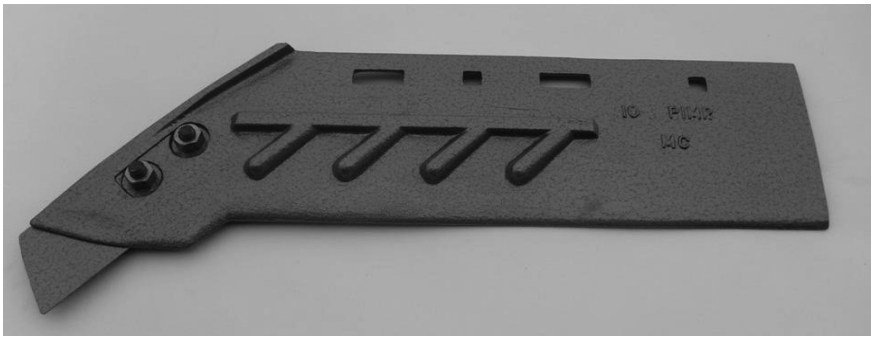


Fig. 14. Cast share for rotating and field plough with welt produced from spheroid ductile cast iron with austempering (ADI)

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KONSTRUKCJA I TECHNOLOGIA WYTWARZANIA ODLEWANYCH LEMIESZY DO PŁUGÓW OBRACALNYCH I ZAGONOWYCH

Streszczenie. W ramach pracy między innymi sformułowano wymogi jakim muszą sprostać lemiesze do pługów obracalnych i zagonowych z punktu widzenia tworzywa odlewniczego, jak też samej konstrukcji odlewu. Jako tworzywo odlewnicze przeznaczone na odlewy lemieszy próbnych wytypowano niskostopowe żeliwo sferoidalne hartowane z przemianą izotermiczną (ADI). Sporządzono wstępny model lemiesza dla potrzeb symulacji komputerowej. Na jej podstawie opracowano koncepcje modeli konstrukcyjnych lemiesza prawego i lewego do pługa obracalnego produkcji polskiej oraz nakładki do tych lemieszy. Następnie opracowano technologię i wykonano prototypową partię odlewów, którą przebadano pod kątem trwałości eksploatacyjnej.

Słowa kluczowe: maszyny i narzędzia rolnicze, narzędzia odlewane, lemiesze, eksploatacja narzędzi, zużycie trybologiczne.