RESEARCH

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Correlation Between Machinability Index and Gray Iron Structural Parameters

Gray iron machinability is one of its most important characteristics. A complex approach to the aim assumes respecting of the direct influence of the casting process to the machinability parameters of the castings. Basic parameters machinability is, before all, gray iron structure which depends on its chemical composition, melting conditions, modification, raw material quality and other factors.
The paper present research results between machinability and gray iron qualitative and quantitative microstructure parameters.

Keywords: machinability, gray iron, microstructure, casting

1. INTRODUCTION

Gray iron machinability, as one of more important gray characteristics, has always been watched from the aspect of cutting control, cutting speed, cutting blade structure, type of hard coating and other technological factors and very rarely, or almost never, from the aspects of structure and material characteristics is, in fact, the basic point of this paper.

Highly productive automatic transfer machines for castings, as it is the case with breaking drums, at high cutting speeds require constant cutting resistances and any variation represents a serious problem at large casting series. For that reason, the target aim of this paper was to promote casting technology in the function of machinability casting advancement.

2. RESEARCH PROGRAMME

The preparation and casting of the test batches was carried out in four ton induction furnaces, using the following charge make up:

- steel motor car body sheet packed in bales,
- returned grey iron (scrap castings, runners and risers),
- carburising and alloying agents.

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All the charge conditioning and alloying materials were pre-analyzed and were added to the charge in the furnace.

After the first batch of castings, was poured, the melt underwent chemical analysis on a Philips *PV 8300* emission spectrometer.

Previously modified liquid metal, prepared in this way, was cast into moulds with a 0.1% SiCa based inoculant. The first cast was followed by batch correction inside the induction furnace and chemical analysis repeated.

Table 1 shows the results of chemical composition tests.

Table 1. Chemical composition of liquid metal

No	Element	Content	
		First batch	Second batch
1.	Carbon	3.00	3.10
2.	Silicon	1.80	1.90
3.	Manganese	0.50	0.85
4.	Boron	0.076	0.032
5.	Phosphorus	0.045	0.054
6.	Sulphur	0.042	0.060
7.	Aluminium	0.030	0.028

Before casting into the moulds, the liquid metal from the second batch was also modified with 0.1%SiCa.

2.2. Drum machinability tests

Cutting resistances F1, F2 and F3 were measured as the parameters to define the machinability index without the application of a cooling agent.

Operations on the test samples were carried out on a universal lathe using accepted computer supported regimes:

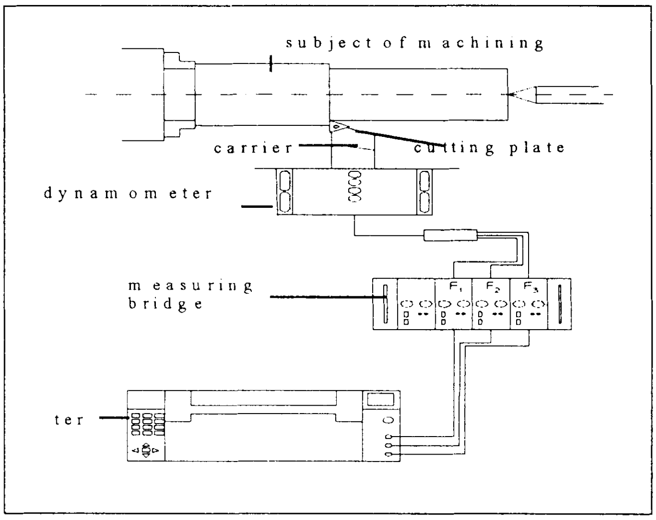

Figure 1. Three component dynamometer

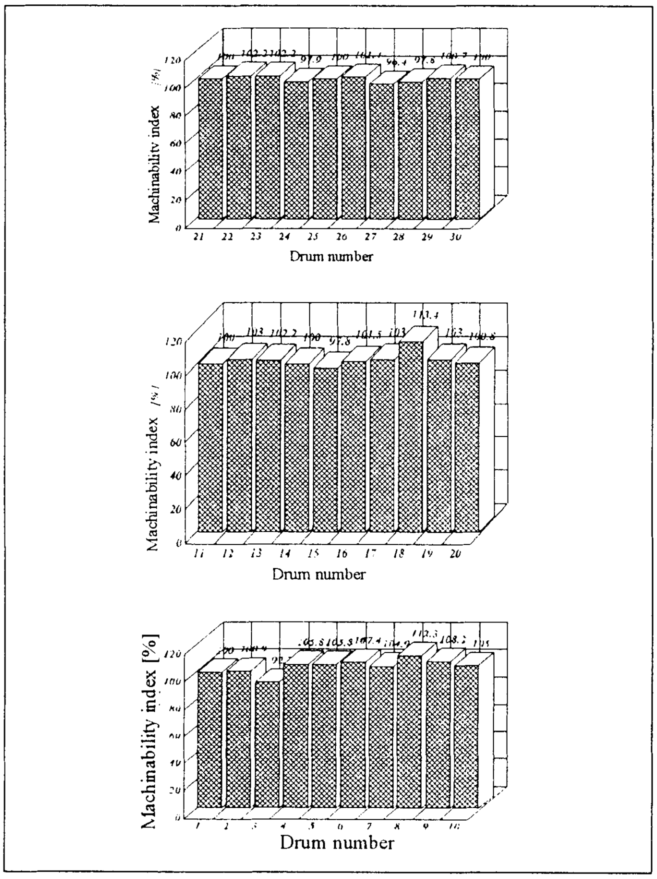

Figure 2. Mean values of machinability index for series 1 (top), series 2 (middle) and series 3 (bottom)

Chemical composition of liquid metal

Coromant SNMA: 120412 Sandvik plate;

Number of revolutions: n=560rpm

Pitch: S=0.112mm/r

Cutting depth: d=0.3mm

3. MEASURING INSTRUMENTS

A dynamometer, connected to the tool carrier *via* tensiometrically resistant feeds, passing the signal through a measuring bridge to amplifier and a recorder (figure 1) was used to measure F1, F2 and F3 cutting resistances and machinability index.

4. MIKROSTRUCTURE TEASTING

Metallographic tests were carried out on samples obtained by cutting pieces from a ring shaped part of the drum which had had its machinability characteristics monitored:

- qualitative microstructure tests
- microstructure assay.

Qualitative microstructure tests were performed according to DIN/69/1964 standard for:

- metal base microstructure
- graphite shape, arrangement and size.

Quantitative microstructure tests were carried for graphite plates representative samples, obtained from all three batches:

- graphite plates surface A_A; m m^2
- perimeter (circumference) La, m m
- gap between graphite plates L_{osn} m m
- graphite plates width L_{gr}, m m.

Other values important for cast microstructure quality assessment were calculated on the basis of the above-mentioned measurement of physical values.

5. RESULTS OF TESTING

The procedure for establishing material machinability characteristics by measuring corresponding cutting resistance components is based on the differences that exist in the formula F1=f(T) for the different series of machining tests when other machining conditions are kept constant.

Because of limited space, only the mean values of the machinability index for both passes of the main cutting resistance (F1) for all three batches are shown (figure 2).

Table 2. Structural graphite parameters of grey iron

No	Samples / charge	Distance between graphite plate Losn (μm)			A_A (μm)			L_A $(\mu m)^2$			Graphite plate width (LGR) ((μm)			Rm N/m ^{2}	HB	N_a x 10^{-3} μm^{-2}	S_V $\mu m^2/m^3$
					min	max	sr	min	max	sr	min	max	sr				
1.	41/I	0.58	11.6	13.9	0.29	225	7.33	2.54	331	19.53	0.16	4.0	0.96	195.3	150.3	9.07	24.8
2.	23/II	1.43	172	24.9	0.39	434	19.8	5.1	362	370	0.25	4.75	1.4	290.1	207	3.48	47.1
3.	29/II	1.35	202	24	0.77	295	19.8	3.6	428	34.9	0.20	5.4	1.55	284.5	208	3.49	44.32
4.	17/III	1.21	150.3	16.6	0.05	257	12.4	0.27	280	26.8	0.01	3.6	1.5	346.3	225	4.91	34.04
5.	19/III	1.43	153	21.6	0.61	182	12.8	5.13	271	28.6	0.07	4.08	1.27	366.6	227	5.68	36.3

6. QUANTITATIVE METALLOGRAPHIC TESTS

Table 2 shows the results of measured values that quantitatively define the microstructure of the castings tested.

Figs 3-7 show correlation between the measured parameters of castings microstructure and machinability index for representative samples from all three batches.

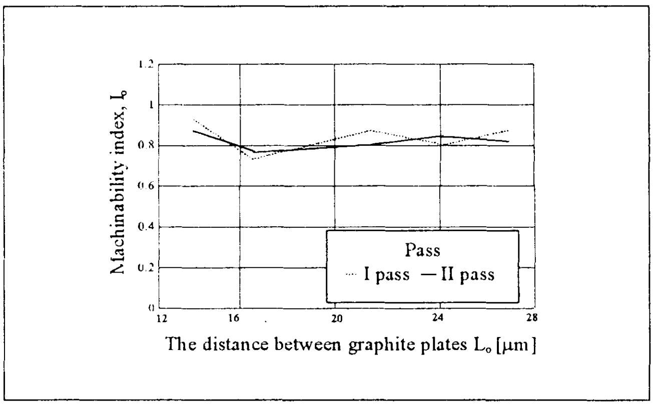

Figure 3. Correlation between machinability index and plate surface

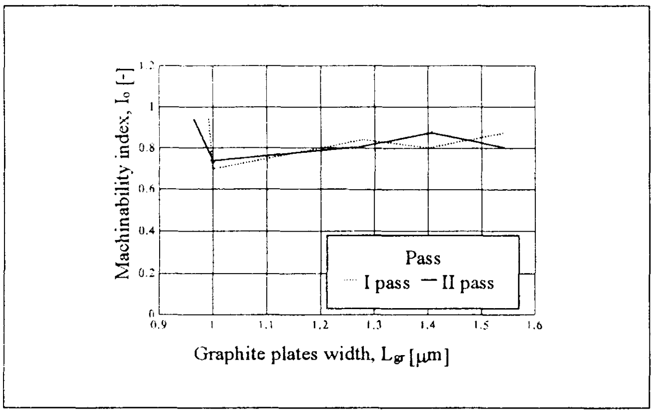

Figure 4. Correlation between machinabilityindex and surface

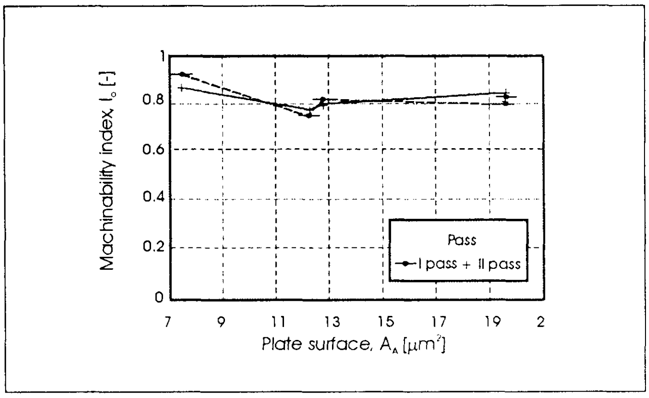

Figure 5. Correlation between machinability index and the distance between graphite plates

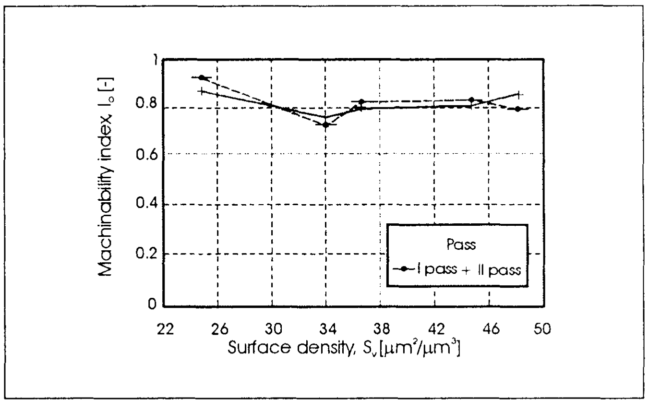

Figure 6. Correlation between machinability index dependence of graphite plate width

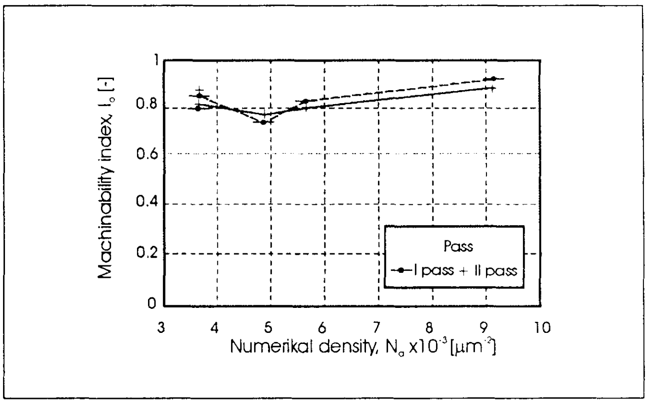

Figure 7. Machinability index dependence on numerical density

7. CONCLUSION

- Obtained results point out the existence of non - unified machinability of tested drums within the same charge.
- It is observed that value machinability index at the third charge is slightly worse than at the second one regardless of increased mechanical properties (Rm and HB results are not presented in this paper). This is the consequence of better inoculation of liquid metal of the third charge relative to the second one.
- With the increase of numeric density N_a, surface of lamella A_A surface density S_V and width of graphite lamellas L_{GR}, also the machinability index is increased if metal base is the same.
- Significantly bigger index of machinability of castings from the first charge relative to the second and the third charge is the result of presence of larger share of ferrite in metal base.

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