

ON APPLICATION OF SPHEROIDAL GRAPHITE IRON FOR MACHINE PARTS

Fuad Begovac
University of Zenica, Faculty for Metallurgy and Materials
Travnička cesta 1, 72000 Zenica
Bosnia and Herzegovina

Dervis Pihura
University of Zenica, Metallurgical Institute "Kemal Kapetanović"
Travnička cesta 7, 72000 Zenica
Bosnia and Herzegovina

ABSTRACT:

Modern technologies ensure the quality and the economy of machine parts manufactured from spheroidal graphite cast iron. While, this technology is in large use in EC countries for half of century and the production volume increases continuously, in Bosnia customers are not too much interested in changing of their habit in connection with use of spheroidal graphite iron (SGI) castings. Up today analysis of research work quantity and foundry industry facilities, and previous production of the SGI castings, it is possible conclude that domestic foundry industry can take a part competitively of the supplying market of SGI castings, also.

Keywords: Spheroidal graphite iron castings, machine parts

1. INTRODUCTION

Presently, spheroidal graphite iron (SGI) castings are, in last decades only occasionally produced and used in domestic metal industry and, in this regard, the situation is contrary to that in industrial countries, where the use of SGI castings increases up to 10 % per year (Fig. 1) [1,2,3,4]. It is justified to expect that domestic industrial branches as energy, transport, agriculture, etc. will be forced for an increasing use of SGI castings, especially for movable and rotating machine parts, as for example:

- The increase of speed on railway requires the substitution of some steel cast parts, as for instance gears, with gears from SGI castings (Fig.1). These gears are used advantageously on operating on railways by the speed of hundred and more kilometres per hour and they are generally mechanical treated with reduction of dimensions up to 50 % [5,6,7].
- Automotive industry needs high quality machine cast parts. Domestic foundry industry has to set up for casting machine blocks from SGI, as well as other machine cast parts.
- In production of energy environmental protection machine parts, domestic energy industry will be faced soon. A great number of movable machine parts for the production of wind energy, except column, are made from SGI castings.

2. DOMESTIC INVESTIGATIONS AND DEVELOPMENT OF SGI CASTINGS

The investigation and development work of production of parts from SGI castings was started approximately three decades ago at the Metallurgical institute "Kemal Kapetanovic" and Faculty for Metallurgical and Materials in Zenica. The technology for the manufacturing of specific SGI machine parts was developed at Institute and than it was transferred to the former foundry of the company Energoinvest in Sarajevo, foundry in Ilijaš and other foundry daughter companies [5,6,7].

The investigations were aimed also to answer questions of broader importance, such as:

- The economics and quality of domestic production of SGI castings;
- The influence of hereditary properties due to the presence of residuals and impurities in the melting charge on the process of spheroidising and the final degree of nodularity;
- The influence of the nodularity and the microstructure on the mechanical properties;
- The effect of the optimal addition of alloys and of the processing parameters of spheroidising [6];
- Kinetics of spheroidising.

Many findings and the accumulated field experience could be still be used for the renewal of the suitable production SGI castings and other different castings [2,3,4], especially since the customers may inquire in connection of diagonally exclusive properties for some specific castings.

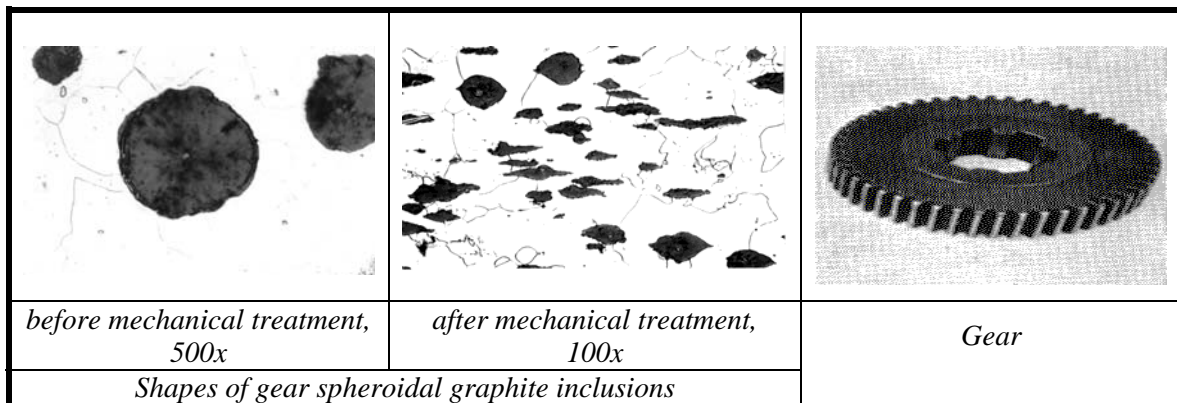


Figure 1. Shapes of gear spheroidal graphite inclusions before and after mechanical treatment of mechanically deformed SGI gear after up to 50 % of SGI castings reduction

Production, sampling and testing of SGI castings was in accordance with standard DIN EN 1563. The results of numerous investigations performed at Institute or abroad (Fig. 2) are transferred to domestic foundries. Examinations, investigations and testing have shown that it was possible to produce plenty of types and species of machine parts, i.e. gears from SGI, etc. Produced SGI castings were with specified mechanical properties and with suitable microstructure and suitable spheroidal graphite formations in accordance with standards from respect of type, shape, size and distribution.

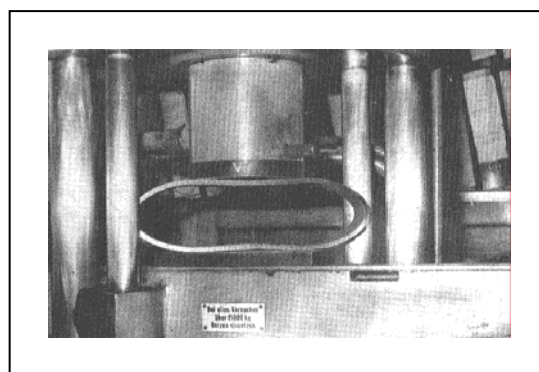


Figure 2. Mechanical testing of SGI castings of suitable test coupon

It is obvious influence of hereditary properties due to the presence of residuals and impurities. It is possible to pronounce that there is some interference of residuals and impurities, which change SGI castings properties, what is not in accordance with values of impurity index or pearlite number.

It is important to pronounce that it is possible to improve mechanical properties by heat treatment. Oxygen activity (a_o) was measured with suitable dipping sonde and values of a_o was below 5 ppm. It indicated that was difficult to expect the loss of carbon by oxidation.

Graphite flotation appears as problem because of lost of carbon by flotation up to 0,30 %. That causes some loss of carbon content after tapping from furnace. Some intervention graphite minimized flotation up to the lowest value.

3. CHARACTERISTICS OF SGI CASTINGS

It is clear that domestic production of castings from SGI material could be revived and improved for material substitution or the import. It is possible to produce castings from SGI for specific use and for substituting of actual of cast steel castings. The melting temperature is for SG cast iron is of about 300 °C lower than that for steel and it is in itself a significant advantage in saving energy and perhaps in ecological sense. This is, beside the better fluidity and the easier mechanical machining and the lower friction the explanation for the continuous increase of the production of machine parts from SGI in countries of EC and USA. It seems natural to expect that also domestic SGI castings should again take the place, as it has had in the foundry industry two decades ago, the more since a great part of the production was delivered to customers in foreign countries on particular terms of quality.

Gradually, year increase of the world production of SGI castings opens the question which grade of cast iron will overwhelm in castings production: SGI or LGI (lamellar), MGI (malleable) or CS (cast steel)? Malleable cast iron production started to decrease in the early 80-thies, while the SG cast iron production increases continuously, partly because the substitution or partly with new types of castings. The increase of SGI becomes clear from the comparison of the casting technology and the cast's properties in Fig. 3 and 4 [8]. The comparison accounts for several factors, such as: chemical analysis, mechanical properties, section and size of cast parts, processing time, assortment, energy consumption, total costs, sampling, testing and examination and control, etc [3,9,10].

The effect of SG formation on tensile strength can be calculated from the equation $R_m = (1 - e^{-\alpha E_0 \epsilon_t}) / \alpha$, (with: E_0 - modulus elasticity, α - factor of the dependence of E_0 and ϵ_t - elongation).

As the cast microstructure of SGI castings depends on the chemical analysis and cooling velocity and could consists of the constituents ferrite, pearlite and free carbides, it can be modified by additional heat treatment [11]. If compared with steel castings, SGI castings are less expensive, show a greater yield of the used melt. The consumption of energy for the production of SGI parts is for one third lower than that for cast steel parts. Also the investment costs for the SGI foundry are lower [3,4].

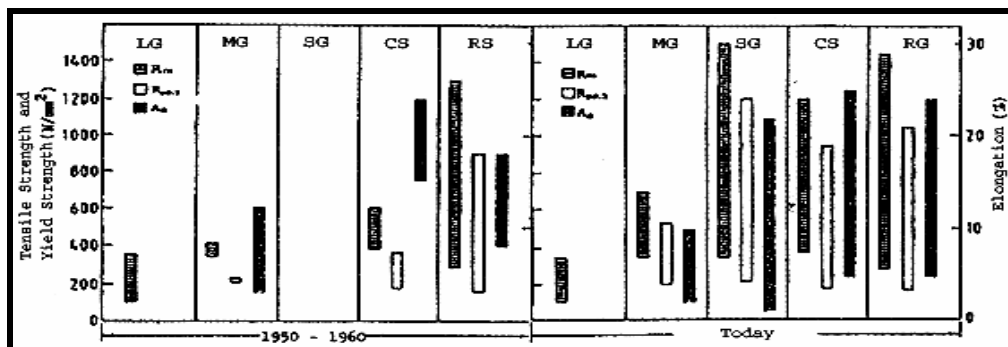


Figure 3. Mechanical properties of cast irons and steels and rolled steels for period 1950 - 1960 year (left) and 2000 (right) [3,9] (LG – Gray iron, MG – Malleable iron, SG – Spheroidal graphite iron, RS – Rolled steel, CS – Cast steel; R_m – Tensile strength, $R_{p0.2}$ – Yield strength, A_5 - elongation)

Basic advantages of SGI castings are accurate dimension, better uniformity of strength properties, less hot and cold cracking and easy heat treatability. Additional advantages of SGI castings are a lower coefficient of thermal expansion, lower shrinkage and piping, better damping properties, better fluidity, better machinability and lower surface scaling. Also, at SGI castings the effect of wall thickness on mechanical properties is smaller [2].

4. FURTHER DEVELOPMENT

The increasing market demand for better and uniform quality of castings and improved mechanical properties as well as the pressure for lowering costs require that foundries develop and use

improvement of technology and new castings grades. They have to perform this in a spite of the fact that already actual optimal combination of different properties is obtained for SGI castings (Fig 3). The world production of SGI castings increases rather fast. However, also methods for the production of parts competing for the same use as that of SGI castings, are being also constantly improved. The SGI foundry industry is forced to compete not only with other iron cast grades, but also other materials, potential substitutes. In this competition SGI castings seem to be in better position than other iron castings, because of the ecologically more friendly production process and better economy. With introduction of technological processes as ADI (Austempered Ductile Iron), etc., for increasing values of mechanical properties of SGI castings (Fig. 3 and 4), it appears possibility of rising the competitiveness of SGI castings, especially for use in more severe conditions of operation [11].

Properties	Cast Iron or Steel				
	Gray	Malleable	White	Steel	Spheroidal
Fluidity	Dark	Dark	Dark	Light	Dark
Machining	Dark	Dark	NA	Light	Dark
Damping	Dark	Dark	Dark	Light	Dark
Surface hardening	Dark	Dark	NA	Light	Dark
Modulus elasticity	Light	Dark	NA	Dark	Dark
Impact energy	Light	Dark	NA	Dark	Light
Corrosion resistant	Dark	Dark	Dark	Light	Dark
Strength / Mass	Light	Dark	NA	Light	Dark
Abrasion	Light	Dark	Dark	Light	Dark
Costs	Dark	Light	Dark	Light	Dark

The best The worst

Figure 4. Properties of cast ferrous materials [9,10]

5. CONCLUSION

The overall competition, involving production economy, make the SGI castings very suited for a number of applications for machine parts. Some technological processes offer possibility for more economic production and weight reduction of castings. The increased production and use of SGI castings is justified if the advanced technology and organisation are achieved and delivery of castings of quality satisfying the export market requirement. Quantity of domestic research work, existing facilities and previous production of the SGI castings indicates on successful substitution a large deal of existing machine parts programme of some important industries, also.

6. REFERENCES

- [1] [www.ductile.org/didata/Section 2/figures](http://www.ductile.org/didata/Section%20figures)
- [2] H. Roeder, 4th International foundrymen Conference - recent Development in the Castings Production; Faculty of Metallurgy, Preceedings Book. 1 - 10 and 76 - 79, Sisak, October 2002.
- [3] R. Hummer et al.: Giesserei, 88 (2001) 9-11, 49-55
- [4] "World Steel production", Worldsteel News, January (2005) 5
- [5] D. Pihura, Livarski vestnik, Ljubljana, 44(1997) 5 - 6. 161/5
- [6] D. Pihura "Production of SGI Castings Type GGG 40 for Istanbul's ISKI in Energoinvest-Steel Foundry - Sarajevo", Energoinvest, Sarajevo, 2000,
- [7] D. Pihura, "Nodularni ljev i dorada valjanjem", II međunatrodno savjetovanje NODULARNI LJEV NA PRAGU TREĆEG MILENIJA; Sisak, 2000.
- [8] F. Kritschtner: Livarski vestnik, (1996), 4, 1-15
- [9] "Gusseisen mit Kugelgraphite": Giesserei Kalender, (1985), 72-81,
- [10] P.M. Cabanne, Hommes & Fonderie, 306 (2000), Aout/Septembre, 18 - 22
- [11] C. Demirel et al., Fondery Trade Journal, 180 (2006), 3639, 286 - 288