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PARTICLE EROSION RESISTANCE OF DUCTILE CAST IRON

Krešimir Grilec
Suzana Jakovljević
Faculty of Mechanical Engineering and Naval Architecture
Ivana Lučića 5, Zagreb
Croatia

Denis Prusac
Technical school Zadar
Nikole Tesle 9c, Zadar
Croatia

ABSTRACT
Particle erosion is a wear loss from surface of solid body caused by a relative motion of fluid with solid particles. When impact angle is low (between 0° and 30°), this kind of erosion is called the abrasive erosion. On the other side, if the impact angle is between 60° and 90°, it is considered the impact erosion. One of the advantages of ductile cast iron in relation to other cast irons is its good wear resistance. However, we must consider that wear resistance depends on conditions of wear. Particle erosion resistance is a function of an impact angle and a kind of erosion particles. In this paper, samples of ductile cast iron were eroded with steel balls of two different sizes at six different angles of impact (15°, 30°, 45°, 60°, 75° and 90°). Test results were presented as a loss of mass, which occurred during the test. Wear scars were analyzed by scanning electron microscope.
Test results showed that ductile cast iron had a higher abrasive erosion resistance (impact angles 15° and 30°) comparing to its impact erosion resistance (impact angles 60°, 75° and 90°). The angle of 60° had a maximum measured wear.
Keywords: erosion resistance, ductile cast iron, abrasive erosion, impact erosion

1. INTRODUCTION
Ductile cast iron is cast pseudobinary iron-carbon alloy, where the graphite mostly having spherical shape, [1]. Ductile iron has high fatigue strength due to spherical shape of graphite, especially after quenching and tempering. Higher toughness can be achieved by austempering. Young's modulus of the ductile iron (approximately 180000 N/mm^2) is higher than the one of the grey cast iron. Furthermore, smothering of vibration is twice worse for the ductile than for the grey cast iron. Besides, ductile cast iron has good bearing properties and resistance to wear, corrosion and oxidation. The special properties (like resistance to aggressive media) can be achieved with alloying, [2].

2. PARTICLE EROSION
Particle erosion is a wear loss from surface of solid body caused by a relative motion of fluid with solid particles. When impact angle is low (between 0° and 30°), this kind of erosion is called the abrasive erosion. On the other side, if the impact angle is between 60° and 90°, it is considered the impact erosion, [2].
Particle erosion typically occurs in the following tribosystems: pump for mud, sand blast machine and pipeline for transport powder.

3. EXPERIMENTAL PART

The experiment was performed on samples of ductile cast iron produced in Shipyard in Split.

3.1. Chemical analysis

Quantitative chemical analysis of ductile cast iron is performed by spectrometer method on SPECTRUMAT-750 GDS Leco in Laboratory for Metal Analysis at Faculty of Mechanical Engineering and Naval Architecture in Zagreb.

Table 1. Analysis of chemical composition of ductile cast iron samples

	Mass portion, %								
	C	Si	Mn	P	S	Cu	Ni	Mo	Mg
Ductile cast iron	2,34	2,72	0,72	0,054	0,011	1,14	0,095	0,016	0,033

3.2. Microstructural analysis

Microstructural analysis is performed in Laboratory for Metallography at Faculty of Mechanical Engineering and Naval Architecture in Zagreb. The microstructure of ductile cast iron sample is shown on figure 1 (ferrite-pearlite matrix). Volume portion of phases are shown in table 2.

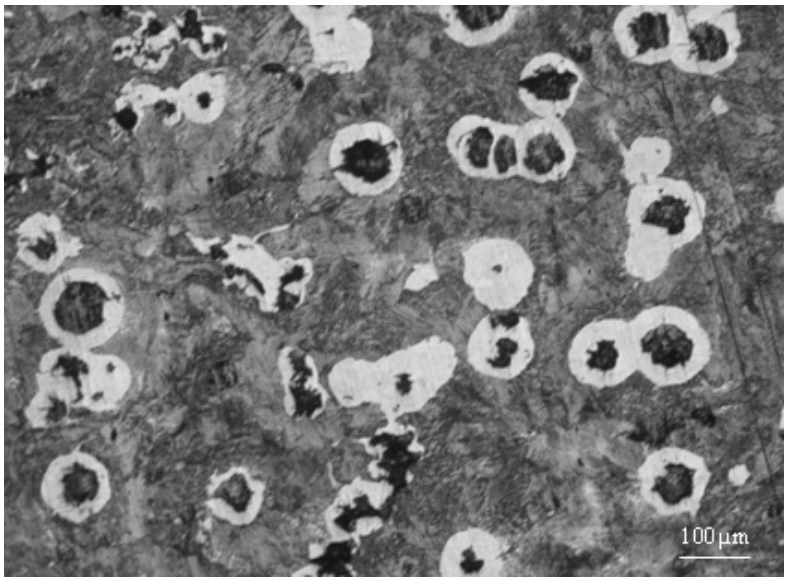


Figure 1. Etched sample of ductile cast iron

Table 2. Volume portions of ductile cast iron phases

Phase	Volume portion, %
graphite	13
ferrite	24
pearlite	63

3.3. Hardness measurements

Measurements of hardness were performed in Laboratory for Testing Mechanical Properties at Faculty of Mechanical Engineering and Naval Architecture in Zagreb.

Table 3. Brinell hardness HB 2,5/1840

	d, mm	HB
1.	1,01	224
2.	1,02	219
3.	1,00	229
4.	1,01	224
5.	1,00	229
mean value	1,01	225

3.4. Test of solid particle erosion resistance

Test of solid particle erosion resistance with steel balls was performed in Laboratory for Tribology on Faculty of Mechanical Engineering and Naval Architecture in Zagreb. The particle erosion tester is shown in Figure 2 (detail are shown in Figure 3)

Figure 2. Particle erosion tester

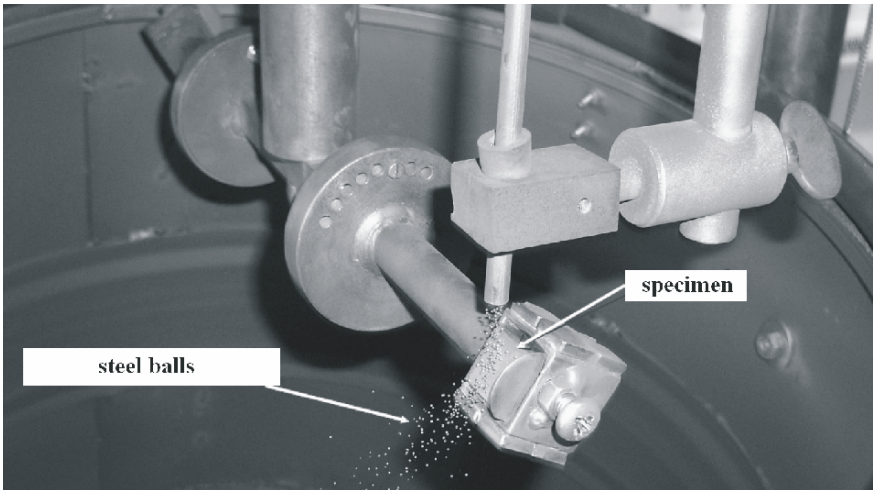


Figure 3. Testing of solid particle erosion

Testing parameters:

- abrasive: steel balls (diameter ϕ700μm and ϕ1100μm)
- revolution: 1440 rev./min
- time of testing: 13min 53 sec
- number of impacts: ~20000
- impact angles: 15°, 30°, 45°, 60°, 75° and 90°
- dimension of samples: 18×18×18 mm

Table 4 and Figure 4 show results of particle erosion testing.

Table 4. Results of particle erosion testing

Impact angle	Mass loss Δm, g	
	Balls ϕ 700	Balls ϕ 1100
15°	0,0008	0,0018
30°	0,0009	0,0020
45°	0,0031	0,0048
60°	0,0044	0,0064
75°	0,0025	0,0045
90°	0,0020	0,0020

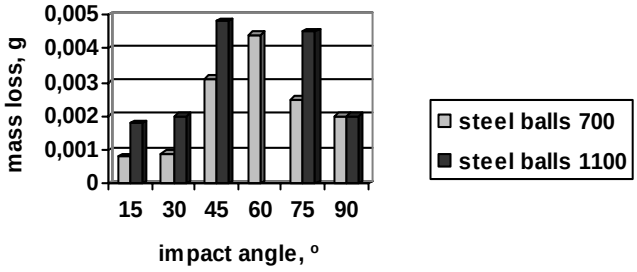
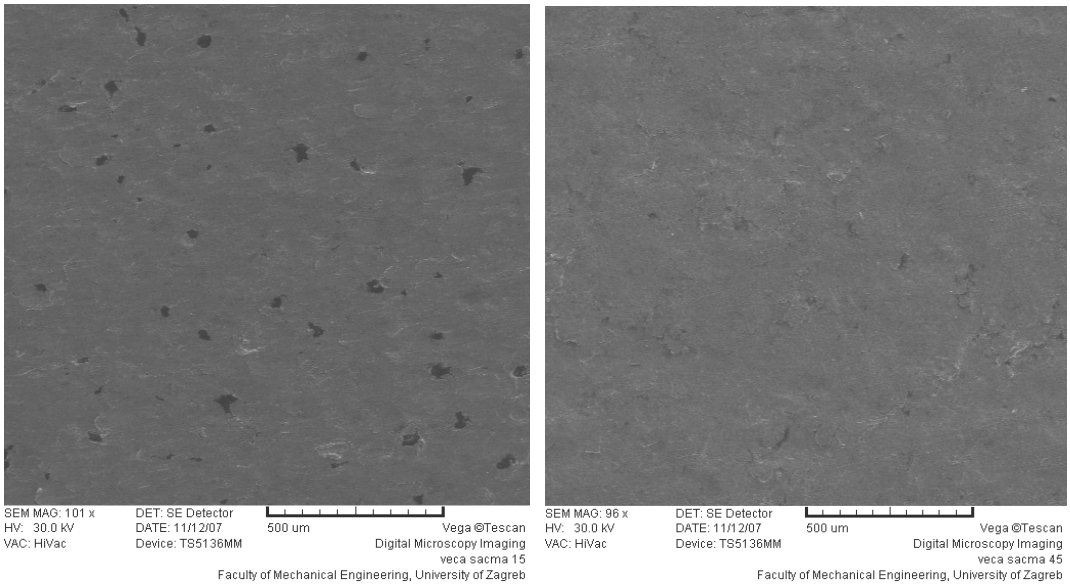


Figure 4. Mass loss of ductile cast iron samples

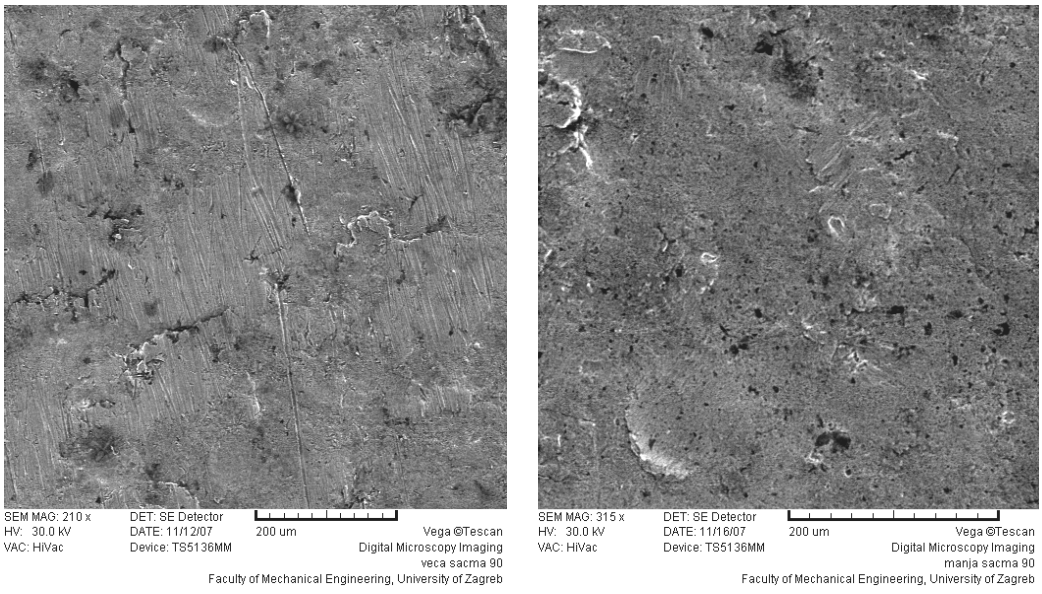
Table 4 and figure 4 show that abrasive erosion resistance (impact angles 15° and 30°) of ductile cast iron was better comparing to its impact erosion resistance (impact angles 60°, 75° and 90°). The maximum measured wear was at 60°.

Figure 5 and 6 show eroded surfaces analyzed by scanning electron microscope. It is visible that nodular graphite appeared in the eroded surface at impact angle of 15°. At impact angle of 45°, nodular graphite is not visible. Wear scars were more observable when the test was performed with steel balls of bigger diameter.



a) *b)*

Figure 5. Specimen surfaces eroded at different impact angle a) angle 15°, b) angle 45°



a) *b)*

Figure 6. Specimen surfaces eroded with different steel balls a) ϕ700, b) ϕ1100

4. CONCLUSION

Test results showed that ductile cast iron had a higher abrasive erosion resistance (impact angles 15° and 30°) comparing to its impact erosion resistance (impact angles 60°, 75° and 90°). The angle of 60° had a maximum measured wear. When increasing the impact angle, nodular graphite becomes less visible.

5. REFERENCES

[1] M. Novosel, D. Krumes: "Željezni materijali, I. dio: Lijevovi", Strojarski fakultet u Slavonskom Brodu, Slavonski Brod, 1994.

[2] ...., Glossary of terms and definitions in the field of friction, wear and lubrication -- tribology, OECD Publications, Paris 1969

[3] V. Ivušić: "Tribologija", Hrvatsko društvo za materijale i tribologiju, Zagreb, 2002.