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The Leading Role of Aluminium in the Growing Production of Castings Made of the Non-Ferrous Alloys

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Abstract

The paper presents changes in the production volume of castings made of non-ferrous alloys on the background of changes in total production of casting over the 2000-2019 period, both on a global scale and in Poland. It was found that the dynamics of increase in the production volume of castings made of non-ferrous alloys was distinctly greater than the dynamics of increase in the total production volume of castings over the considered period of time. Insofar as the share of production of the non-ferrous castings in the total production of castings was less than 16% during the first two years of the considered period, it reached the level of 20% in the last four years analysed. This share, when it comes to Poland, increased even to the greater degree; it grew from about 10% of domestic production of castings to over 33% within the regarded 2000-2019 period. The greatest average annual growth rate of production, both on a global scale and in Poland, was recorded for aluminium alloys as compared with other basic non-ferrous alloys. This growth rate for all the world was 4.08%, and for Poland 10.6% over the 2000-2019 period. The value of the average annual growth rate of the production of aluminium castings in Poland was close to the results achieved by China (12%), India (10.3%) and the South Korea (15.4%) over the same period of time. In 2019, the total production of castings in the world was equal to about 109 million tonnes, including over 21 million tonnes of castings made of non-ferrous alloys. The corresponding data with respect to Poland are about 1 million tonnes and about 350 thousand tonnes, respectively. In the same year, the production of castings made of aluminium alloys was equal to about 17.2 million tonnes in the world, and about 340 thousand tonnes in Poland.

Keywords: Foundry production, Non-ferrous alloys, Aluminium alloys

1. Introduction

Castings accompany man for about five thousand years [1], and the modern casting technologies are considered as basic methods of production both of elements of various machines and devices, as well as other items, for example artistic ones or the products used in medicine [2-6]. Both the materials, i.e. metals and alloys used for the production of castings, and the production

methods evolved and changed over the past years. The unceasing struggle for bringing the product structure to perfection, for example by decreasing the product mass, which is of particular importance not only for the means of transport, but also for a series of other product (e.g. in the IT industry, in control and measuring devices, in household appliances, or recreational and sport equipment), always led and still leads to the interest in light metals and, even more, in their alloys.

According to J. Jemielewski [7], metals probably appeared on the world stage in the following order: copper, silver, tin, bronzes, lead, iron. Nowadays, beside the iron-based alloys which were the most commonly used materials for the production of castings for many years, the non-ferrous alloys are more and more frequently applied in foundry production. The non-ferrous metals can be classified according to various criteria; one of them is the division into light and heavy metals, and the boundary value separating these groups is the density of $4.5 \text{ g}\cdot\text{cm}^{-3}$ [8]. Jemielewski [7] distinguishes also the group of very heavy metals (with density exceeding $13 \text{ g}\cdot\text{cm}^{-3}$). Light metals of significant practical value include mainly magnesium (density $\rho = 1.738 \text{ g}\cdot\text{cm}^{-3}$), beryllium ($\rho = 1.848 \text{ g}\cdot\text{cm}^{-3}$), aluminium ($\rho = 2.79 \text{ g}\cdot\text{cm}^{-3}$), and titanium ($\rho = 4.507 \text{ g}\cdot\text{cm}^{-3}$). The group of heavy metals is significantly greater than the group of light metals, although only zinc ($\rho = 7.13 \text{ g}\cdot\text{cm}^{-3}$) and copper ($\rho = 8.29 \text{ g}\cdot\text{cm}^{-3}$) along with their alloys exhibit the relatively high practical significance, while nickel ($\rho = 8,90 \text{ g}\cdot\text{cm}^{-3}$) and its alloys can be still considered as significant, but to the lesser degree.

Pure non-ferrous metals, although often characterised by valuable, sometimes even unique, features, are in practice much less often used than their alloys. It results from the fact that they exhibit lower mechanical properties than their alloys [9-15]. The industry practice prefers therefore the use of the non-ferrous alloys for the production of castings, and the greatest shares fall to the aluminium, magnesium, copper, and zinc alloys.

The data concerning the production volume of castings in the world and in selected countries qualified as the leading producers, frequently including the structure of production, have been published in the American monthly 'Modern Casting' since 1966. The respective factsheets are usually published in December issues, while information concerns the previous year.

It seems to be interesting to analyse closely the changes in the production of castings, both on a global scale and with respect to Poland, putting the attention to the production of castings made of the non-ferrous alloys. These materials, and particularly aluminium alloys, decidedly gain still greater importance in the production of castings in recent years. Aluminium alloys play significant, even peculiar role in the production of castings in Poland.

The production of castings made of ferrous alloys in XXI century, both on a global scale and in Poland, was the theme of survey reported e.g. in Ref. [16]. In the past years, there were also attempts to determine the directions of changes in the production of casting in the world and with respect to Poland [17-21]. Authors are of the opinion that the present paper can be a valuable complement to the previous studies.

2. Production of castings in the world and in Poland

Figs. 1 and 2 present changes in the production volume of castings made of ferrous and non-ferrous alloys over the years

2000-2019 on a global scale and with respect to Poland, respectively. The values representing the volume of the total production of castings and the volume of production of the non-ferrous castings, both in the world and in Poland during the mentioned period of time are gathered in Table 1.

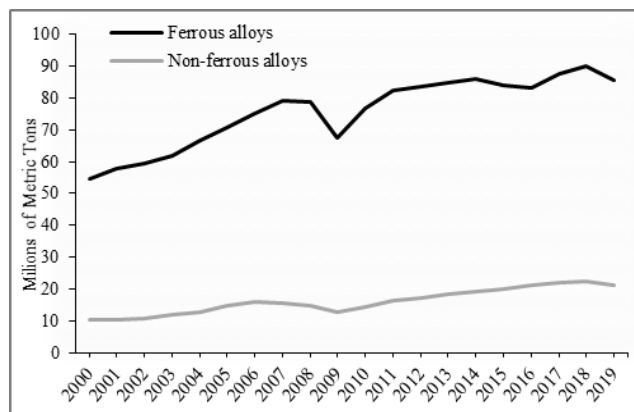


Fig. 1. World foundry production volume with respect to the ferrous and the non-ferrous castings over the years 2000-2019; based on Refs. [22-41]

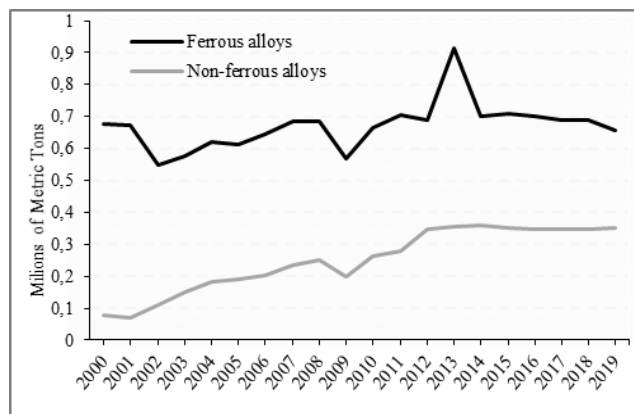


Fig. 2. Foundry production volume in Poland with respect to the ferrous and the non-ferrous castings over the years 2000-2019; based on Refs. [22-41]

The above mentioned data indicate that in the past years, over the period of last two decades, the foundry production volume distinctly increased, with regard both to the ferrous and the non-ferrous castings. The calculated values of the average annual growth rate of both the total production of castings and the production of the non-ferrous castings, both on a global scale and in Poland, over the three selected periods of time, i.e. over the years 2000-2010 (10 annual increments) and 2010-2019 (9 annual increments), as well as over the whole considered period, are presented in Table 2.

Table 1.

Total foundry production volumes and the production volumes with respect to the non-ferrous castings in the world and in Poland over the years 2000-2019 (based on Refs. [22-41])

Year	THE WORLD			POLAND		
	Total foundry production volume, tonnes	Production volume with respect to the non-ferrous castings, tonnes	Share of the produced non-ferrous castings in the total production of castings, %	Total foundry production volume, tonnes	Production volume with respect to the non-ferrous castings, tonnes	Share of the produced non-ferrous castings in the total production of castings, %
2000	64 750 239	10 251 844	15.83	753 600	77 400	10.27
2001	68 311 197	10 452 991	15.30	745 200	72 200	9.69
2002	70 209 475	10 887 996	15.51	660 086	110 038	16.67
2003	73 554 626	11 768 042	16.00	729 400	151 000	20.70
2004	79 745 467	12 886 122	16.16	804 500	184 200	22.90
2005	85 741 078	14 601 031	17.03	804 500	190 000	23.62
2006	91 368 121	16 054 360	17.57	849 020	203 820	24.01
2007	94 919 007	15 707 124	16.55	921 900	235 600	25.56
2008	93 449 270	14 590 822	15.61	936 600	252 400	26.95
2009	80 343 064	12 714 898	15.83	770 000	200 000	25.97
2010	91 673 839	14 451 028	15.76	928 150	263 350	28.37
2011	98 593 122	16 216 333	16.45	983 751	279 151	28.38
2012	100 834 681	17 097 125	16.96	1 036 800	348 300	33.59
2013	103 229 774	18 301 278	17.73	1 266 100	354 000	27.96
2014	105 182 881	19 272 932	18.32	1 058 300	358 300	33.86
2015	104 129 257	20 042 180	19.25	1 062 050	352 950	33.23
2016	104 378 931	21 199 802	20.31	1 048 800	348 100	33.19
2017	109 863 577	22 087 710	20.10	1 036 500	346 500	33.43
2018	112 738 168	22 247 292	19.73	1 036 500	346 500	33.43
2019	109 059 975	21 257 405	19.49	1 006 464	351 464	34.92

The calculated values of the average annual growth rate of production (conf. data in Table 2) indicate that both the total production of castings and the production of the non-ferrous castings on a global scale increased with the same dynamics (by about 3.5% per annum over the 2000-2010 period). During the following nine years the average annual growth rate for the production of the non-ferrous casting was already much greater than for the total production of castings (about 4.4% versus 1.9%). It should be emphasized that the average growth rate for the considered 20 years (19 annual increments) was greater for the production of the non-ferrous castings (3.9% annually) than for the total production of castings (about 2.8% annually).

The production of castings in Poland also increased over the years 2000-2019, but the total production of castings grew at the less average annual growth rate than the rate achieved on a global

scale for all considered periods of time; for the period 2000-2019 this dynamics was almost two times less in Poland than in the world (about 1.5% versus about 2.8%). However, as far as only the non-ferrous castings are concerned, the situation is quite different. The average annual growth rate for this type of production over the years 2000-2010 was almost four times greater in Poland than in the world (about 13% against about 3.5% – conf. data in Table 2). During the following nine years the average annual growth rate on a global scale reached 4.5% though, while in Poland it dropped to the value of about 3.3%. Still, taking into account the whole 2000-2019 period, the average growth dynamic with respect to the production of the non-ferrous castings in Poland was more than twice as large as in the world (about 8.3% versus 3.9%).

Table 2.

Average annual growth rate of both the total production of castings and the production of the non-ferrous castings in the world and in Poland over the selected periods of time (based on Refs. [22-41])

Average annual growth rate, %					
Total production of castings over the period		Production of the non-ferrous castings over the period			
2000-2010	2010-2019	2000-2019	2000-2010	2010-2019	2000-2019
THE WORLD					
3.54%	1.95%	2.77%	3.49%	4.38%	3.91%
POLAND					
2.11%	0.90%	1.53%	13.03%	3.26%	8.29%

The high dynamics of production growth with respect to the non-ferrous castings, higher than the growth rate for the total production of castings, was directly reflected in an increase of the share of the formerly mentioned type of production in the total production volume, both on a global scale and in Poland (conf. data in Table 1). It is particularly prominent in case of Poland; the mentioned share rose from about 10% in 2000 to more than 33% recorded for years 2014-2019.

Tables 3 and 4 present the production volumes of castings made of cast alloys of the basic non-ferrous metals on a global scale and in Poland, respectively, over the years 2000-2019.

The values of the average annual growth rates calculated for the production of castings made of cast alloys of the basic non-ferrous metals, both on a global scale and in Poland, are to be found in Tables 5 and 6, respectively.

Data contained in Table 3 indicate that the global production of non-ferrous castings increased in the field of castings made of aluminium alloys (from about 8 million tonnes to over 17 million tonnes), copper alloys (from over one million tonnes to almost two million tonnes), and magnesium alloys (from about 100 thousand tonnes to over 280 thousand tonnes, this latter value corresponds to the year 2018). On the other hand, the production of castings made of zinc alloys decreased (from about 830 thousand tonnes to about 640 thousand tonnes). In the latter case, however, the production of castings fluctuated over a wide range in the past years; it reached only 470 thousand tonnes in 2009, while in 2016 it exceeded one million tonnes.

The data concerning the production of castings made of various types of non-ferrous alloys in Poland over the 2000-2019 period (conf. Table 4) inform that the production of castings made of aluminium alloys rose almost seven times (to about 340 thousand tonnes), while a threefold decrease was observed for the castings made of copper alloys (to the level of 6 thousand tonnes). The production volume with respect to zinc alloys dropped to about 2.5 thousand tonnes, but in some years it exceeded the level of 13 or even 14 thousand tonnes. It is hard to assess the growth

tendency with respect to the magnesium alloys, since a series of data is lacking; it is worth signalling, however, that in years 2010 and 2012 it exceeded the level of either 4 or 3 thousand tonnes, respectively.

Table 3.

Global production volumes of castings made of cast alloys of the basic non-ferrous metals over the years 2000-2019 (based on Refs. [22-41])

Year	Production of castings made of cast alloys of the below-mentioned metals, tonnes				
	Al	Cu	Mg	Zn	Other non-ferrous metals
2000	8 045 648	1 058 120	104 873	829 651	213 552
2001	8 178 319	1 025 192	116 761	804 018	328 701
2002	8 635 414	1 076 495	136 325	844 419	195 343
2003	9 340 398	1 141 565	135 252	903 391	247 436
2004	10 357 764	1 239 283	134 206	907 841	247 028
2005	11 718 025	1 511 270	239 227	936 661	195 848
2006	12 278 534	1 485 341	1 256 866*	941 110	92 509
2007	12 727 106	1 596 834	278 496	939 394	165 294
2008	10 932 434	1 808 580	268 675	664 136	916 997
2009	10 237 431	1 379 467	152 774	473 170	472 056
2010	10 879 515	1 652 401	196 685	528 978	1 193 449*
2011	13 197 181	1 799 294	181 931	505 614	532 313
2012	14 051 924	1 743 817	226 673	587 947	486 764
2013	15 357 327	1 788 602	175 816	453 861	525 672
2014	16 324 073	1 745 611	160 808	545 661	496 779
2015	16 053 014	1 761 182	198 121	675 022	1 354 841*
2016	17 876 299	1 872 213	317 578	1 005 656*	128 056
2017	19 076 302	1 776 282	196 645	666 869	371 612
2018	18 853 404	1 965 884	284 981	678 396	464 627
2019	17 205 447	1 899 368	60 138	637 875	1 454 577*

* the value given in the pertinent Reference differs distinctly from other data and may be flawed

Table 4.

Production volumes of castings made of cast alloys of the basic non-ferrous metals in Poland over the years 2000-2019 (based on Refs. [22-41])

Year	Production of castings made of cast alloys of the below-mentioned metals, tonnes*				
	Al	Cu	Mg	Zn	Other non-ferrous metals
2000	50 000	18 000	-	7 400	2 000
2001	46 000	17 200	-	7 350	1 650
2002	97 922	5 127	72	6 605	312
2003	134 500	6 300	-	8 100	2 100
2004	167 000	7 400	20	9 150	630
2005	174 300	6 300	30	8 600	770
2006	185 400	7 300	-	11 120	-
2007	216 000	7 000	100	10 900	1 600
2008	236 800	8 200	-	6 000	1 400
2009	200 000	-	-	-	-
2010	237 475	7 935	4 140	13 800	-
2011	256 112	8 411	-	14 628	-
2012	330 500	5 500	3 300	8 000	1 000
2013	340 000	6 000	-	8 000	-
2014	340 000	6 000	-	8 000	4 300
2015	334 600	6 950	-	7 540	3 860
2016	331 500	6 100	-	7 600	2 900
2017	330 000	6 100	-	7 500	2 900
2018	330 000	6 100	-	7 500	2 900
2019	340 000	6 000	-	2 464	3 000

* sign ‘-’ was entered for the occasionally lacking data

The values of the average annual growth rate with respect to the production of castings made of the basic non-ferrous alloys, both on a global scale (see Table 5) and in Poland (see Table 6) allow to determine the characteristic trends of this production for the three periods of time selected for consideration. If only the 2000-2019 period is considered, one can state that the highest dynamics of growth occurred for alloys of ‘other non-ferrous

metals’ (i.e., for alloys which are not based on Al, Cu, Mg, or Zn); the average annual growth rate for this production exceeded 10.6%. Production of castings made of this ‘other non-ferrous’ alloys, however, covers only a few percent of production of all non-ferrous castings. The corresponding growth rate for global production of aluminium-based castings was equal to 4.1%, and it was even lower for copper alloys (3.1%). As far as Polish foundry industry is concerned, one can speak of a dynamic growth of the production of castings only with respect to the castings made of aluminium alloys (the average annual growth was 10.6%).

Table 5.

Average annual growth rate of the production of castings made of cast alloys of the basic non-ferrous metals on a global scale over the selected periods of time (based on Refs. [22-41])

Data for the period	Average annual growth rate of production of castings made of cast alloys of the below-mentioned metals, %				
	Al	Cu	Mg	Zn	Other non-ferrous metals
2000-2010	3.06	4.56	6.49	-4.40	18.78
2010-2019	5.22	1.56	4.74*	2.10	2.22
2000-2019	4.08	3.13	5.71*	-1.37	10.63

*calculations were made for data up to the year 2018

Table 6.

Average annual growth rate of the production of castings made of cast alloys of the basic non-ferrous metals in Poland over the selected periods of time (based on Refs. [22-41])

Data for the period	Average annual growth rate of production of castings made of cast alloys of the below-mentioned metals, %*				
	Al	Cu	Mg	Zn	Other non-ferrous metals
2000-2010	16.86	-7.86	-	6.43	-
2010-2019	4.07	-3.06	-	-17.42	-
2000-2019	10.62	-5.62	-	-5.62	2.16

* sign ‘-’ was entered for the occasionally lacking data

Tables 7 to 11 give the values of foundry production volumes for specified non-ferrous alloys by countries. The largest producers and Poland were taken into account, and the subsequent Tables present data in the following order: production of castings made of aluminium alloys, copper alloys, magnesium alloys, zinc alloys, and, finally, other non-ferrous alloys.

Table 7.

Foundry production volumes with respect to castings made of aluminium alloys in countries leading in this field and in Poland, along with the average annual growth rate of the production (based on Refs. [22-41])*

Country	Annual production, tonnes			Average annual growth rate of production (%) over the period		
	2000	2010	2019	2000-2010	2010-2019	2000-2019
China	799 196	3 800 000	6 850 000	16.87	6.77	11.97
USA	1 846 800	1 233 771	1 795 190	-3.95	4.26	-0.15
India	210 000	-	1 364 652	-	-	10.35
Japan	1 204 219	925 508	437 500	-2.60	-7.99	-5.19
Germany	645 575	797 690	996 127	2.14	2.50	2.31
Russia	600 000	340 000	588 000	-5.52	6.28	-0.11
Brazil	108 000	248 454	164 718	8.69	-4.46	2.25
Korea	40 700	344 900	623 500	23.83	6.80	15.45
Italy	679 600	730 702	810 647	0.73	1.16	0.93
France	348 591	286 647	348 062	-1.94	2.18	-0.01
Mexico	600 000	600 469	832 770	0.01	3.70	1.74
Poland	50 000	237 475	340 000	16.86	4.07	10.62

* sign '-' was entered for the occasionally lacking data

Table 8.

Foundry production volumes with respect to castings made of copper alloys in countries leading in this field and in Poland, along with the average annual growth rate of the production (based on Refs. [22-41])*

Country	Annual production, tonnes			Average annual growth rate of production (%) over the period		
	2000	2010	2019	2000-2010	2010-2019	2000-2019
China	119 937	700 000	800 000	19.29	1.49	10.50
USA	292 500	264 897	319 130	-0.99	2.09	0.46
Japan	86 977	79 293	70 900	-0.92	-1.24	-1.07
Germany	91 227	77 167	77 225	-1.66	0.01	-0.87
Russia	-	90 000	117 600	-	3.02	-
Brazil	15 000	16 539	20 993	0.98	2.69	1.78
Korea	19 600	25 100	24 500	2.50	-0.27	1.18
Italy	123 700	69 000	66 438	-5.67	-0.42	-3.22
France	20 499	19 420	17 409	-0.54	-1.21	-0.86
Mexico	135 000	140 701	215 500	0.41	4.85	2.49
Poland	18 000	7 935	6 000	-7.86	-3.06	-5.62

* Due to the lack of data with respect to India, this country was omitted here; sign '-' was entered for the occasionally lacking partial data

Table 9.

Foundry production volumes with respect to castings made of magnesium alloys in countries leading in this field and in Poland, along with the average annual growth rate of the production (based on Refs. [22-41])*

Country	Annual production, tonnes			Average annual growth rate of production (%) over the period		
	2000	2010	2019	2000-2010	2010-2019	2000-2019
USA	66 600	106 140	-	4.77	-	-
Japan	79	6 954	-	56.48	-	-
Germany	21 134	14 859	15 472	-3.46	0.45	-1.63
Russia	-	35 000	75 600	-	8.93	-
Brazil	6 000	4 768	5 040	-2.27	0.62	-0.91
Korea	-	-	12 000	-	-	-
Italy	8 600	6 800	7 097	-2.32	0.48	-1.01
Mexico	-	109	-	-	-	-
Poland	-	4 140	-	-	-	-

* Due to the lack of data with respect to China, India, and France these countries were omitted here; sign ‘-’ was entered for the occasionally lacking partial data

Table 10.

Foundry production volumes with respect to castings made of zinc alloys in countries leading in this field and in Poland, along with the average annual growth rate of the production (based on Refs. [22-41])*

Country	Annual production, tonnes			Average annual growth rate of production (%) over the period		
	2000	2010	2019	2000-2010	2010-2019	2000-2019
China	118 956	-	-	-	-	-
USA	312 300	204 116	330 258	-4.16	5.49	0.29
Japan	37 306	26 185	-	-3.48	-	-
Germany	78 841	40 188	57 182	-6.52	4.00	-1.68
Russia	-	15 000	-	-	-	-
Brazil	12 000	2 797	1 175	-13.55	-9.19	-11.51
Italy	95 600	60 760	74 036	-4.43	2.22	-1.34
France	3 452	23 669	24 486	21.23	0.38	10.86
Mexico	120 000	1 007	79 500	-38.00	62.49	-2.14
Poland	7 400	13 800	2 464	6.43	-17.42	-5.62

* Due to the lack of data with respect to India and Korea these countries were omitted here; sign ‘-’ was entered for the occasionally lacking partial data

Table 11.

Foundry production volumes with respect to castings made of other non-ferrous alloys (i.e. the alloys not considered as the basic ones) in countries leading in this field and in Poland, along with the average annual growth rate of the production (based on Refs. [22-41])^{*}

Country	Annual production, tonnes			Average annual growth rate of production (%) over the period		
	2000	2010	2019	2000-2010	2010-2019	2000-2019
China	-	300 000	250 000	-	-2.01	-
USA	181 800	59 874	48 070	-10.51	-2.41	-6.76
India	-	750 000	-	-	-	-
Japan	7 364	4 911	1 030 000	-3.97	81.12	29.70
Germany	5 335	4	5	-51.30	2.51	-30.72
Russia	-	20 000	100 800	-	19.69	-
Korea	5 000	11 500	-	8.69	-	-
Italy	1 200	900	481	-2.84	-6.72	-4.70
France	-	2 830	2 486	-	-1.43	-
Mexico	3 000	-	15 200	-	-	8.92
Poland	2 000	-	3 000	-	-	2.16

* Due to the lack of data with respect to Brazil, this country was omitted here; sign ‘-’ was entered for the occasionally lacking partial data

Data quoted in Tables 7 to 10 indicate that the global largest producers of castings in 2019 were:

- for aluminium alloys: China with production (in million tonnes) of about 6.8, then (also in million tonnes) USA – about 1.8, India – about 1.4, Mexico and Italy – about 0.8 each, Korea and Russia – about 0.6 each; Japan – about 0.4, France and Poland – about 0.3 million tonnes each;
- for copper alloys (in thousand tonnes): China – about 800, USA – about 320, Mexico – about 215, Russia – about 118, Germany – about 77, Japan – about 71, Italy – about 66, Brazil – about 21, and France – about 17 thousand tonnes;
- for magnesium alloys (in thousand tonnes): Russia – about 76, Germany – about 15, Korea – about 12, Italy – about 7, and Brazil – about 5 thousand tonnes;
- for zinc alloys (in thousand tonnes): USA – about 330, Mexico – about 79, Italy – about 74, Germany – about 57, France – about 24, and Poland – about 2 thousand tonnes.

In case of castings made of the alloys of non-ferrous metals not included to the group of four basic metals (i.e. Al, Cu, Mg, and Zn), the largest producers in 2018 were (conf. data in Table 11): Japan with production of about 1,030 thousand tonnes, China – about 250 thousand tonnes, Russia – about 101 thousand tonnes, and USA – about 48 thousand tonnes.

Conclusion

The gathered data and their analysis allow to notice that the production of castings made of the non-ferrous alloys distinctly increased over the years 2000-2019, both on a global scale and in Poland. The dynamics of this increase was greater than the

dynamics of increase of the total production of castings for both the global and the domestic scale.

If the share of production of the non-ferrous castings in the total production of castings was about 16% on a global scale (and about 10% in Poland) in the first years of the current century, it reached the level of about 20% (about 33% in Poland) in years 2016-2019.

The annual production volume of castings made of aluminium alloys amounted to about 18 million tonnes on a global scale in last two years of the analysed period; as for Poland, this value reached about 335 thousand tonnes. Taking into account the initial and the final data recorded for the considered period, one can find that the global production of castings made of aluminium alloys increased by more than twice (the average annual growth rate slightly exceeded 4%), while in Poland it increased almost seven times (the average annual growth rate exceeded 10.6%).

It is worth mentioning that if the share of Polish foundry industry in total production of castings in the world amounted to about 0.92% in 2019, simultaneously its share in global production of castings made of aluminium alloys reached about 1.98%.

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