ARCHIVES of FOUNDRY ENGINEERING

Published quarterly as the organ of the Foundry Commission of the Polish Academy of Sciences

ISSN (1897-3310)
Volume 9
Issue 3/2009

173 – 176

31/3

An attempt of assessing the production perspectives concerning malleable iron castings

M.S. Soiński[a]*, D. Trepka[a], K. Lewandowski[b]
[a]Chair of Foundry, Technical University of Częstochowa, av. Armii Krajowej 19, Częstochowa, Poland
[b]Research worker emeritus of Foundry Institute, Cracow, Poland
*Corresponding author. E-mail address: soinski.ms@wip.pcz.pl

Received 20.04.2009; accepted in revised form 24.04.2009

Abstract

The paper presents a historical outline of production of the malleable cast iron castings on the territory of Poland during the past over a hundred years. There have been also gathered data concerning the total quantity of castings and the quantity of malleable iron and nodular iron castings produced in twelve selected countries over the period from 1993 to 2006. The percentage of malleable iron to total production of castings, and for a purpose of comparison the percentage of nodular cast iron to total production of castings, has been determined for these countries. A distinct decreasing tendency can be seen with respect to the production of malleable iron castings, while an increasing trend exists in production of nodular iron castings.

Keywords: Ductile iron, Nodular cast iron, Production

1. Introduction

One of the cast iron types of already several hundred years' tradition is malleable iron. Beginnings of the production of castings made of this alloy reach the XVII century. Then in England the first patents concerning this material have been registered. In 1804 S. Lucas obtained a patent on production of malleable cast iron by annealing of the initial cast iron in iron ore being an oxygen carrier; it was used for the decarburization of castings [1]. In 1826, basing on his practice gained in England, Seth Boyden started production of malleable cast iron in USA [2]. Thanks to the properties of local raw materials he achieved for the first time blackheart malleable; for a long time it has been called American malleable. The production of pearlitic malleable is mentioned as early as in 1820, however its mass production was started in the thirties of the XIX century. At the same time the pearlitic malleable with nodular pearlite was for the first time produced in USA. Since that time many various types of pearlitic malleable have been manufactured in USA [1].

Malleable cast iron was for the first time mentioned in Polish in 1820. The first foundry producing malleable on the territory of (then partitioned) Poland (about 1880) was owned by A. Zarzecki and placed in Cracow [1].

The following foundry started in 1892. This was Ernest Erbe's Manufacture of Forged and Cast Products, nowadays called the EE S.A. Cast Iron Foundry in Zawiercie. Since 1916 there has existed Iron Foundry and Machine Manufacture in Drawski Młyn.

In 1934 the production of castings made of 'malleable cast of black core', i.e. of blackheart malleable, was begun by The Casting House in Drawski Młyn, and has been continued up till now, the name of factory being meanwhile changed to the Cast Iron Foundry 'DRAWSKI'.

It should be mentioned that in 1937 The Casting House in Drawski Młyn overtook almost completely the production of malleable castings for 'Polski Fiat' motor cars and 'Sokół' motorcycles. The high level of technology implemented in Drawski Młyn is confirmed by the fact that the foundry exported castings of blackheart malleable to some French factories [2].

Up to 1937 there existed twelve foundries producing malleable cast iron in Poland, and seven of them continued this production after the Second World War. Since 1957 fourteen foundries have produced malleable in Poland, two of them mastering the production of whiteheart malleable.

The production of malleable in Poland gradually increased during the subsequent years, reaching over 69 thousand tons by year by the end of the sixties of the last century. Since the total amount of produced ferrous alloy castings exceeded then 2.7 million tons, this gave about 2.5% of the total production. The end of the eighties brought a decrease of production of castings, also of those of malleable cast iron. In 1991 only 26.3 thousand tons of malleable castings were produced, what gives the decrease by 62.2% as compared with the year 1980.

2. Production of castings in the selected twelve countries, 1993-2006

Table 1 gathers quantities of the total production of castings and the production of castings made of malleable and nodular cast iron over the years 1993-2006. The schedule includes only the countries which belong to the group of the largest producers of castings in the world.

Table 1.
Amounts of the total production of castings and the production of malleable and nodular iron castings in the selected countries over the years 1993-2006 [3-15]

	Quantity of produced castings (in metric tons)											
	Brazil			China			France			Spain		
Year	Total	Malleable iron	Nodular iron	Total	Malleable iron	Nodular iron	Total	Malleable iron	Nodular iron	Total	Malleable iron	Nodular iron
1993	1485000	lack of data	lack of data	12355580	404200	1267840	2027259	10121	810093	624800	16000	170000
1994	1485000	lack of data	lack of data	11626170	364590	1321230	2269913	10261	869192	624800	16900	170000
1995	1610005	30393	302666	11332000	422195	1341049	2269913	10261	869192	847700	21500	296000
1996	lack of data	lack of data	lack of data	10903200	367300	1434900	2269900	10300	869200	868900	22000	297000
1997	1575364	27297	307161	11080442	354454	1564066	2433951	9558	955449	895000	22300	318000
1998	1570000	29000	329000	10194006	293488	1431238	2588953	12831	1036578	848500	21000	298000
1999	1573952	32861	361458	12647476	359923	2063192	2490413	10542	963869	1188000	22600	480000
2000	1810000	33000	379000	10954629	400594	2333470	2665192	8268	lack of data	1188000	22600	480000
2001	1760000	27000	387000	14888992	428235	2730160	2527146	5860	lack of data	1572300	22600	617000
2002	1970631	23189	493652	16261563	451788	2994986	3018180	lack of data	lack of data	1628620	22750	642600
2003	2249413	lack of data	lack of data	18145966	400000	3630000	2484527	lack of data	1095100	1149678	lack of data	420000
2004	2829916	50165	596989	22420452	570620	5603410	2465617	lack of data	1000900	1309249	lack of data	551800
2006	3087045	21014	750432	28094168	517214	6843019	2408241	1358	1071145	1330001	17300	623000
	India			Japan			Germany			Poland		
1993	1575615	72140	36239	6681781	156447	1991542	3475871	75299	899291	750650	28070	52040
1994	2875000	110000	120000	6740690	147350	2016488	3815174	78520	979231	794940	30620	59000
1995	3061000	88000	180000	6978741	146959	2082027	4140276	77000	1062000	853750	30050	70000
1996	lack of data	lack of data	lack of data	6957200	142400	2140500	3932100	52000	1056000	824400	24900	96400
1997	3385900	95500	198400	7082427	137699	2159115	4120048	49000	1136000	799000	25900	120000
1998	3385900	85500	198400	6223596	107736	1965505	4448692	49584	1254217	707850	24650	81000
1999	3240000	50000	260000	5972122	101566	1897055	4332639	43989	1216470	694200	18700	86500
2000	3120000	40000	250000	6276320	97771	1937507	4542010	37968	1316431	753600	20300	90500
2001	3155000	30000	285000	5841175	92884	1806671	4643430	39490	1269392	745200	18300	105200
2002	3267000	30000	300000	5751760	81064	1742123	4595442	38277	1276751	660086	14642	101907
2003	4038000	39000	363000	6111405	81173	1930529	4722583	38994	1342280	729400	15700	93200
2004	4623000	40000	442000	6386449	77366	1894832	4984473	52597	1428394	804500	24300	99900
2006	7179300	62300	762000	7927626	56401	2035845	5480900	56103	1661189	849020	24400	129400
	Turkey			Ukraine			USA			Great Britain		
1993	791700	11600	69500	lack of data	lack of data	lack of data	11713500	215100	3334500	1244500	19000	385000
1994	728680	11330	75000	lack of data	lack of data	lack of data	13267000	234000	3691000	1268600	20000	392000
1995	800160	12960	79700	998045	26045	23000	14428000	249000	4027000	1371700	21500	416000
1996	lack of data	lack of data	lack of data	lack of data	lack of data	lack of data	14074000	232000	4034000	1452000	22000	454000
1997	941599	14000	86549	998800	26000	23000	14333000	207000	4128000	1453100	22000	410000
1998	959700	12000	123000	929271	23000	28000	13223700	204300	3771000	1924300	27400	716100
1999	874120	7550	136000	840948	18000	24000	13710000	184000	3999000	1924300	27400	716100
2000	965000	7000	130000	947239	18000	30000	lack of data	lack of data	lack of data	968200	18200	356000
2001	905800	7800	132000	1369150	12500	85000	11871000	143100	3591000	968200	18200	356000
2002	921600	7600	139000	974170	10000	40000	11811742	115214	3703190	886300	15300	326000
2003	955000	6000	187000	974170	10000	40000	12069563	105233	3828300	1221500	lack of data	366500
2004	982000	6000	308000	974170	10000	40000	12314121	163293	4014292	1273000	14000	362000
2006	1209500	6500	368000	974140	10000	40000	12454738	lack of data	4128598	1100000	10000	335000

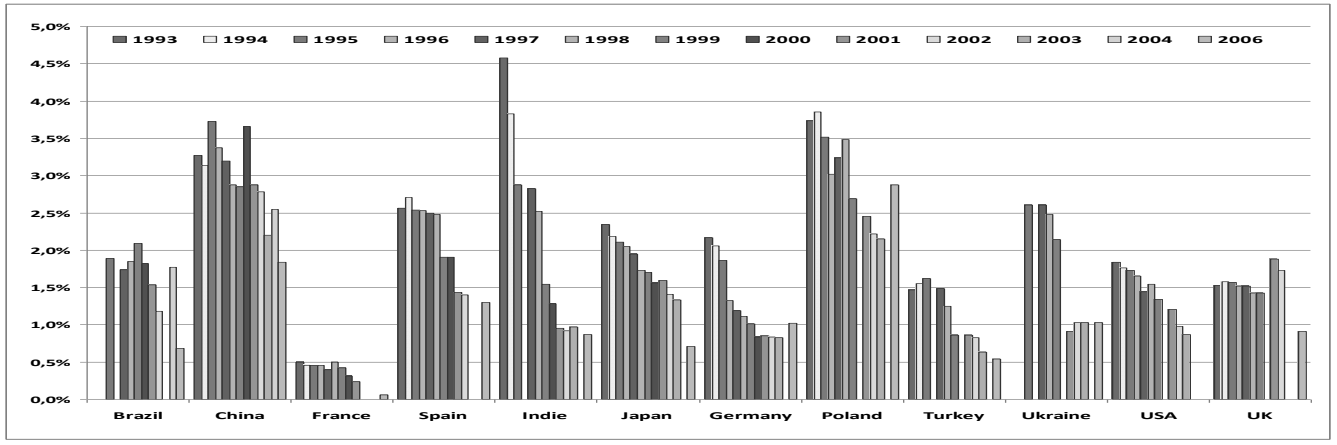

Fig. 1. The contribution of malleable iron castings to the total amount of castings produced in the selected 12 countries. The subsequent bars from left to right refer to the successive years from the period 1993-2006. If data are lacking, the bar is omitted [3-15]

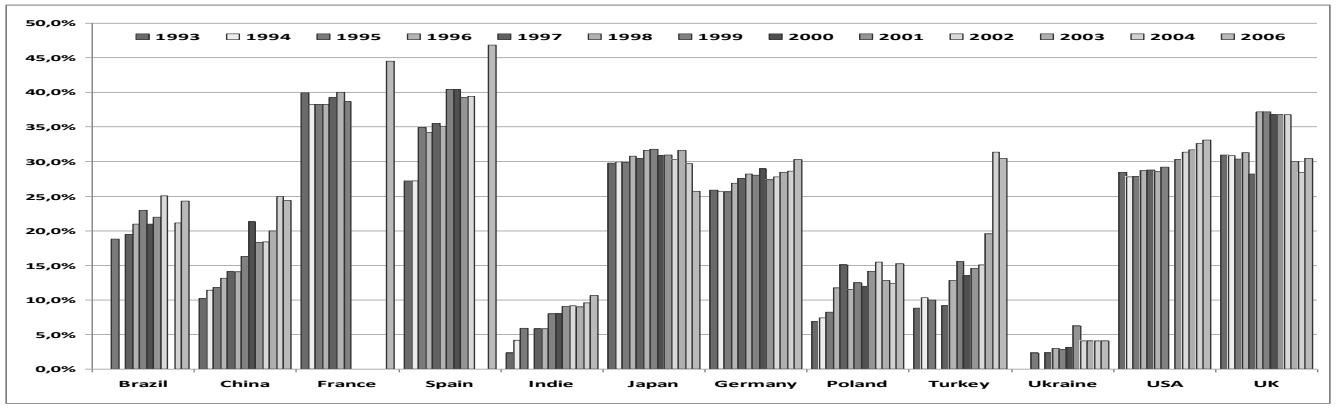

Fig. 2. The contribution of nodular iron castings to the total amount of castings produced in the selected 12 countries. The subsequent bars from left to right refer to the successive years from the period 1993-2006. If data are lacking, the bar is omitted [3-15]

The data in Table 1 allow for looking over the changes in production quantity which took place in the individual countries over the period of 15 past years. An increase in production over this period is particularly distinct in:

- Brazil – from about 1.5 million tons to about 3.1 million tons,
- China – from about 12 million tons to about 28 million tons,
- Spain – from about 0.6 million tons to about 1.3 million tons,
- India – from about 1.6 million tons to about 7.2 million tons,
- Germany – from about 3.5 million tons to about 5.5 million tons,
- Turkey – from about 0.8 million tons to about 1.2 million tons.

Figure 1 presents the contributions of the produced malleable iron castings to the total production of castings in the considered countries over the years 1993-2006. For comparison, Figure 2 shows similar data with respect to the nodular iron castings.

3. Conclusion

A comparison of a series of data given e.g. in standards concerning the malleable cast iron [16] and nodular cast iron [17] allows for stating that the mechanical properties of both materials are quite similar in many cases. For example the tensile strength of blackheart malleable can exceed 800 MPa and the elongation of whiteheart malleable can be higher than 12%. In some cases, e.g. when there is a necessity of eliminating the influence of the wall thickness on the structure and mechanical properties of a casting, the malleable iron still prevails over the nodular cast iron.

Nevertheless the analysis of data from Table 1 does not allow for any illusions, the production of castings made of malleable cast iron permanently decreases. The Figure 1 distinctly shows that the fraction of castings made of this alloy in the total amount of produced castings also decreases. Ten or fifteen years ago the fraction of castings made of malleable in total casting production of the analysed countries exceeded 2.5% only in China, Spain, India, Poland, and Ukraine. In the last analysed year 2006 casting production in Poland was characterised by the highest fraction of malleable iron castings among all the considered countries; it was equal to 2.9%. It can be estimated that the fraction of malleable

iron castings in total casting production of the highly developed countries, such as Japan, Germany, USA, Great Britain, is at present at the level of 1%; and in France is maintained at 0.5% for last several years. It should be added that the production of malleable iron castings has distinctly fallen down (to about 1% fraction) in Brasil, Spain, India, Turkey, and Ukraine during recent several years.

A comparison between the fractions of malleable iron castings and nodular iron castings in the total casting production (see Figs 1 and 2) allows for stating that the production drop concerning the production of casting made of the first of the above mentioned alloys is as a rule accompanied by an increase in the production of nodular iron castings. This takes place for the case of Brazil, China, Spain, India, Germany, Poland, Turkey, Ukraine, USA, and Great Britain. The fraction of nodular iron castings was kept at a constant, but relatively high level in two of the considered countries: France (about 40%) and Japan (about 30%).

The decreasing significance of production of malleable iron castings is related to the high production costs. They result from the remarkable energy consumption of the technological process; beside the energy necessary to produce 'common' castings, the additional significant amount of energy in the case of malleable is consumed by heat treatment.

It should be also stressed that the yield, defined as the ratio of mass of good castings to the mass of the ??? molten metal, stays at a remarkably low level for the case of malleable cast iron. It equals to about 33%, according to the authors of the Ref. [18], while its average value for ferrous alloys (in Poland in the period 2005-2006) it was at about 59% level.

The performed analysis allows for stating that malleable cast iron is not a material of further development potential. Its contribution to the total production of castings permanently decreases (mainly in favour of nodular cast iron), and its relatively high fraction in the total amount of casting production in Poland (as compared with other countries) is not very promising.

References

[1] J. Rączka, Malleable cast iron, PWT, Warsaw (1961) (in Polish).

[2] American Malleable Iron. A Handbook, Malleable Founders Society, Cleveland (1944).

[3] A review of foreign technical reports. March-April 1995; Foundry Review (Przegląd Odlewnictwa), No.2 (1995) 12 (in Polish).

[4] Foundry Review (Przegląd Odlewnictwa), No.3 (1996) 77 (in Polish).

[5] Information bulletin of the Foundry Chamber of Commerce, Cracow, March, No. 3 (1997); Foundry Review (Przegląd Odlewnictwa), No. 3 (1997) 6 (in Polish).

[6] J. Marcinkowski, Foundry practice in Poland and other selected countries, Foundry Review (Przegląd Odlewnictwa) No. 6 (1998) 195 (in Polish).

[7] Information bulletin of the Foundry Chamber of Commerce, Cracow, March, No. 3 (1999); Foundry Review (Przegląd Odlewnictwa), No. 3 (1999) 8 (in Polish).

[8] Information bulletin of the Foundry Chamber of Commerce, Cracow, March, No.3 (2000); Foundry Review (Przegląd Odlewnictwa), No. 3 (2000) 11 (in Polish).

[9] Information bulletin of the Foundry Chamber of Commerce, Cracow, February, No.2 (2001); Foundry Review (Przegląd Odlewnictwa), No. 2 (2001) 8 (in Polish).

[10] Information bulletin of the Foundry Chamber of Commerce, Cracow, February, No. 2 (2002); Foundry Review (Przegląd Odlewnictwa), No. 2 (2002) 3 (in Polish).

[11] Information bulletin of the Foundry Chamber of Commerce, Cracow, January, No. 1 (2003); Foundry Review (Przegląd Odlewnictwa), No. 1 (2003) 2 (in Polish).

[12] Information bulletin of the Foundry Chamber of Commerce, World production of castings in 2002, Cracow, March, No. 3 (2004); Foundry Review (Przegląd Odlewnictwa), No. 3 (2004) 263-264 (in Polish).

[13] Foreign News, A record of world production of castings in 2003, Foundry Review (Przegląd Odlewnictwa), No. 6 (2005) 421– 422 (in Polish).

[14] „Światowy Spis Produkcji Odlewów - 2004", Foundry Review (Przegląd Odlewnictwa), No.3(2006)128 (in Polish).

[15] J. Marcinkowski, World production of castings, Foundry Review (Przegląd Odlewnictwa), No. 1-2 (2008) 33.

[16] PN – EN -1562 : 200 Standard. Foundry. Malleable cast iron (in Polish).

[17] PN – EN -1563 : 200 Standard. Foundry. Nodular cast iron (in Polish).

[18] M. Holtzer, I. Karkulewicz, K. Olendrzyński, Estimation of CO_2 process emission during the production of ferrous alloy castings, Foundry Review (Przegląd Odlewnictwa), No. 5-6 (2008) (in Polish).