



Casting Production in Poland Versus European Trends in 21st Century

M.S. Soiński , A. Jakubus * 

Jakub from Paradyz Academy in Gorzow Wielkopolski, 25 Teatralna St., 66-400 Gorzow Wielkopolski, Poland

* Corresponding author: E-mail address: jakubusaneta@wp.pl

Received 14.05.2024; accepted in revised form 12.07.2024; available online 23.07.2024

Abstract

This article presents changes of the total casting production volumes and of the production of castings made from basic casting alloys in Poland, in Europe and worldwide in years 2001–2021. Analogous casting production parameters were compared for Poland, Europe and countries being the leading European and global manufacturers in years 2001, 2011 and 2021. The leading casting manufacturers in Europe (with the manufacturing volume exceeding 1 million tons in the mentioned years) include Germany, Italy, the Ukraine, France and Spain. For years, the largest casting manufacturer worldwide has been China. In 2001–2021, global casting production increased from ca. 68 million tons to ca. 97 million tons (i.e. by ca. 42%), whereas the European one decreased from ca. 17 million tons to ca. 12 million tons (i.e. by close to 30%). In the analyzed period, the Polish production volume grew from ca. 0.75 million tons to ca. 0.88 million tons (i.e. by ca. 17%). The presented data reveal the decreasing importance of gray cast iron and cast steel and the increasing one of ductile cast iron and aluminum alloys. However, the Polish average annual growth rate for aluminum alloy casting production was 10.3%, whereas the global one was 3% and the European one 0.7%.

Keywords: Casting production, Gray cast iron, Ductile cast iron, Cast steel, Aluminum alloys

1. Introduction

This century, the casting industry has undergone many changes both globally and in Europe, including Poland [1–7]. This resulted from the need to adapt to the sustainable development requirements and to operate in the increased competition conditions (primarily from Asian manufacturers, i.e. China and India). Moreover, the casting production volumes were affected by two global crises, the first of them stemming from the financial market slump in 2008–2009 and the other caused by the COVID-19 pandemic.

It seems important to trace the casting production changes in Poland and Europe in this century. Although global casting production increased from ca. 68 million tons to ca. 97 million tons (i.e. by over 42%) [8, 9] in 2001–2021 (there are no data for the subsequent period), the European one decreased from ca. 17 million tons to ca. 12 million tons (i.e. by close to 30%) [10–11].

However, in the analyzed period, the Polish production volume grew from ca. 0.75 million tons to ca. 0.88 million tons (i.e. by ca. 17%).

2. Global casting production

Figure 1 presents changes of the total casting production and casting production from basic alloys globally from 2001 to 2021.

In the analyzed period, the leading casting manufacturer globally has been China for 21 years [11]. The production volumes and shares in the global volume of the leading global casting manufacturers in 2021 were as follows (for U.S., data for 2020 was presented due to the absence of data for 2021):

- China – 54,050,000 tons – 55%
- India – 12,448,657 tons – 13%



- U.S. – 9,748,811 tons – 9%
- Japan – 4,555,179 tons – 5%
- Russia – 4,200,000 tons – 4%
- Germany – 3,964,536 tons – 4%

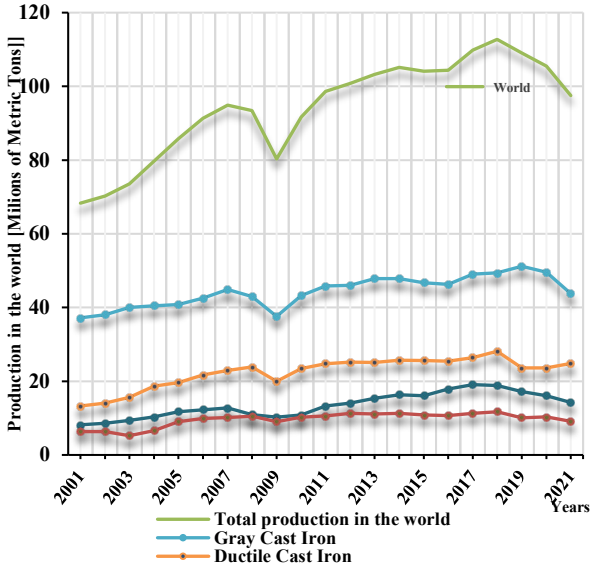


Fig. 1. Total casting production and casting production from basic alloys globally in 2001–2021. Based on data in [11–31]

It should be stressed that, despite the crisis caused by COVID-19 pandemic, casting production in China grew (when compared to the volumes in 2021 and 2019) by ca. 7%, whereas in the other leading manufacturing countries, including India, U.S., Japan or Germany, it decreased by 12%, 14%, 35% and 30% respectively.

3. Casting production in Poland and in Europe

The European share of casting production was ca. 25% in 2001 and ca. 12% in 2021 of the global casting production. For the Polish casting sector, the values were 1.09% and 0.90% respectively. Figure 2 depicts the changing shares of Poland and Europe in the global casting production for the last 20 years (2001–2021).

The leading casting manufacturers in Europe (based on the production volume) include Germany, Italy, the Ukraine, France and Spain. Poland takes the sixth place.

In 2021, in Europe, most castings were made from gray cast iron (ca. 38% of the total production volume), 31% of the volume was made from ductile cast iron, 24% of it from aluminum alloys and ca. 4% from cast steel. The remaining volume was made from non-aluminum non-ferrous metals [11].

Figure 3 presents changes of the total casting production in Europe in 2001–2021 and changes of those values considering the basic casting alloys.

Opposite to the global casting production in the analyzed period, characterized by production volume increase from ca. 68 million tons in 2001 to more than 97 million tons in 2021, the European casting production volume fell from ca. 16.85 million tons to ca.

11.76 million tons (i.e. by 30%). In the analyzed period, the major reduction was observed for casting production from gray cast iron and cast steel, from ca. 9 million tons to ca. 4.4 million tons, respectively, i.e. by a bit more than 50%, and from ca. 1.14 million tons to ca. 0.49 million tons, i.e. by 57% respectively. Solely ductile cast iron and aluminum alloy casting production displayed any growth trends. For the former above-mentioned material, in the analyzed period production volume increased from ca. 3.4 million tons to over 3.6 million tons (i.e. by ca. 6%), whereas for the latter from ca. 2.45 million tons to ca. 2.79 million tons (i.e. by 14%).

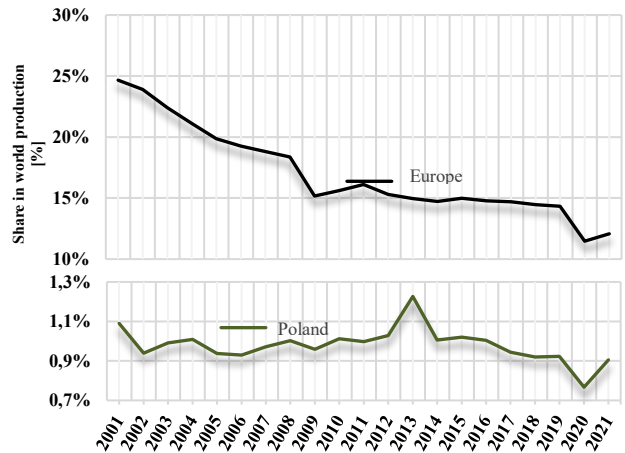


Fig. 2. Share of Poland and other European countries in the global casting production in 2001–2021 [11–31]

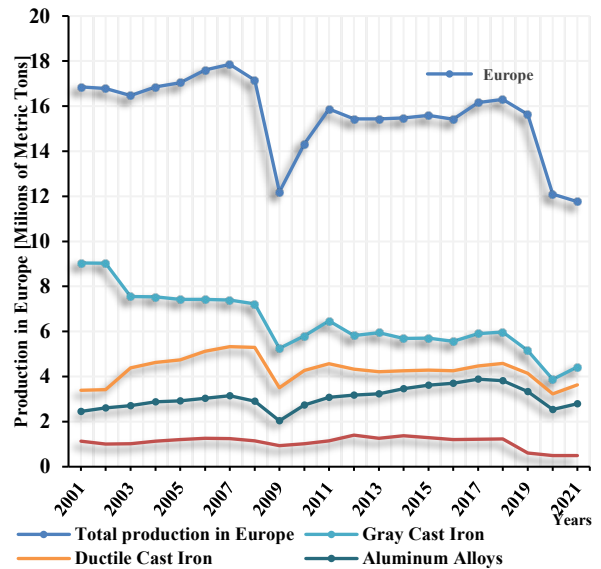


Fig. 3. Total casting production and casting production from basic alloys in Europe in 2001–2021. Based on data in [11–31]

Changes of the casting production volume in Poland in 2001–2021 are presented in Figure 4. In the analyzed period, casting production volume grew from 745 thousand tons to 882 thousand tons, i.e. by a bit more than 18%. The major customers of the Polish foundries include the automotive sector (60%) as well as the

machinery and construction (10%), engineering (10%), metallurgical (10%) and energy sector (3%) [32]. In the analyzed period, the production of castings from gray cast iron and cast steel fell by ca. 20% (i.e. from 495 thousand tons to 392.4 thousand tons and from 54.5 thousand tons to 43.6 thousand tons, respectively).

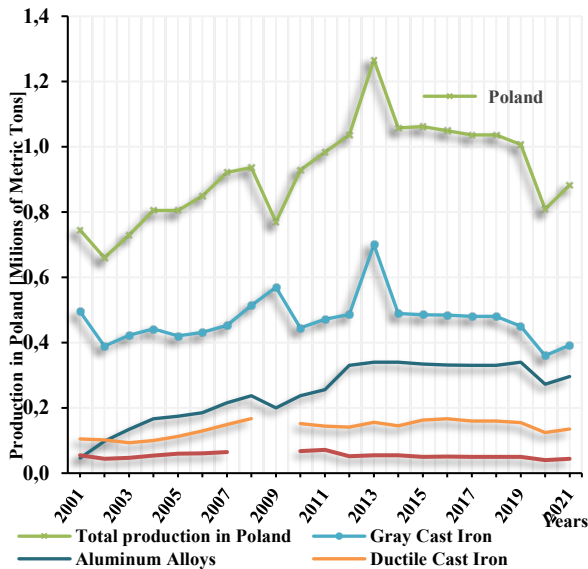


Fig. 4. Total casting production and casting production from basic alloys in Poland in 2001–2021. Based on data in [11–31]

The upward trends were recorded for ductile cast iron (casting production volume increased from 105.2 thousand tons to 135.2 thousand tons), i.e. growth by ca. 28%. Production volume of aluminum alloy castings increased very fast, or even abruptly. The volume for those alloys' castings was 46 thousand tons in 2001 and 296.5 thousand tons in 2021 (growth by more than 540%).

Table 1 lists the volumes of the total casting production and of the casting production from the basic casting alloys for the leading European manufacturers in 2011 and 2021. The table depicts the share of the countries in the European production volume and the average annual rates of production volume changes in 2001–2011; 2011–2021 and 2001–2021. According to the quoted data, the largest European casting manufacturer is Germany, with more than 34% share in the European production (in 2021). Subsequent places are taken by Italy (with the share of ca. 16%), Ukraine (13%); France (13%), and Spain (ca. 10%). Poland takes the sixth place, with close to 900 thousand tons of castings produced which corresponds to 7.5% share in the European production. It should be stressed that in the analyzed 20-year period, among the analyzed countries, solely the Polish casting industry reports production volume growth (by ca. 0.9% a year on average).

The alloy used in the largest amounts both in Europe and in Poland was gray cast iron. Its share in casting production in Europe in 2001, 2011 and 2021 was 53.7%; 40.7% and 37.7% respectively. As much as 42% of the European gray cast iron production volume is attributed to German foundries which made less than 1.9 million tons of castings from that alloy in 2021. Gray cast iron castings

made in Germany include primarily mechanical component parts (ca. 1.26 million tons), machine parts (ca. 0.38 million tons) and other components, i.e. molds, railroad transport components, fixtures, steel industry accessories (ca. 0.23 million tons) [32]. Although Germany was the largest gray cast iron casting manufacturer in Europe in 2001, 2011 and 2021, the average annual rate of changes in the production volumes using that alloy in the analyzed period (2001–2021) was negative (-1.1%). It is worth noting that this index has a similar value to the analogous index for the Polish casting sector (-1.2%). In 2001, the Polish production volume of gray cast iron castings was 495 thousand tons, whereas in 2021 it was a bit over 392 thousand tons. In 2001, the second best country when it came to gray cast iron casting production in Europe was France (a bit over 2 million tons). For France, the analyzed 20-year period was characterized by a very high reduction of the average annual rate of changes in the gray cast iron production volumes (-7%). The gray cast iron casting production volume in France in 2021 (ca. 0.5 million tons) was just one fourth of the volume in 2001.

According to data presented in Table 1, the global cast steel casting production grew in 2001–2021 from ca. 6.4 million tons to ca. 9.1 million tons, with the average annual growth rate of 1.9%. In the analyzed period, the European cast steel casting production decreased from a bit over 1.1 million tons to close to 0.5 million tons. The average annual “European” reduction rate of cast steel casting production volumes was -4.3%, with the highest value of that index attributed to the French casting sector (-5.6%). For Poland, it was -1.2%, with the production volumes reduced from 54.5 thousand tons to 43.6 thousand tons.

Particular attention is deserved by casting production from ductile cast iron being the only casting ferrous alloy for which the production volume in Europe (including in Poland) was higher in 2021 than in 2001. Globally, the average annual production growth rate for the ductile cast iron in 2001–2021 was the highest, considering the basic casting alloys, and was 3.3%. The analogous rate for Europe was 0.4%, whereas for Poland it was 1.3%.

Casting production from ductile cast iron was ca. 31% of the total casting production volume in Europe in 2021. Despite the increase of the ducting cast iron casting production in Europe in 2001–2021, the share of European manufacturers in the production of castings made from cast iron with spheroidal graphite in the global volume decreased from ca. 26% in 2001 to ca. 15% in 2021.

The largest manufacturer of ductile cast iron castings in Europe in the analyzed period was Germany. The ductile cast iron production in 2021, amounting to ca. 1.1 million tons, corresponds to more than 31% of share of that country in the total production volumes pertaining to that material in Europe.

It is worth noting that although the initial 10 years of the analyzed period (2001–2011) displayed an upward trend with the average annual rate of production volume changes of 3.3% (production volumes of ductile cast iron castings grew from ca. 1.27 million tons to ca. 1.70 million tons), the subsequent 10 years (2011–2021) recorded a downward one. Production volumes fell to ca. 1.14 million tons at a rate of -4.3%. It should be stressed that the ductile cast iron casting production in Germany had an annual production decrease rate of -0.6% in the entire analyzed period.

Table 1.

Comparison of the total casting production volumes and the production volumes for castings made from basic casting alloys in Poland, Europe and in countries being the leading manufacturers in Europe and globally in 2001, 2011 and 2021 [11, 12, 22]

Country	Total foundry production volume, tons			Share of the global foundry production [%]			Share in European foundry production [%]			Average annual rate of change in production volume in years:		
	2001	2011	2021	2001	2011	2021	2001	2011	2021	2001-2011	2011-2021	2001-2021
TOTAL CASTING PRODUCTION												
Germany	4 643 430	5 466 695	3 964 536	6.80%	5.54%	4.07%	27.56%	34.42%	33.71%	1.8%	-3.5%	-0.8%
Italy	2 393 337	2 213 287	1 939 354	3.50%	2.24%	1.99%	14.21%	13.94%	16.49%	-0.9%	-1.5%	-1.1%
Ukraine	1 369 150	1 000 000	1 560 000	2.00%	1.01%	1.60%	8.13%	6.30%	13.26%	-3.4%	5.1%	0.7%
France	2 527 146	2 046 826	1 551 855	3.70%	2.08%	1.59%	15.00%	12.89%	13.19%	-2.3%	-3.0%	-2.5%
Spain	1 572 300	1 243 756	1 128 484	2.30%	1.26%	1.16%	9.33%	7.83%	9.59%	-2.6%	-1.1%	-1.7%
Poland	745 200	983 751	882 028	1.09%	1.00%	0.90%	4.42%	6.19%	7.50%	3.1%	-1.2%	0.9%
Total in Europe	16 848 307	15 880 093	11 761 920	24.66%	16.11%	12.07%	—	—	—	-0.7%	-3.3%	-1.9%
Total in the World	68 311 197	98 593 122	97 486 186	—	—	—	—	—	—	4.2%	-0.1%	1.9%
PRODUCTION OF GRAY IRON CASTINGS												
Germany	2 303 089	2 541 011	1 873 700	6.19%	5.54%	4.28%	25.47%	39.27%	42.30%	1.1%	-3.3%	-1.1%
Italy	966 432	692 298	616 200	2.60%	1.51%	1.41%	10.69%	10.70%	13.91%	-3.6%	-1.3%	-2.3%
Ukraine	844 250	640 000	-	2.27%	1.40%	-	9.34%	9.89%	-	-3.0%	-	-
France	2 012 184	734 500	503 900	5.41%	1.60%	1.15%	22.26%	11.35%	11.38%	-10.6%	-4.1%	-7.0%
Spain	576 200	444 900	322 800	1.55%	0.97%	0.74%	6.37%	6.88%	7.29%	-2.8%	-3.5%	-3.0%
Poland	495 000	471 800	392 400	1.33%	1.03%	0.90%	5.48%	7.29%	8.86%	-0.5%	-2.0%	-1.2%
Total in Europe	9 040 677	6 470 596	4 429 152	24.31%	14.11%	10.12%	53.7%	40.7%	37.7%	-3.6%	-4.1%	-3.7%
Total in the World	37 194 171	45 870 050	43 786 115	—	—	—	—	—	—	2.4%	-0.5%	0.9%
PRODUCTION OF DUCTILE IRON CASTINGS												
Germany	1 269 392	1 698 235	1 140 900	9.56%	6.85%	4.60%	37.36%	37.19%	31.40%	3.3%	-4.3%	-0.6%
Italy	378 664	469 051	385 900	2.85%	1.89%	1.55%	11.14%	10.27%	10.62%	2.4%	-2.1%	0.1%
Ukraine	85 000	40 000	—	0.64%	0.16%	—	2.50%	0.88%	—	-8.0%	—	—
France	—	831 600	665 000	—	3.36%	2.68%	—	18.21%	18.30%	—	-2.5%	—
Spain	617 000	584 200	608 800	4.65%	2.36%	2.45%	18.16%	12.80%	16.75%	-0.6%	0.5%	-0.1%
Poland	105 200	143 800	135 160	0.79%	0.58%	0.54%	3.10%	3.15%	3.72%	3.5%	-0.7%	1.3%
Total in Europe	3 397 634	4 565 802	3 633 571	25.58%	18.42%	14.64%	20.2%	28.8%	30.9%	3.3%	-2.5%	0.4%
Total in the World	13 279 921	24 782 540	24 822 992	—	—	—	—	—	—	7.2%	0.0%	3.3%
PRODUCTION OF CAST STEEL CASTINGS												
Germany	189 394	217 548	143 800	2.97%	2.05%	1.58%	16.68%	18.85%	29.10%	1.6%	-4.5%	-1.4%
Italy	77 441	73 658	56 800	1.21%	0.69%	0.62%	6.82%	6.38%	11.49%	-0.6%	-2.8%	-1.6%
Ukraine	354 400	275 000	—	5.56%	2.59%	—	31.22%	23.83%	—	-2.8%	—	—
France	129 328	108 900	43 100	2.03%	1.03%	0.47%	11.39%	9.44%	8.72%	-1.9%	-9.8%	-5.6%
Spain	78 500	77 200	69 200	1.23%	0.73%	0.76%	6.91%	6.69%	14.00%	-0.2%	-1.2%	-0.7%
Poland	54 500	71 400	43 600	0.85%	0.67%	0.48%	4.80%	6.19%	8.82%	3.0%	-5.3%	-1.2%
Total in Europe	1 135 240	1 153 993	494 169	17.80%	10.87%	5.43%	—	—	—	0.2%	-9.0%	-4.3%
Total in the World	6 376 642	10 617 738	9 096 308	—	—	—	—	—	—	5.8%	-1.7%	1.9%
PRODUCTION OF CASTINGS FROM ALUMINUM ALLOYS												
Germany	652 178	843 745	701 118	7.97%	6.37%	4.93%	26.59%	27.44%	25.15%	2.9%	-2.0%	0.4%
Italy	751 000	833 000	727 254	9.18%	6.29%	5.11%	30.62%	27.09%	26.08%	1.2%	-1.5%	-0.2%
Ukraine	52 000	45 000	—	0.64%	0.34%	—	2.12%	1.46%	—	-1.6%	—	—
France	315 494	326 777	299 016	3.86%	2.47%	2.10%	12.86%	10.63%	10.72%	0.4%	-1.0%	-0.3%
Spain	253 300	112 989	106 185	3.10%	0.85%	0.75%	10.33%	3.67%	3.81%	-8.6%	-0.7%	-4.5%
Poland	46 000	256 112	296 480	0.56%	1.93%	2.08%	1.88%	8.33%	10.63%	21.0%	1.6%	10.3%
Total in Europe	2 452 852	3 075 067	2 788 267	29.99%	23.22%	19.60%	6.7%	7.3%	4.2%	2.5%	-1.1%	0.7%
Total in the World	8 178 319	13 242 181	14 226 841	—	—	—	—	—	—	5.5%	0.8%	3.0%

On the other hand, for Poland, despite its small share in the ductile cast iron casting production in 2021 globally (ca. 0.5%) and in Europe (close to 4%), the recorded rate of production volume increase was the highest among all analyzed countries in the analyzed 20-year period. Due to the absence of data, it was impossible to determine the parameters for the casting sector in the Ukraine and France.

Years 2001–2021 brought the most significant increase in aluminum alloy casting production, both globally and for Europe, including Poland. When the global casting production was characterized by the average annual growth rate of 1.9%, that value was 3% for aluminum alloys. The analogous data for Poland reached 0.9% and 10.3%, respectively. On the other hand, for European manufacturers the only casting production types which recorded growth, despite the clear reduction of the total casting production volumes in 2001–2021, included ductile cast iron and aluminum alloys. The average annual increase in the production volumes in 2001–2021 for the former of the above alloys was ca. 0.4%, whereas for the latter it was 0.7%.

The largest manufacturers of aluminum casting alloys in Europe in 2021 included Italy, Germany, France and Poland which reached this fourth place from 10th one in 2001. In the analyzed 20-year period, the Polish production of aluminum alloy castings grew by ca. 250 thousand tons. Its particular growth rate was recorded in 2001–2011, by ca. 210 thousand tons with the average annual growth rate of production in that period was 21%. For Poland, it is therefore impossible to mention any leading role relating to casting production in recent years [33].

4. COVID-19 versus casting production

Decreased demand, delivery chain interruption and production limitations caused by COVID-19 pandemic did not spare the casting sector [34, 35]. To compare the circumstances before and after the pandemic, Table 2 lists the total casting production volumes in Poland, in the leading manufacturing countries in Europe and globally in 2019–2021.

Table 2.

Total casting production volumes and the production volumes for basic casting alloys in Poland, Europe and in countries being the leading manufacturers in Europe and globally in 2019, 2020 and 2021 [11, 30, 31]

Country	Production in tons			Average annual rate of change in production volume in years:		
	2019	2020	2021	2019-2020	2020-2021	2019-2021
Germany	4 951 011	3 482 883	3 964 536	-29.7%	13.8%	-10.5%
Italy	2 067 699	1 552 209	1 939 354	-24.9%	24.9%	-3.2%
Ukraine	1 560 000	1 560 000	1 560 000	0%	0%	0%
France	1 696 743	1 398 107	1 551 855	-17.6%	11.0%	-4.4%
Spain	1 267 207	1 055 783	1 128 484	-16.7%	6.9%	-5.6%
Poland	1 006 464	809 200	882 028	-19.6%	9.0%	-6.4%
Total in Europe	15 628 567	12 100 285	11 761 920	-22.6%	-2.8%	-13.2%
Total in the World	109 059 975	105 505 602	97 486 186	-3.3%	-7.6%	-5.5%

It is characteristic that the reduction in the total casting production in Europe in 2019–2020 (by ca. 3.5 million tons) was equal to the decrease in the global production volumes. However, the global reduction was 3%, whereas in Europe it was close to 23%. On the other hand, in 2021, the production of castings when compared to 2020 was ca. 340 thousand tons (i.e. ca. 2.8%) lower by in Europe and ca. 8 million tons (i.e. ca. 7.6%) globally. In Poland, during the first pandemic year (2020), the casting production volumes were close to 20% lower than in 2019 (production fell from ca. 1 million tons to a bit above 800 thousand tons). However, in 2021 it was ca. 9% higher than in 2020.

Comparing the average annual values of the production volume decrease in 2019–2021 for the casting sector in Poland, Europe and globally, it should be noted that its highest value was reached for Europe (-13.2%). With respect to Poland and the world, the casting production volumes reduced at a similar pace, with the average annual index describing that phenomenon being -6.4% and -5.5% respectively.

5. Conclusions

The comparison of the casting production volumes in 2001 and 2021 globally and in Europe shows that although the former values increased from 68 million tons to ca. 97 million tons, the latter decreased from ca. 16.8 million tons to ca. 11.8 million tons. Casting production in Poland in the analyzed period looks good, as its volume grew from ca. 745 thousand tons to ca. 882 thousand tons. The leading casting manufacturers in Europe include Germany, Italy, the Ukraine, France and Spain, with Poland taking the sixth place.

The quoted data indicate the decreasing importance of casting production from gray cast iron and cast steel in Europe and in Poland. The average annual reduction rate of the production volumes for such cast metal types was -3.7% in Europe and -1.2% in Poland in 2001–2021. Globally, the production volumes of castings made from that alloy increased by 0.9% annually on average. For the cast steel, the average annual reduction rate of the production volumes were -4.3% and -1.2% for Europe and Poland respectively. On the other hand, the global production of cast steel castings grew by 1.9% a year on average.

In 2001–2021, the global production volumes of castings from ductile cast iron and aluminum alloys grew significantly. The average annual growth rates for the production volumes of castings made from the above materials reached 3.3% and 3% respectively, which means that they were significantly higher than the average annual growth rates for the total global casting production volumes (1.9%). The production volumes for castings made from ductile cast iron grew in Europe and Poland as well, though at different rates. For Poland, the average annual growth was ca. 1.3%, whereas for Europe this index was 0.4%.

Relating to Europe and Poland, the growth rates for casting production from aluminum alloys also show significant differences. In the analyzed 20-year period, the average annual production volume growth was 0.7% in Europe, whereas in Poland it was 10.3% a year on average. The production volume of castings made from aluminum alloys in Poland grew from 46 thousand tons in 2021 to more than 296 thousand tons in 2021, i.e. by more than 540%.

Finally, it should be stressed that COVID-19 pandemic resulted in a significant decrease in the casting production volumes. In 2019–2020, the European production decreased by ca. 3.5 million tons (i.e. by ca. 23%), whereas the Polish one by ca. 0.2 million tons (20%).

References

- [1] Patalas-Maliszewska, J. Topczak, M. & Kłos, S. (2020). The level of the additive manufacturing technology use in polish metal and automotive manufacturing enterprises. *Applied Sciences*. 10(3), 735, 1-20. DOI:10.3390/app10030735.
- [2] Kampa, A. & Gołda, G. (2018). Modelling and simulation method for production process automation in steel casting foundry. *Archives of Foundry Engineering*. 18(1), 47-52. DOI: 10.24425/118810.
- [3] Gruzman, V.M. (2020). Foundry production digitalization. *Materials Science and Engineering*. 966(1), 012127, 1-6. DOI:10.1088/1757-899X/966/1/012127.
- [4] Scharfa, S., Sander, B., Kujath, M., Richter, H., Eric Riedelb, E., Stein, H., & Felde, J. (2021). FOUNDRY 4.0: An innovative technology for sustainable and flexible process design in foundries. *Procedia CIRP*. 98 73-78. <https://doi.org/10.1016/j.procir.2021.01.008>.
- [5] Odlewnie Polskie S.A. (2024). *Prace badawczo-rozwojowe*. Retrieved April 15, 2024, from <https://odlewniepolskie.pl/innowacje-i-nauka/prace-badawczo-rozwojowe/>.
- [6] Odlewnie Polskie S.A. (2024). *Report on the operations of Spółka Akcyjna Odlewnie Polskie with its registered office in Starachowice in 2021*. Retrieved April 20, 2022, from: <https://odlewniepolskie.pl/>.
- [7] Czerepak, M. & Piątkowski, J. (2023). Casting of combustion engine pistons before and now on the example of FM Gorzyce. *Archives of Foundry Engineering*. 23(2), 58-65. DOI: 10.24425/afe.2023.144296.
- [8] Soiński, M.S., Skurka, K., Jakubus, A. & Kordas, P. (2015). Structure of foundry production in the world and in Poland over the 1974-2013 period. *Archives of Foundry Engineering*. 15(spec.2), 69-76.
- [9] Sobczak, J. & Dudek, P. (2021). The current state of foundry in the context of the world economy. *Przegląd Odlewnictwa*. 11-12, 594-607. from https://kimim.pan.pl/files/Sobczak_Dudek.pdf. (in Polish).
- [10] Soiński, M.S., Skurka, K., Jakubus, A. (2015). Changes in the production of castings in Poland in the past half century in comparison with world trends. In: *Selected problems of process technologies in the industry*. Częstochowa. Eds. Faculty of Production Engineering and Materials Technology of the Częstochowa University of Technology, 2015. Monograph. ISBN: 978-83-63989-30-9, pp.71-79. (in Polish).
- [11] Industry Outlook: Sales Expected to Keep Growing. *Modern Casting*, (January 2023), 33–35.
- [12] 36th Census of World Casting Production - 2001. *Modern Casting*, (December 2002), 22-24.
- [13] Know Your Competition 37th Census of World Casting Production - 2002. *Modern Casting*, (December 2003), 23-25.
- [14] 38th Census of World Casting Production - 2003. *Modern Casting*, (December 2004), 25-27.
- [15] 39th Census of World Casting Production - 2004. *Modern Casting*, (December 2005), 27-29.
- [16] 40th Census of World Casting Production - 2005. *Modern Casting*, (December 2006), 28-31.
- [17] 41st Census of World Casting Production - 2006. *Modern Casting*, (December 2007), 22-25.
- [18] 42nd Census of World Casting Production - 2007. *Modern Casting*, (December 2008), 24-27.
- [19] 43rd Census of World Casting Production - 2008. *Modern Casting*, (December 2009), 17-21.
- [20] 44th Census of World Casting Production. *Modern Casting*, (December 2010), 23-27.
- [21] 45th Census of World Casting Production. *Modern Casting*, (December 2011), 16-19.
- [22] 46th Census of World Casting Production. *Modern Casting*, (December 2012), 25-29.
- [23] 47th Census of World Casting Production. Dividing up the Global Market. *Modern Casting*, (December 2013), 18-23.
- [24] 48th Census of World Casting Production. Steady Growth in Global Output. *Modern Casting*, (December 2014), 17-21.
- [25] 49th Census of World Casting Production. Modest Growth in Worldwide Casting Market. *Modern Casting*, (December 2015), 26-31.
- [26] 50th Census of World Casting Production. Global Casting Production Stagnant. *Modern Casting*, (December 2016), 25-29.
- [27] Census of World Casting Production. Global Casting Production Growth Stalls. *Modern Casting*, (December 2017), 24-28.
- [28] Census of World Casting Production. Global Casting Production Expands. *Modern Casting*, (December 2018), 23-26.
- [29] Census of World Casting Production. Total Casting Tons. Hits 112 Million. *Modern Casting*, (December 2019), 22-25.
- [30] Census of World Casting Production Total Casting Tons Dip in 2019. *Modern Casting*, (January 2021), 28-30.
- [31] Census of World Casting Production Fewer Castings Made in 2020. *Modern Casting*, (December 2021), 26-28.
- [32] *Report CAEF - The European Foundry Association 2021*. Retrieved April 20, 2022, from <https://www.caef.eu/downloads-links/>.
- [33] Soiński, M.S. & Jakubus, A. (2021). The leading role of aluminium in the growing production of castings made of the non-ferrous alloys. *Archives of Foundry Engineering*. 21(3), 33-42. DOI: 10.24425/afe.2021.136110.
- [34] Gajdzik, B. & Wolniak, R. (2021). Influence of the COVID-19 crisis on steel production in Poland compared to the financial crisis of 2009 and to boom periods in the market. *Resources*. 10(1), 4, 1-17. DOI: 10.3390/resources10010004.
- [35] Rokicki, T., Bórawski, P. & Szeberenyi, A. (2023). The impact of the 2020–2022 crises on EU countries' independence from energy imports, particularly from Russia. *Energies*. 16(18), 6629, 1-26. DOI: 10.3390/en16186629.