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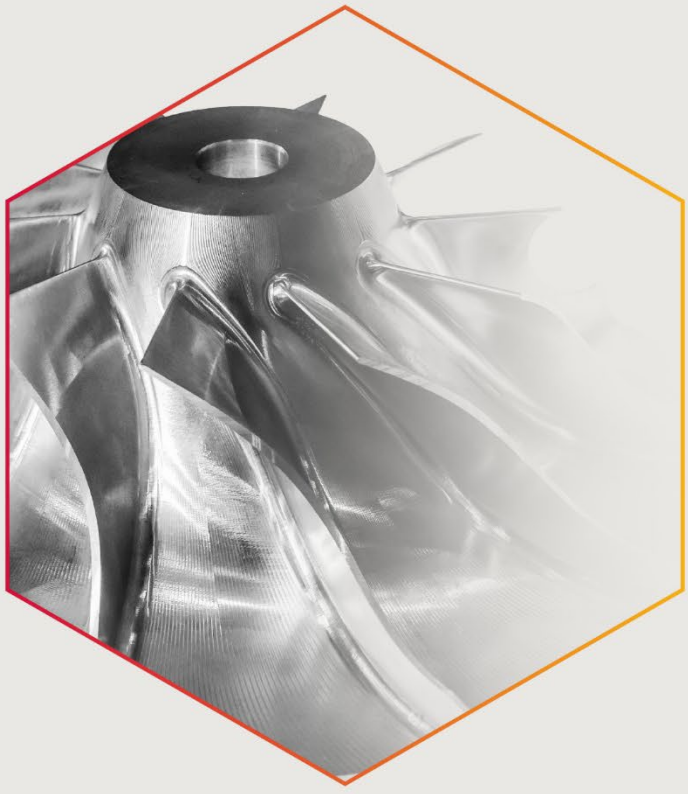

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NETCASTPL4.0
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(Grant Agreement number 101159771)

D6.1 Market analysis and needs in the area of light-weighting castings for Foundry 4.0 in Poland

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NetCastPL4.0 aims to enhance excellence and innovation capacity at AGH, putting AGH in a leading position to nuclei the Networking Pole for Castings Foundry Innovation and Sustainability to face the strategic challenges of Poland and EU foundries and of lightweight components end-user industry. It also aims to engage the country in pan-European collaborative efforts on this topic twinning with the Consiglio Nazionale delle Ricerche (Italy) and AALTO University (Finland). It will put AGH This will be achieved through realization of following specific objectives implemented via 7 WPs:

1. Improving the overall capacity and resources at AGH in advanced lightweight castings science & technology and in emerging Industrial Sustainability assessment and management practices and tools.
2. Conducting exploratory research on "High-tech cast iron and Al alloys for lightweighting castings for the medium and heavy-loaded conditions produced by green molding materials" demonstrating enhanced capacity in novel lightweight materials and components fabrication, modelling and characterisation.
3. Establishing an AGH European Networking Pole on Lightweight Castings Innovation and Sustainability. This will enhance the replication potential developed at AGH, creating strategic partnerships with Research organizations, Universities, Foundries, Industry, Public and Governmental Organizations, and Agencies in light-weighting casting components and Technologies for casting foundries 4.0 development.
4. Providing new results and experiences analysing 3 case-studies in production of light-weight castings components in medium and heavy loaded conditions and automotive for the preparation of a Guide Document on Best Available Practices in the Green Foundries Industry.
5. Leveraging the NetCastPL4.0 partnership at a European level and creating the enabling conditions for a long-lasting joint collaboration.
6. To arrange schools and training workshops in partner countries for scientists and for potential follower foundries and other relevant stakeholders.
7. Raising mobility (internal and external) of scientists and staff in green molding/casting science and technologies.
8. Improving the research management and administration skills at AGH, by creating the Department of European cooperation within AGH.
9. Fostering gender equality issues at AGH and in the castings foundry through implementation of the action plan for Equality, Inclusion, and Diversity.

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1. Scope of the deliverable

The objective of the deliverable relates to a market analysis in terms of light-weighting castings for Foundry 4.0 in Poland. Market needs in the area of light-weighting castings production in Poland is defined in this report and is assessed from the main viewpoints of the NetCastPL4.0-project. The task was conducted in cooperation with Polish Foundrymen's Association and Foundry Chamber of Commerce in Poland. Statistical data on the production volume of light-weighting castings in Poland and data on the use of such castings in the automotive, aviation, energy industries, etc. will be compiled.

2. Current situation of the foundry industry in Poland and Europe

The summary of the situation of the foundry industry is made from the statistical data provided by the *Polish Foundry Chamber of Commerce* to the NetCastPL4.0-project. The report "Production of thin-walled castings in Poland compared to Europe, including casting alloys: superalloys, aluminum alloys, ductile cast iron, and cast steel. Current status and perspectives." can be found in full in **Attachment 1** of this deliverable report.

The foundry industry in Poland currently comprises over 300 foundries, employing nearly 20,000 people, and producing a total of approximately 750,000 tons of castings. The predominant materials used in casting production are ***gray and ductile iron***, as well as ***non-ferrous alloys (mainly aluminum alloys)***. Steel castings account for approximately 4.6% of total casting production. In terms of industries the castings are used in, the main users of Polish castings are automotive industry (65%), construction (9%), machinery industry (9%), iron and steel industry (7%), energy industry (3%), while the remaining 7% is classified as other industries. Nearly 50% of Polish casting production is exported. 90% of the exports goes to the European Union, with Germany being the largest destination of Polish castings. The Polish casting production volumes have followed the general European foundry industry trends in the 2000's, having bigger disruptions related to the 2008 financial crisis and the pandemic in 2020. The resurgence of production in the 2020's has been followed by a slight decline in production in 2023 and 2024.

In the report, the status of thin-walled castings in the foundry industry was elaborated. The definitions of thin walled in the scope of analysis is as follows: for aluminum alloys, thickness of less than 2 mm is considered, while for cast iron and steel castings, a wall thickness of up to 10 mm is considered thin-walled. The main casting processes related thin-walling were die and pressure die casting, and investment casting.

Of the companies in Poland, ***non-ferrous foundries are the main producers of thin-walled castings***. The customers for thin-walled aluminum alloy castings are primarily ***global automotive companies***, which outsource production to Poland with product quality and lower production costs than in Western Europe in mind. The permanent mold methods employed in this type of production lend themselves naturally into making thin-walled structures.

Ductile iron is another material gaining popularity in the production of thin-walled castings. From an economic perspective, thin-walled ductile iron castings can be less expensive than counterparts made from aluminum alloys. Additionally, they can exhibit superior mechanical properties. An analysis conducted by the Foundry Chamber of Commerce shows that among foundries producing ductile iron products, ***a growing number of companies include thin-walled castings in their portfolios.*** This may already account for nearly 30% of the total production of ductile iron castings in Poland.

One of the material groups traditionally used in thin-walled geometries are superalloys. They are classified as advanced materials that require precise manufacturing techniques. Superalloys are crucial in production of turbine blades and other components exposed to extreme conditions. Cast superalloys are also used in energy, chemical, and medical industries, where high corrosion and high-temperature resistance are required.

In the case of steel castings, the situation of thin-walling is quite stark compared to non-ferrous and cast iron alloys. Despite the developing technologies for the production of thin-walled structures, Polish steel foundries do not, for the most part, focus on the production of thin-walled castings. Some of the known challenges with regards to cast steels are the lesser fluidities and high pouring temperatures compared to cast irons.

Summarizing the research conducted by Polish Foundry Chamber of Commerce among Polish and European foundries and an analysis of the needs of modern industries that purchase castings, it can be concluded that ***thin-walled castings offer very broad development prospects***. The main industries interested in this solution are ***automotive, aviation, and electronics, where weight reduction is crucial.*** Although there are no official statistics on thin-walled casting production volumes, ***Polish Foundry Chamber of Commerce's research predicts that currently thin-walled castings are responsible for over 20% of total production in Poland.*** The demand for thin-walled castings is expected to show a growing trend, with increasing requirements for simultaneous lightness and strength in components.

One future aspect highlighted in the report is ***CBAM (Carbon Border Adjustment Mechanism)***, being implemented by the European Commission. If fully implemented in covering additional products and castings imported into the EU, it has potentially large effects in the European foundry market. Many thin-walled castings come to the EU, primarily from Asia. Potential addition of the tax, importing them into the EU will become less profitable. ***To meet demand, it will be necessary to increase supply within the EU, being a great potential for foundries.***

3. Market and Market Needs Analysis in the Area of Lightweight Castings for Foundry 4.0 in Poland

The Polish Foundry Chamber of Commerce report highlighted several aspects in European foundry industry trends related to thin-walled castings. To investigate the needs further, a survey was designed within the NetCastPL4.0 project team. Polish Foundrymen's Association was commissioned to distribute the survey to its' members and compile a report on the findings. The purpose of the survey was to gather information on the current state, needs, and development barriers related to lightweight castings in the Polish foundry industry, with particular focus on the Foundry 4.0 concept. The study also addressed the use of modern technologies, digital transformation, demand for specific material properties, and the industry's readiness to collaborate on sustainability and carbon footprint reduction. The questionnaire was addressed to Polish foundries.

3.1 Survey design

The designed survey is included in **Attachment 3.** The questions were divided into four main areas:

- General company information
- Market needs and expectations
- Foundry 4.0 and digital technologies
- Market assessment and outlook

3.2 Report results

3.2.1 Respondent profile

The survey had 32 respondents. 78% of them had been operating in the market for over 20 years, and 13% for over 10 years. 66% of respondents represented ***Small and Middle-sized Enterprises (SME)*** (employing up to 250 employees), and 34% were large enterprises.

Aluminum was the most used non-ferrous metal, with 16 respondents. 5 respondents confirmed using magnesium, and 4 confirmed using zinc. Respondents also listed other alloys used in casting production, such as nickel, cobalt, brass, bronze, copper, and tin.

Among the ferrous metals and their alloys, the most used include ductile iron (17 respondents) and gray cast iron (16 respondents). Carbon steel, including structural and carbon tool steel, was used by 12 respondents, and alloy steel (stainless steel, alloy tool steel, and high-speed steel) by 10 respondents. 3 respondents indicated the use of other ferrous alloys, such as ADI, high-manganese cast steel, and high-chromium cast iron.

When the production of thin-walled castings in Poland is considered***, it is worth noting that the most common materials, are aluminum (52.670 tons) and ductile iron (48.422 tons). Gray cast iron is also popular, with production of 28,049 tons.*** Thin-walled castings produced from other material groups are much less common. The most common molding process used by respondents

was sand casting, which 22 respondents used. 9 respondents used die casting in their production process.

The main customers for thin-walled castings produced by the respondents are ***machinery, tool, and agricultural industries*** (26 respondents). A significant part of thin-walled castings is also produced for the ***automotive industry*** (15 respondents). Only 7 respondents produce thin-walled castings for the energy industry. 96% of respondents exported their products outside of Poland.

3.2.2 Market needs

Over 50% of respondents noted an increase in demand for lightweight castings over the past five years, while 28% did not see such a change. ***This was primarily observed in automotive*** (21 respondents) and ***machinery industry*** (16 respondents). Demand for thin-walled castings was observed also in aerospace (8 respondents) and energy industries (7 respondents).

The most important requirements for the castings are ***dimensional precision*** (21 respondents) and ***mechanical strength*** (21 respondents). ***Light weight of the castings also appears to be important***, as indicated by 16 respondents. Respondents in general see no shortage of casting suppliers specializing in lightweight castings (81% of respondents).

On the general feelings of innovation in the foundry market, ***over 80% of respondents positively assessed the current level of innovation***. 53% of respondents rated this level as average, and 22% as high. Only 3% of respondents considered the level of innovation to be very low. ***69% of respondents confirm that they are looking for new technology partners*** in the field of lightweight casting now or in the future, 28% of them seeing this need only in the future. 31% of respondents confirmed that they are not looking for support from technology partners at this very moment.

The survey included questions about the perceived barriers in thin-walled casting utilization. According to respondents, ***the main barriers hindering development of production are primarily high production costs***, being noted by 25 respondents. 9 respondents also cited lack of modern technologies, while persistently low demand for this type of castings was noted by 8 respondents.

Support that would contribute to the development of lightweight castings in Poland was surveyed, respondents indicating the most important option as the possibility of ***investment financing*** – 27 respondents. ***Research and development (R&D) support*** is also an important aspect for the development of lightweight castings, as highlighted by 20 respondents. ***53% percent of the surveyed foundries offer lightweight castings***, and ***22% are considering expanding their offering to include lightweight castings.***

3.2.3 Industry 4.0

Industry 4.0 integrates information and communication technologies with production processes, and the goal is to increase efficiency, flexibility, and productivity by integrating people, machines, and systems into a single network. ***97% of respondents were familiar with the concepts of Industry 4.0, although 53% of them emphasize that they are only partially familiar with the concept.***

Process automation was the most frequent area of usage (22 respondents). Over 50% of respondents also use ***robotics and 3D printing*** in their production processes. ***The least popular technologies are the Internet of Things*** (IoT) (3 respondents) and ***artificial intelligence*** (6 respondents). The ***main barrier on implementation is high cost***, as confirmed by 29 respondents (90%). Another obstacle is ***lack of appropriate technological knowledge among employees*** (8 respondents) and employee resistance (5 respondents).

Collaboration with internal or external research and development centers is important in developing usage of Industry 4.0. ***All respondents declared willingness to collaborate***, with 12% stating that such collaboration depends solely on the nature of the project. The interest in the Industry 4.0 concept is visible among the respondents, with 69% of them declaring their willingness to participate in the Foundry 4.0 demonstration and pilot projects, and 31% interested in participating sometime in the future. ***44% of respondents report a need for advisory support in digital transformation***. 40% are undecided in this regard, and ***only 16% definitely do not require support.***

3.2.4 Sustainability and carbon footprint

Carbon footprint is becoming a key issue in foundry supply chains. Reducing their footprint allows companies to ***reduce operating costs, improve their reputation in the society, and contribute to sustainable development.*** With requirements to calculate and report carbon footprints, foundries are paying close attention. 38% of respondents indicated that ***within the next five years, environmental impact and carbon footprint will become key factors in selecting casting suppliers***. 31% of respondents had no opinion on this matter.

Currently, 28% of respondents see no consideration of carbon footprints when castings are purchased. 38% of respondents find it difficult to comment on this issue. 35% of respondents do not see the need to collaborate with casting suppliers to jointly develop and implement carbon footprint reduction strategies throughout the supply chain. Approximately 29% of them believe the opposite.

Approximately 40% of respondents expect suppliers to proactively propose solutions to reduce environmental impact, such as using recycled materials or energy-efficient processes. Currently, nearly 50% of respondents are see no willingness to pay higher prices for castings with a lower carbon footprint.

3.2.5 Future outlook

Respondents rated the ***domestic development potential for lightweight castings as high (44%) and medium (38%).*** Additionally, the demand is expected increase over the next five years, noted by 60% of respondents.

As a summary, the respondents noted actions that would support in responding to the situation. The most frequently mentioned actions were:

- reduction of energy prices for energy-intensive industries

- introduction of subsidies for foundries and support of investments in new technologies and automation
- training of staff (management, sales, and technical designers of finished products), including expanding knowledge on the impact of alloying and wall thickness
- systemic changes supporting operations in heavy industry, including changes in raw materials and energy policies, reducing tax burdens and interest rates, halting increases in the minimum wage, and introducing customs duties on castings from Asia
- collaboration with research institutions

From these results, ***the industry is seeing more demand for lightweight casting production***. To support the capabilities of foundries to supply such castings, ***networking, training and collaboration with R&D entities is needed***. The economic situation is also a key issue, with needs ***in investments, raw materials, energy, and competitiveness with imports from outside EU being seen as challenges.***

1. Assessment of the report results in the scope of NetCastPL4.0 actions

The outlined results from the surveys can be summarized as follows. Key points related to the NetCastPL4.0-project can be highlighted in the statistical data acquired from the reports.

The Drive of Automotive Industry in Lightweighting

The automotive industry is a key driver for development and use of lightweight non-ferrous castings. The currently used casting processes are mainly permanent mold technologies, such as die, and pressure die casting processes. NetCastPL4.0 exploratory research is tackling challenges in high strength aluminum-copper alloys. Additionally, the potential use of high strength cast iron alloys like ADI (Ausferritic Ductile Irons) was seen in the survey responses. This highlights the importance of continued research and development in these alloy systems.

Aluminium Alloys and Cast Irons

In the general industry trends and usage, aluminum alloys and cast irons were the main interest in lightweight casting design. Cast steels are widely utilized in many industries, but analyzed from both reports, lightweight design is not a major consideration when these alloys are used. Superalloys and thin-walled components are a natural combination, used in heavily stressed aerospace and energy industries. However, the cost of production will be a clear limiting factor in wider usage of these alloys outside of these specific industries. In this scope, aluminum and cast-iron alloys are seen as a clear market development leaders with regards to thin-wall castings.

Growing Demand in General

The industry is seeing a general increased demand for lightweight castings. In part, this stems from reduction of material use, in applications where the reduction of weight is crucial. The combined cost reduction through lesser material use is also seen as a key benefit.

European Union-level actions, Sustainability and Environmental Criteria

Environmental aspects are becoming key factors in foundry supply chains from several points of view. Carbon footprint is seen as a major factor in foundry product supplier selection in the future, and large-scale actions are needed to reach lower footprints. CBAM (Carbon Border Adjustment Mechanism) is generally seen as having great potential in providing a fair competitive situation for the European foundry industry with regards imports from outside the EU. The actions that can be taken to reduce carbon footprints will lead to at least temporary increase in production costs through new investments and higher technological demands, and thus a fair economical competition between parties in and outside of EU is needed. The NetCastPL4.0-project for example emphasizes green technologies in the use of materials and molding processes, providing knowledge for the network partners and wider audiences.

Growing Demand Identified from the Foundry Survey

The growing demand for thin-walled and lightweight castings were also identified in the responses of the surveyed foundries. The respondents saw no shortage of suppliers capable of producing these kinds of castings, but as the majority of respondents saw the demand growing in the next few years, inaction in development actions is will not be enough to meet these with current technologies only.

High Production Costs Are a Major Barrier

Although the potential in thin-walled and lightweight castings is quite universally seen throughout the foundry industry, one barrier in future utilization is seen. The main one being higher production costs. This links heavily also to the sustainability aspects mentioned previously. It should be made sure that production costs won't be driving companies out of implementing various green technologies.

Need for Partners and Networking

Only a minority of the respondents saw no real need for partner actions in developing processes and manufacturing systems to reach future goals in lightweighting. This indicates potential in the networking actions being done in the NetCastPL4.0 project. Matchmaking of potential partners

Industry 4.0 Awareness vs Implementation

The respondents were very aware of the new trends in manufacturing, but many were only partially knowledgeable of the different possibilities. Additionally, not so many had actually implemented these technologies in their manufacturing systems. This posits a clear potential for R&D partners to provide expertise in potential applications and concrete actions in the future.

Future Market Outlook

From all of these results, the industry is seeing more demand for lightweight casting production. To support the capabilities of foundries to supply such castings, networking, training and collaboration with R&D entities is needed. Although there is a clear demand, supporting actions from different entities are needed to realize this potential. The economic situation is a key issue, with needs in investments, raw materials, energy, and competitiveness with imports from outside EU being seen as challenges.

Polish Foundry Chamber of Commerce
Odlewnicza Izba Gospodarcza
ul. Dukatów 8, 31-431 Kraków
www.oig.com.pl

Kraków, July 30th 2025

Report:

"Production of thin-walled castings in Poland compared to Europe, including casting alloys: superalloys, aluminum alloys, ductile cast iron, and cast steel. Current status and perspectives."

1. Current situation of the foundry industry in Poland and Europe,
2. Production of thin-walled castings – technologies:
    a. High Pressure Die Casting,
    b. Die casting,
    c. Investment casting.
3. Production of thin-walled castings - materials:
    a. Thin-walled castings made of aluminum alloys,
    b. Thin-walled castings made of ductile iron,
    c. Thin-walled castings made of superalloys,
    d. Thin-walled castings made of cast steel,
4. Advantages of thin-walled castings:
5. Development perspectives for the thin-walled castings market:

Ad 1. Current situation of the foundry industry in Poland and Europe:

The foundry industry in Poland currently comprises over 300 foundries, employing nearly 20,000 people, and producing a total of approximately 750,000 tons of castings (data for 2023 - according to preliminary data, production in 2024 decreased by 20%).The predominant materials used in casting production are gray and ductile iron, as well as non-ferrous alloys (mainly aluminum alloys). Steel castings account for approximately 4.6% of total casting production.

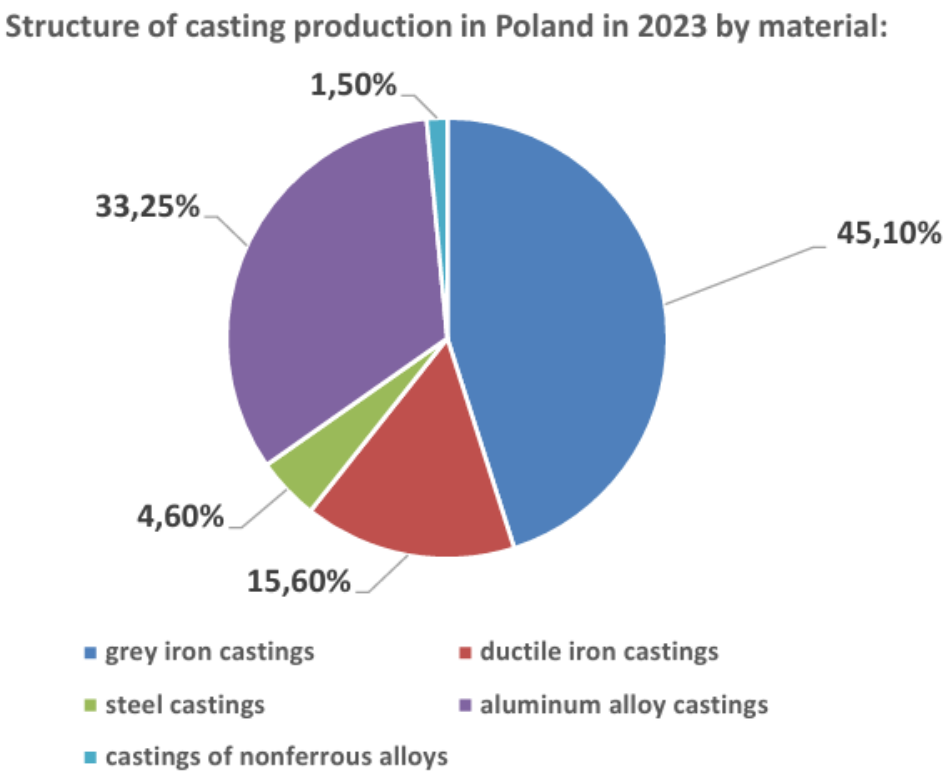


Fig. 1. Structure of casting production in Poland in 2023 by material.

Main markets for Polish castings:

In terms of branches, the main recipients of Polish castings are: automotive industry (65%), construction (9%), machinery industry (9%), iron and steel industry (7%), energy industry (3%) and others (7%).

Nearly 50% of domestic casting production is exported. 90% of exports goes to the European Union market, with Germany being the largest recipient of Polish castings.

Figure 1: Polish Ferrous Casting Production (volume)

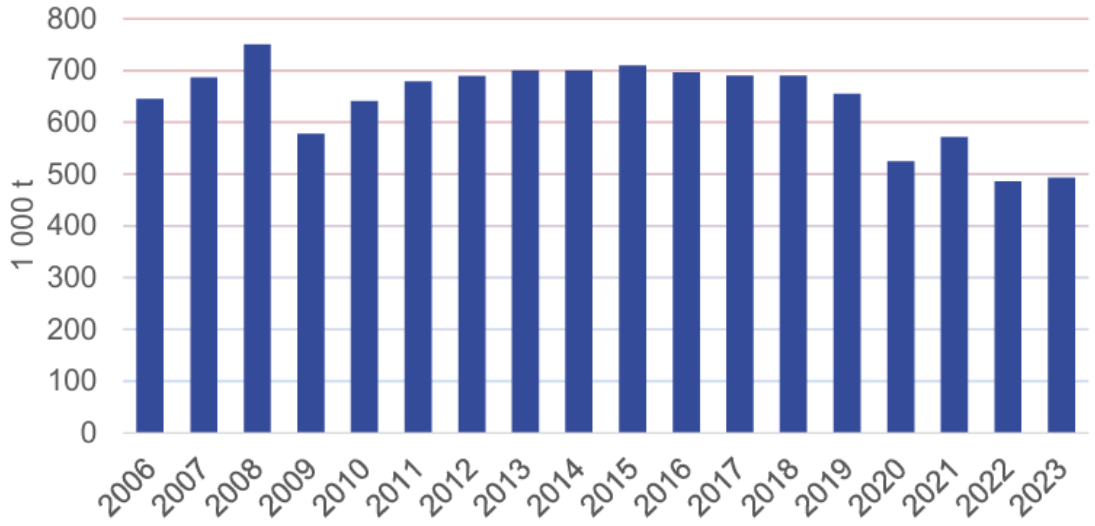


Fig. 2. Polish Ferrous Casting Production from 2006 to 2023 (volume in 1000 t.)

Source: EFF

Figure 2: Polish Non-Ferrous Casting Production (volume)

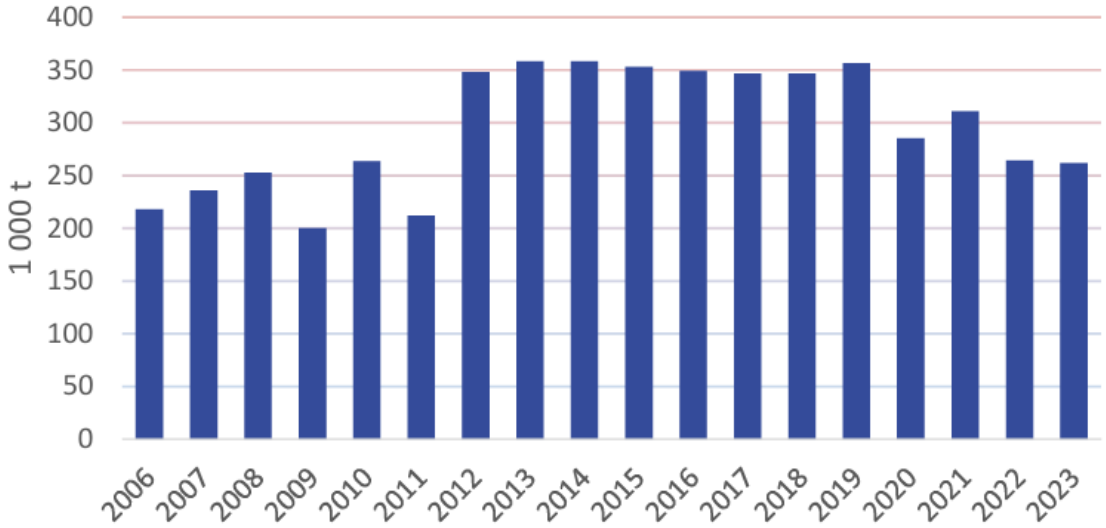


Fig. 3. Polish Non-Ferrous Casting Production from 2006 to 2023 (volume in 1000 t)

Source: EFF

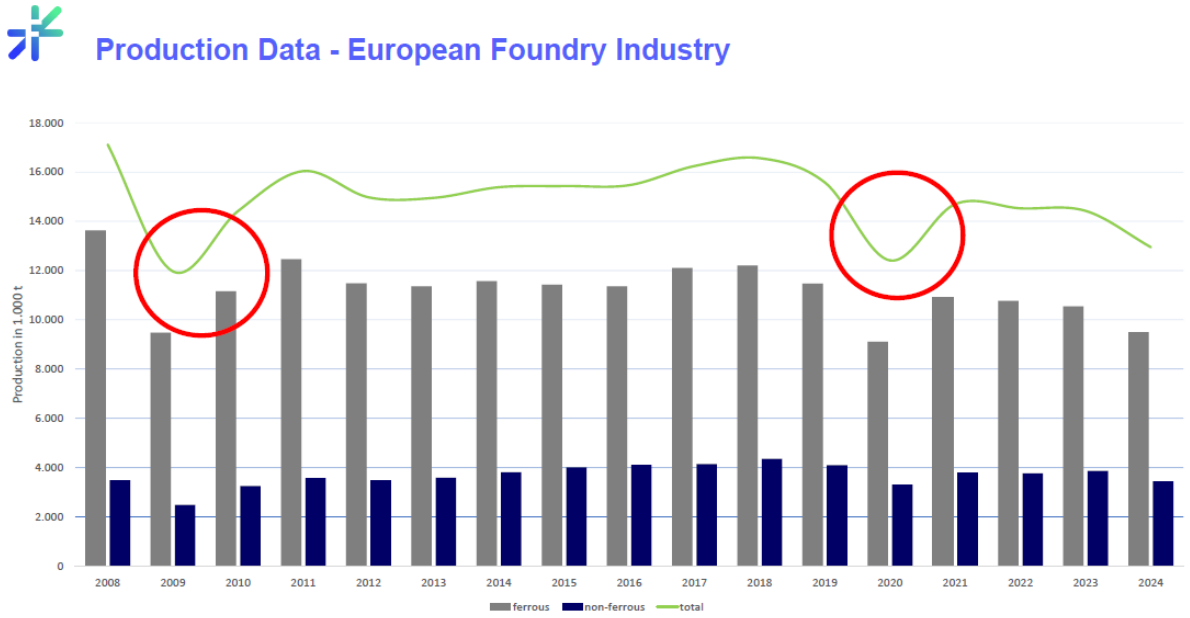


Fig. 4. Casting production in EFF member countries from 2006 to 2023.

Source: EFF

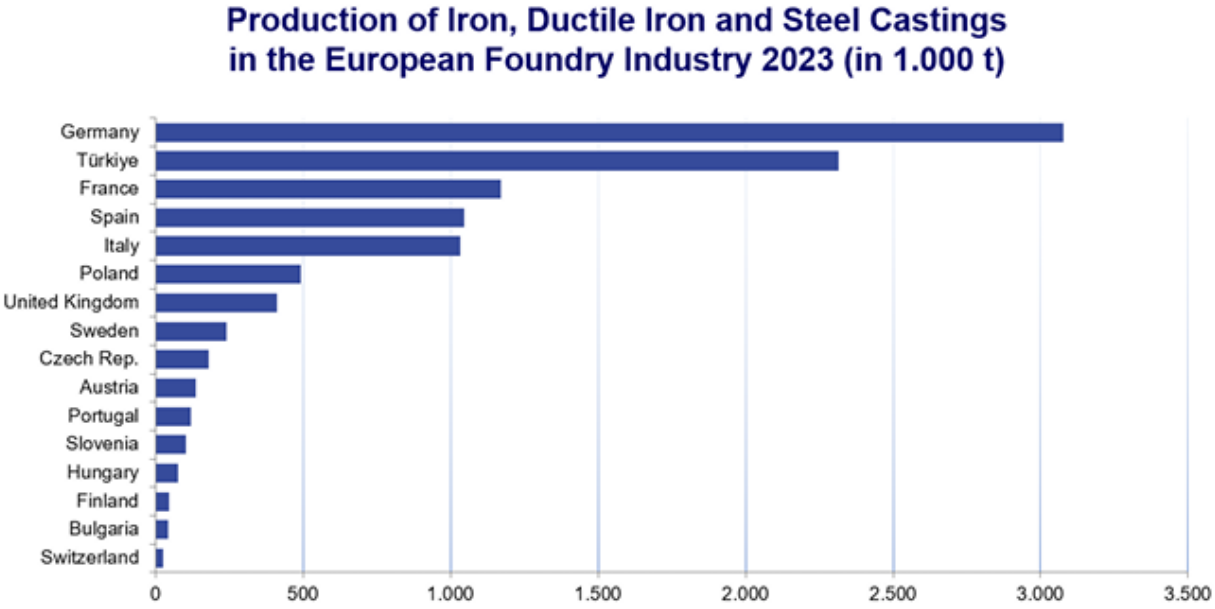


Fig. 5. Production of iron, ductile iron, and steel castings in the countries associated with the European Foundry Federation (EFF) in 2023.

Source: CAEF Yearbook 2023.

Taking into account non-ferrous metal castings, Poland is the 5th largest producer in the European Union (approximately 250,000 tons of castings)

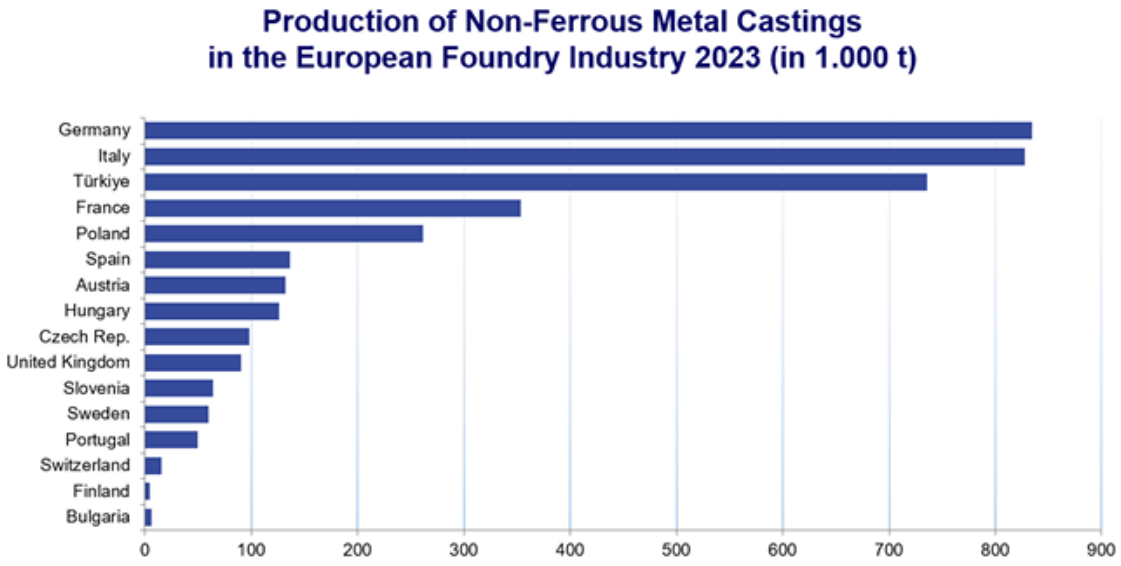


Fig. 6. Production of non-ferrous metal castings in EFF – European Foundry Federation member countries in 2023. Source: CAEF Yearbook 2023.

Table 21
Total production in 1000 t - Non-ferrous metal castings

Country	2019	2020	2021	2022	2023	2022/21 in %	2023/22 in %
Austria	144,8	121,4	139,6	141,9	132,1	1,7	-6,9
Belgium	1,0	1,7	1,6				
Bulgaria			6,0	6,1	6,1	0,8	0,0
Croatia	45,8	65,9	60,8	34,1	74,9	-43,9	119,6
Czech Rep.	116,0	94,5	108,3	105,5	98,0	-2,6	-7,1
Denmark	3,5		3,2				
Finland	5,3	4,1	6,1	6,3	4,5	2,8	-27,9
France	392,4	330,7	339,9	340,4	353,7	0,1	3,9
Germany	1019,2	769,4	806,1	810,3	834,2	0,5	3,0
Hungary	124,0	121,7	121,6	126,0	126,0	3,6	0,0
Italy	827,3	659,2	880,5	820,6	828,0	-6,8	0,9
Norway a)	6,5		5,9				
Poland	356,5	285,2	310,9	264,2	261,6	-15,0	-1,0
Portugal	56,5	50,3	50,6	51,5	49,2	1,8	-4,5
Slovenia	75,7	53,1	64,3	66,4	64,0	3,3	-3,6
Spain	153,9	124,6	127,7	131,4	136,3	2,9	3,7
Sweden	65,1	56,4	60,0	60,0	60,0	0,0	0,0
Switzerland	15,9	13,6	14,8	15,4	15,6	4,1	1,0
Türkiye	573,0	506,8	655,5	738,8	735,4	12,7	-0,5
United Kingdom	165,8	120,1	114,5	97,3	90,0	-4,7	-7,5
Total CAEF	**4102,6**	**3312,8**	**3817,0**	**3763,5**	**3869,6**	**-1,7**	**2,8**

a) without copper (only 2 foundries = no data collection)

Table 1. Production of non-ferrous metal castings in EFF – European Foundry Federation member countries in 2023.
Source: CAEF Yearbook 2023.

Ad 2. Production of thin-walled castings - technologies:

In this report, we present the production of thin-walled castings. By definition, these are precision castings characterized by thin walls. For aluminum alloys, this means a thickness of less than 2 mm, while for cast iron and steel castings, a wall thickness of up to 10 mm is considered the limit. Thin-walled casting production in Poland and Europe is as follows:

The main technologies for the production of thin-walled castings are:

a. Pressure die casting: Primarily used for aluminum, zinc, magnesium, and brass alloys, it allows for thin walls as thin as 0.5 mm. It allows for tolerances to be maintained within ±0.05 mm thanks to controlled injection and rapid mould cooling. Often used in high-volume production of electronic components and mechanical housings.

b. Die casting: using long-life steel or cast iron moulds, allows for the production of parts with better mechanical properties than sand casting.

c. Investment casting is a process for producing metal castings with complex shapes and high precision. It involves creating a wax model, which is then surrounded by a refractory material to form a mold. After removing the wax (by melting or rinsing), molten metal is poured in, taking the shape of the model. This allows for thin walls (up to 1 mm) but requires a multi-stage mould and core preparation process. A significant advantage of this method is the dimensional repeatability and high surface quality of the castings, as well as the ability to cast products from various metal alloys.

Ad 3. Production of thin-walled castings - materials:

a. Thin-walled castings from ultralight alloys:

Among the analyzed companies in Poland, non-ferrous metal foundries are the main producers of thin-walled castings. They supply the automotive, aerospace, and household appliance industries. The customers for thin-walled aluminum alloy castings are primarily global automotive companies, which outsource production to Poland due to the guaranteed highest product quality and lower production costs than in Western Europe.

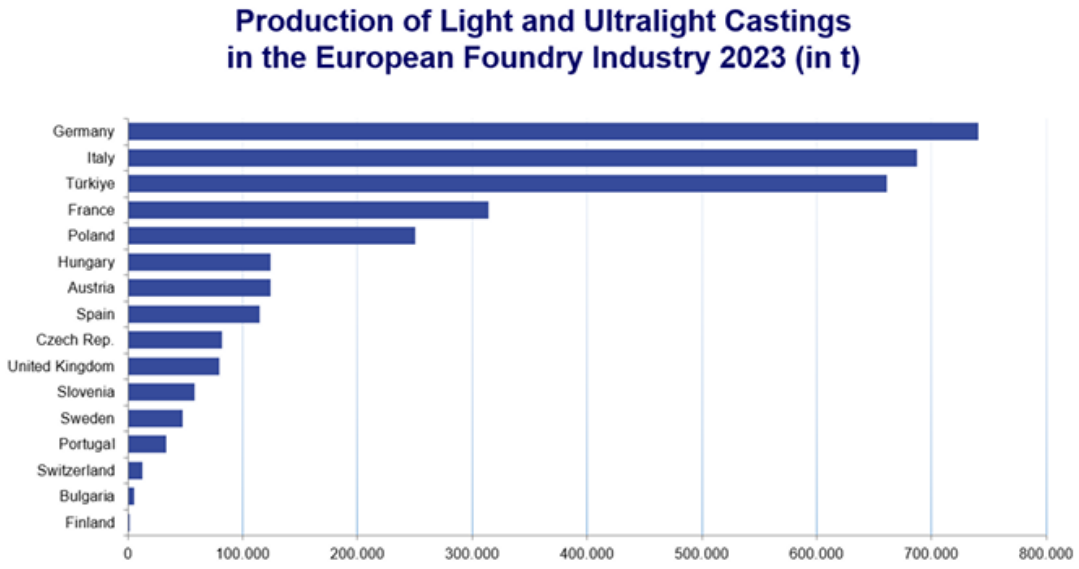


Fig. 7. Production of light and ultralight castings in 2023 in EFF - European Foundry Federation (EFF).
Source: CAEF Yearbook 2023

Table 28
Total production in t - Light and ultralight castings

Country	2019	2020	2021	2022	2023	2022/21 in %	2023/22 in %
Austria	133406,0	111302,0	127971,0	131859,0	123972,0	3,0	-6,0
Belgium	683,0	539,0					
Bulgaria			5700,0	5730,0	5730,0	0,5	0,0
Croatia							
Czech Rep.	95000,0	77700,0	89400,0	87600,0	82200,0	-2,0	-6,2
Denmark	2224,0						
Finland	2184,0	1730,0	3604,0	3604,0	1797,0	0,0	-50,1
France	348062,0	293528,8	299015,9	299255,4	314266,9	0,1	5,0
Germany	1011598,7	673227,0	716615,9	716465,0	740610,0	0,0	3,4
Hungary	122675,0	119186,0	119304,0	124013,0	124013,0	3,9	0,0
Italy	685584,0	543972,0	732536,9	685046,5	687213,0	-6,5	0,3
Norway	6526,0						
Poland	340000,0	272000,0	296480,0	252008,0	250000,0	-15,0	-0,8
Portugal	37009,0	31966,0	33050,0	34859,0	33673,0	5,5	-3,4
Slovenia	54625,0	44618,0	52692,0	55576,0	57912,0	5,5	4,2
Spain	129345,0	101317,0	106185,0	110522,0	114618,0	4,1	3,7
Sweden	48000,0	39195,0	45000,0	48000,0	48000,0	6,7	0,0
Switzerland	12699,0	10815,0	11726,0	12362,0	12531,0	5,4	1,4
Türkiye	504328,0	450264,0	579124,0	665930,5	660832,0	15,0	-0,8
United Kingdom	149100,0	104522,0	99296,0	87649,0	79510,0	-11,7	-9,3
Total CAEF	**3.683.049**	**2.875.882**	**3.317.701**	**3.320.479**	**3.336.878**	**0,1**	**0,5**

Table 2. Production of non-ferrous metal castings in EFF – European Foundry Federation member countries in 2019–2023.
Source: CAEF Yearbook 2023.

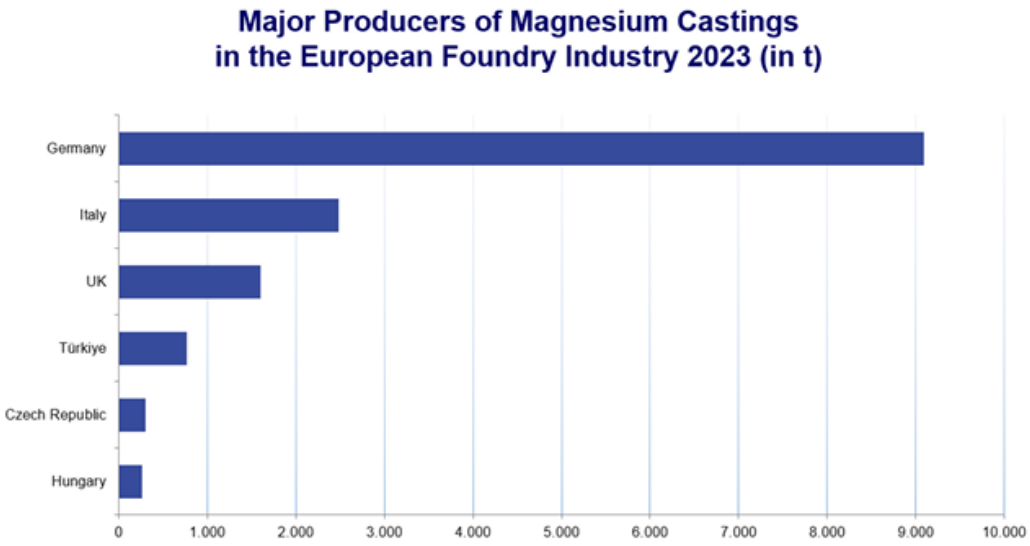


Figure 4. Main producers of magnesium alloy castings in the European Union in 2023 (in tons)
Source: CAEF Yearbook 2023

b. Thin-walled castings made of ductile iron: Ductile iron is another material gaining popularity in the production of thin-walled castings. Research shows that thin-walled ductile iron castings are an excellent base material for heat treatment, as they do not require expensive alloying elements or long heat treatment times. An increasing number of thin-walled castings are being produced from ADI.

From an economic perspective, thin-walled ductile iron castings are significantly less expensive than their counterparts made from aluminum alloys. Additionally, they can exhibit superior mechanical properties.

Research published studies indicate that prototype tests have already been conducted on thin-walled castings: a bracket, a compressor impeller, an automotive control arm, and a wheel rim made of ductile iron, which (taking into account their mechanical properties) could significantly compete with aluminum alloy castings.

Ductile iron exhibits excellent fluidity in thin-walled channels. Thin-walled castings of considerable size can be obtained, and the addition of Cu and Ni significantly improves the mechanical properties of ductile iron in thin-walled

castings. An analysis conducted by the Foundry Chamber of Commerce shows that among foundries producing ductile iron products, a growing number of companies include thin-walled castings in their portfolios. This may already account for nearly 30% of the total production of ductile iron castings in Poland.

c. Thin-walled castings made of superalloys:

Superalloys are a group of metal alloys characterized by exceptional strength and resistance to high temperatures, making them suitable for use in extreme environments, such as jet engines and gas turbines. Characteristic features of superalloys include:

- Ability to operate at high temperatures. They withstand heavy loads without cracking or deformation.
- High deformation resistance: Castings retain their shape and dimensional stability at high temperatures.
- High corrosion and oxidation resistance: They protect the material from degradation in aggressive environments.

Superalloys are advanced materials that require precise machining and appropriate manufacturing techniques. Their unique properties enable the creation of reliable and efficient solutions in many industries.

Superalloys are crucial for the production of turbine blades, steering gear segments and other components exposed to extreme conditions. Casting superalloys also finds applications in the energy, chemical, and medical industries, where high corrosion and high-temperature resistance are required. Superalloy castings are used in many important sectors of the economy, including:

a) Aerospace industry: production of turbine blades in jet engines and gas turbines, where materials are exposed to high temperatures and loads,
b) Energy industry: construction of gas and steam turbines in power plants,
c) Chemical industry: production of chemical equipment and other devices operating in aggressive environment,
d) Space industry: components for spacecrafts and satellites,
e) Other applications: production of implants, shafts, rings and other components exposed to high temperatures and mechanical loads.

d. Thin-walled castings made of cast steel:

Despite the developed technology for the production of thin-walled steel castings, Polish steel foundries do not, for the most part, focus on the production of thin-walled castings.

4. Advantages of thin-walled castings:

- Wall thickness allows for material savings and a reduction in the weight of the finished part.
- Thin walls translate into lower weight of the finished castings, which is important in many applications, such as the automotive industry.
- Thin-walled castings are characterized by good mechanical strength despite their thin wall thickness.
- Thin-walled castings are used in many industries, such as automotive, electronics, aerospace, and many others.

In summary, thin-walled casting is an advanced technology that allows the production of precise and lightweight metal parts with complex shapes, which is widely used in many industries.

Perspectives for the thin-walled castings market:

Summarizing research conducted by Polish Foundry Chamber of Commerce among Polish and European foundries and an analysis of the needs of modern industries that purchase castings, it can be concluded that thin-walled castings offer very broad development prospects. The main industries interested in this solution are automotive, aviation, and electronics, where weight reduction is crucial.

Although there are no official statistics on thin-walled casting production volumes, Polish Foundry Chamber of Commerce's own research predicts that currently **thin-walled castings are responsible for over 20% of total production in Poland**. This percentage is even higher in countries such as Germany, Italy, and Spain.

The demand for thin-walled castings is expected to show a growing trend. This is directly related to technological developments and increasing requirements for lightness and strength of products. Research centers are constantly conducting research on new metal alloys that will enable even thinner walls and provide improved mechanical properties of castings.

At the same time foundries specializing in thin-walled castings will gain a competitive advantage by offering lighter and more efficient products. Thin-walled castings allow

for a significant reduction in the weight of finished products. Despite their thin walls, these castings are characterized by high mechanical strength. Modern casting technologies enable high dimensional precision and surface quality.

In many cases, thin-walled castings are more cost-effective than other manufacturing methods (e.g., replacing aluminum alloy castings with ductile iron castings). However, the thin-walled casting process requires strict quality control and adherence to standards.

Another aspect is the CBAM carbon tax, being implemented by the European Commission. It's possible that in the coming months or years, it will cover additional products and castings imported into the EU from other countries. Many thin-walled castings come to the EU primarily from Asian countries. Then, after adding the tax, importing them into the EU will become less profitable. To meet demand, it will be necessary to increase supply using production within the EU. This is a great opportunity for foundries.

In summary, thin-walled castings are a promising technology with the potential for further development and application in various industries. Advances in technology and materials will fuel their continued growth.

Analysis of the Survey Results – NetCastPL.4.0

Market and Market Needs Analysis in the Area of Lightweight Castings for Foundry 4.0 in Poland

NETCASTPL4.0
- NETWORKING -

Prepared by Network Partner:

Stowarzyszenie Techniczne Odlewników Polskich
Polish Foundrymen's Association

1. Introduction

The survey was prepared as part of the NetCastPL4.0 project, commissioned by the project partner - Faculty of Foundry Engineering, AGH University of Science and Technology in Kraków.

The statistical study was conducted by the Polish Foundrymen's Association - a Network Partner of the NetCastPL4.0 Project. The study materials, including questions, were prepared by the Faculty of Foundry Engineering at AGH University of Science and Technology.

The purpose of this survey was to gather information on the current state, needs, and development barriers related to lightweight castings in the Polish foundry industry, with particular focus on the Foundry 4.0 concept. The study also addressed the use of modern technologies, digital transformation, demand for specific material properties, and the industry's readiness to collaborate on sustainability and carbon footprint reduction. The questionnaire was addressed to Polish foundries. The questions were divided into four main areas: (I) general company information, (II) market needs and expectations, (III) Foundry 4.0 and Digital technologies, and (IV) market assessment and future outlook. The analysis of responses helps identify current trends, the level of technological advancement in enterprises, key obstacles to the development of lightweight casting technologies, and areas that require strategic and investment support. The collected data serve as a valuable resource for shaping development policies, supporting cluster initiatives, and designing R&D projects aimed at innovation in the foundry sector.

2. Methodology

- Form: Online survey
- Data collection period: 26.06 – 31.07.2025
- Number of respondents: 32

Odlewnia Ostrowiec Sp. z o.o., SKB Drive tech, CPP Rzeszów, Odlewnia KAW-MET Marek Kawiński Sp. z o.o., PGO SA , Specodlew, FERRO-TERM Sp. z o.o., Nemak Poland , Odlewnia SILUM Sp. z o.o., Limatherm S.A., Eurocast Industries Sp z o.o. Sp kom, Norlys S.A., Odlewnia Cena MYSTAL sp. z o.o., Teksid Iron Poland, Odlewnie Polskie S.A., Polcast, Interarms, Metalodlew SA, Hydro-Vacuum S.A., Alteams Poland Sp. z o.o., LENAAL Sp. z o.o. Sp. k., Victaulic Polska, Meta-zel,

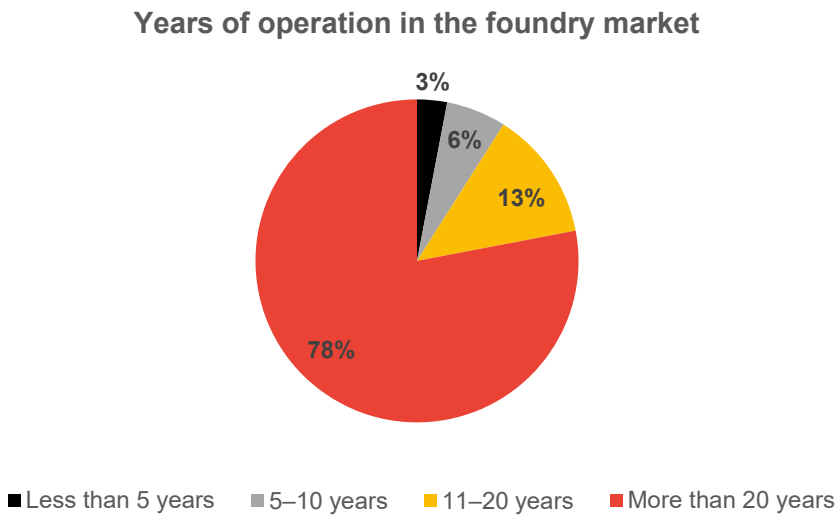
Odlewnia Zub, NeoCast- Paweł Darłak, Pomet , Odlewnia Gawrych, WSK Rzeszów , Fansuld, Odlewnia Żeliwa "Drawski"S.A., KGHM Zanam, Metalpol Węgierska Górka

- Participant profile: Polish foundries

3. Respondent Profile

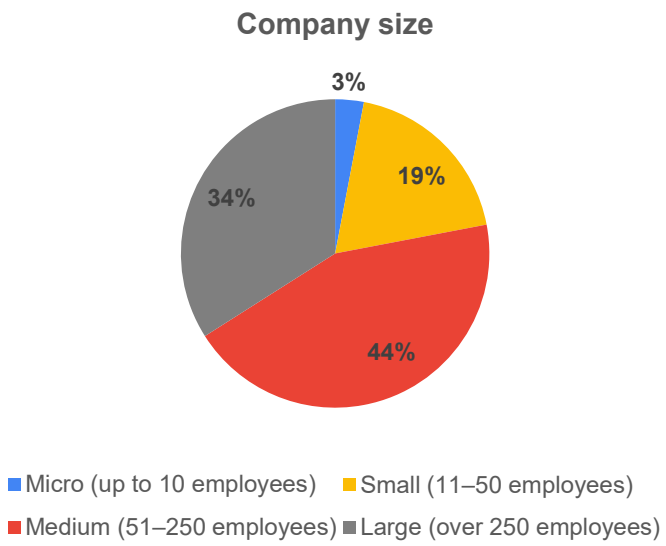
3.1. Years of operation in the foundry market

32 foundries participated in the survey. 78% of them had been operating in the market for over 20 years, and 13% for over 10 years, demonstrating the extensive experience and established position of the respondents in the Polish foundry market.



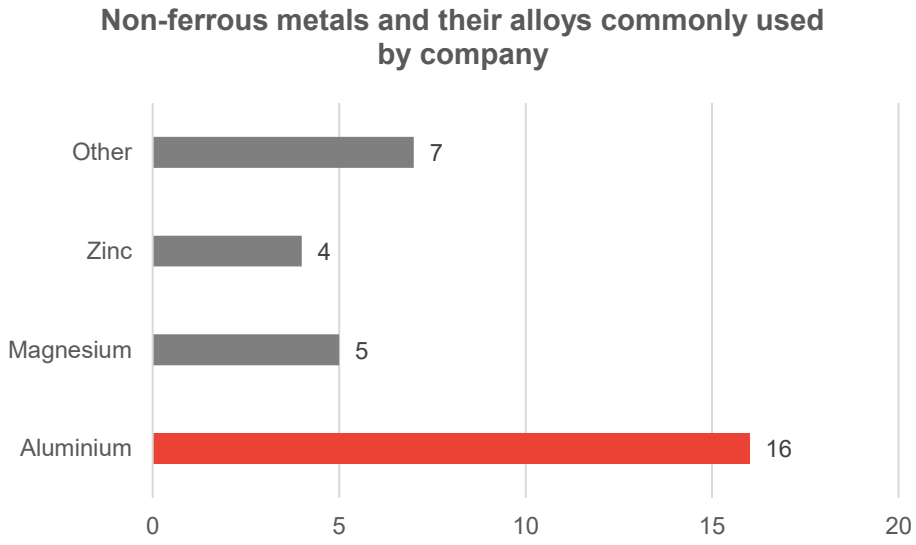
3.2. Company size

66% of respondents represented SMEs (employing up to 250 employees), and 34% were large enterprises.

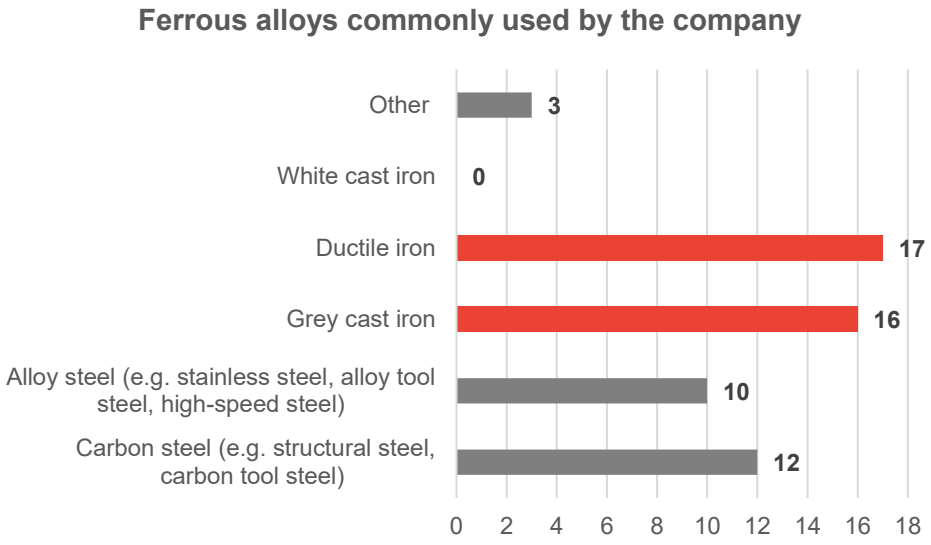


3.3. Materials and technologies used

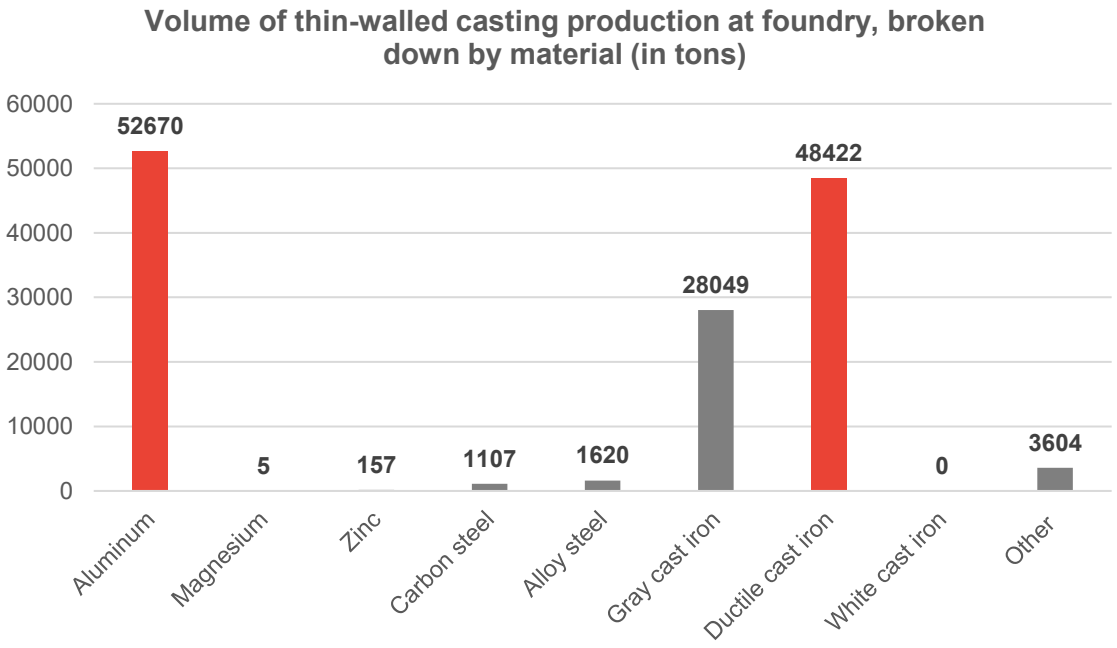
Considering the materials used, aluminum was the most commonly used non-ferrous metal, with 16 respondents. Thin-wall aluminum casting production volume in the surveyed foundries was 52.670 tons. 5 respondents confirmed using magnesium, and 4 confirmed using zinc. Respondents also listed other alloys used in casting production, such as nickel, cobalt, brass, bronze, copper, and tin.



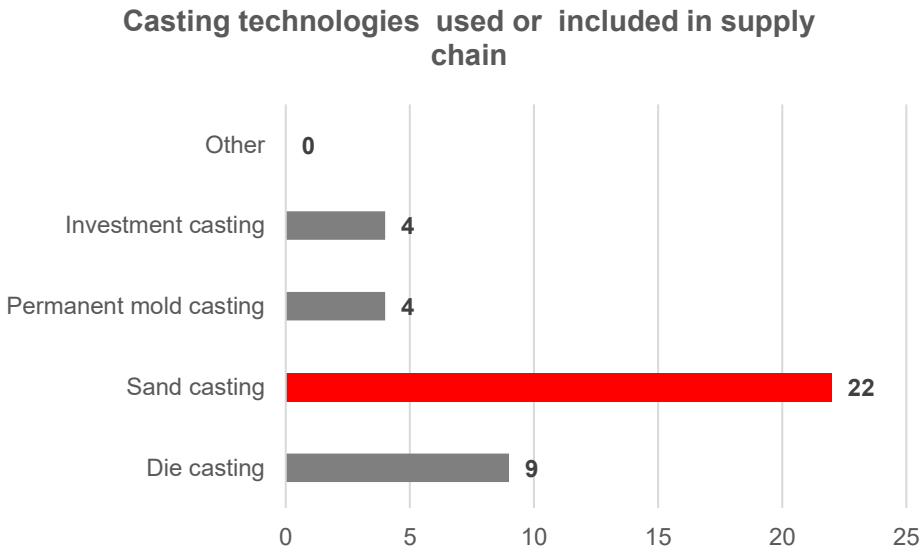
Among the ferrous metals and their alloys, the most commonly used include ductile iron (17 respondents) and gray cast iron (16 respondents). According to the respondents, thin-walled casting production amounts to 28,049 tons of gray iron and 48,422 tons of ductile iron. Carbon steel, including structural and carbon tool steel, was used by 12 respondents, and alloy steel (stainless steel, alloy tool steel, and high-speed steel) by 10 respondents. 3 respondents indicated the use of other ferrous alloys, such as ADI, high-manganese cast steel, and high-chromium cast iron.



When analyzing the production of thin-walled castings in Poland, it is worth noting that the most commonly used casting materials, as indicated by respondents, are aluminum (52.670 tons) and ductile iron (48.422 tons). Gray cast iron is equally popular, with production at 28,049 tons. Thin-walled castings produced from white cast iron, magnesium, and steel are the least common, which is also due to the low overall production of castings from these materials. Other materials used in thin-walled castings include copper (approximately 3,000 tons), and nickel and cobalt (approximately 600 tons).

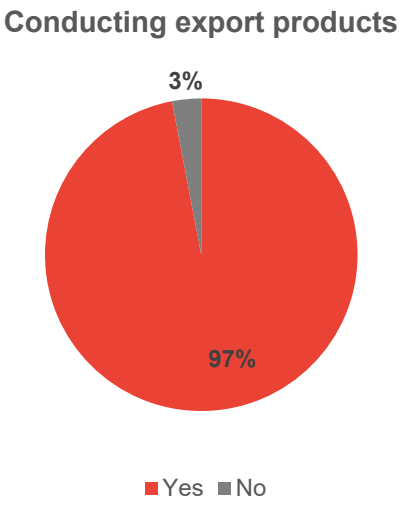


The most common foundry technology used by respondents was sand casting, which was selected by 22 respondents. 9 respondents use die casting in their casting production process.

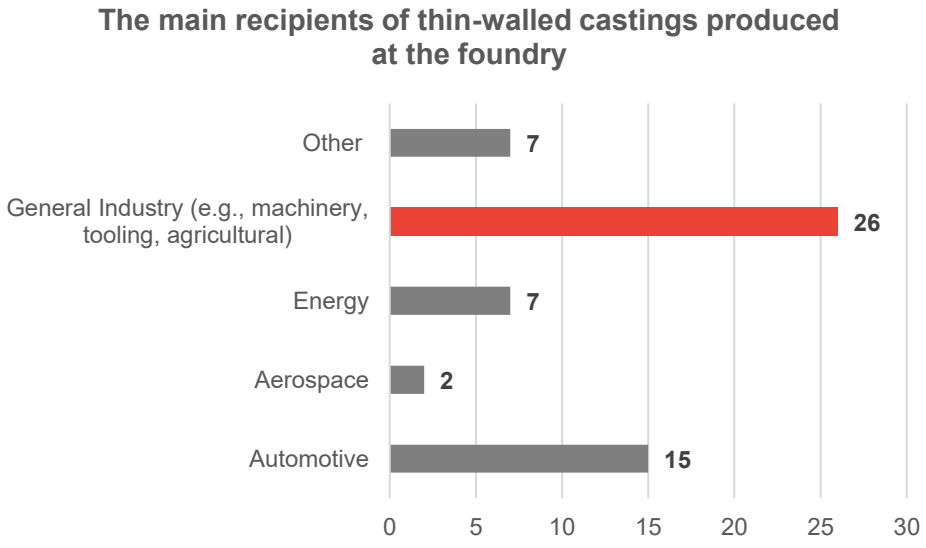


3.4. Export areas and main recipient industries

96% of respondents export, confirming the export-oriented nature of the Polish foundry industry.



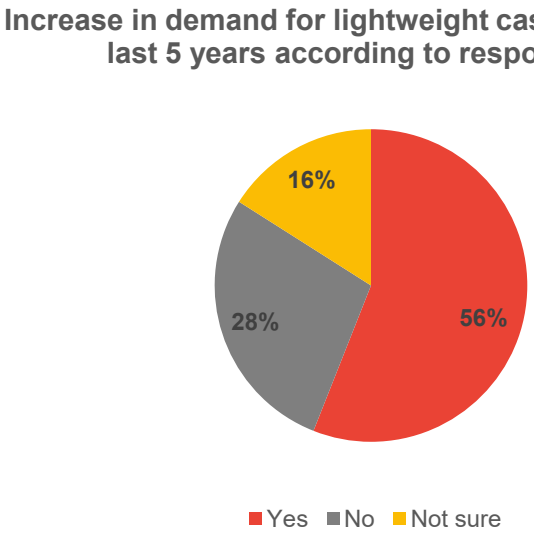
The main recipients for thin-walled castings produced by respondents are industry, including the machinery, tool, and agricultural industries (26 respondents). A significant part of thin-walled castings is also produced for the automotive industry (15 respondents). Only 7 respondents produce thin-walled castings for the energy industry. Other recipients also included the home appliance and military industries.



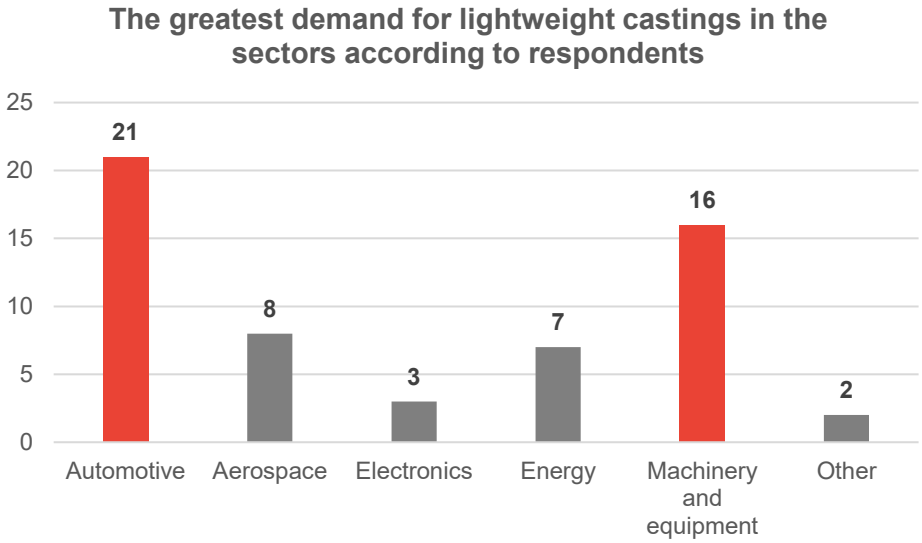
4. Results and Interpretation

4.1. Market needs and expectations

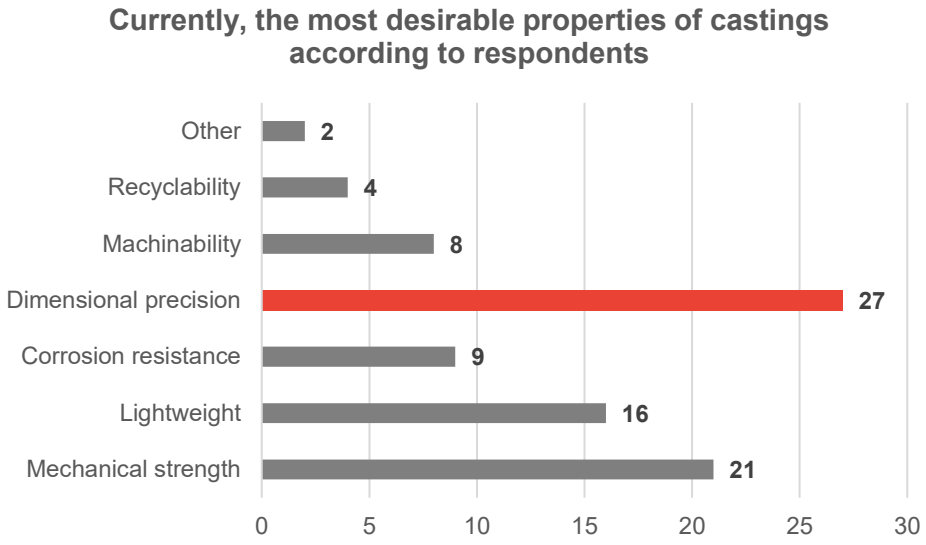
Over 50% of respondents noted an increase in demand for lightweight castings over the past five years. 28% did not experience this trend.



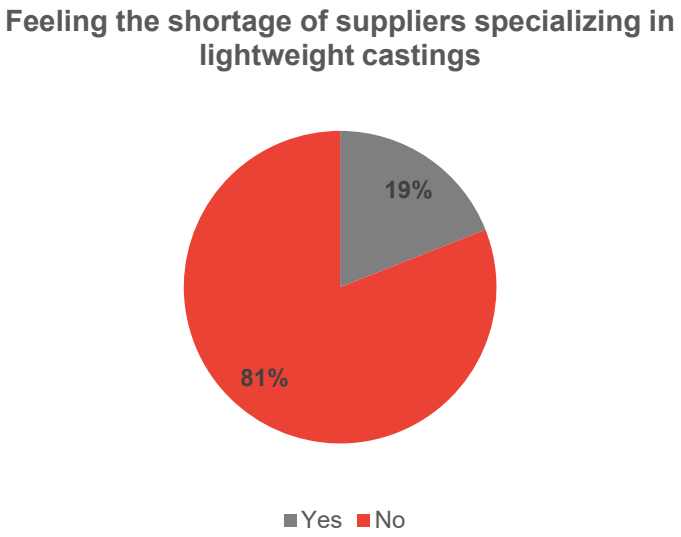
This demand was primarily observed in the automotive industry (21 respondents) and the machinery industry (16 respondents). Similar demand for thin-walled castings was observed in the aerospace industry (8 respondents) and the energy industry (7 respondents).



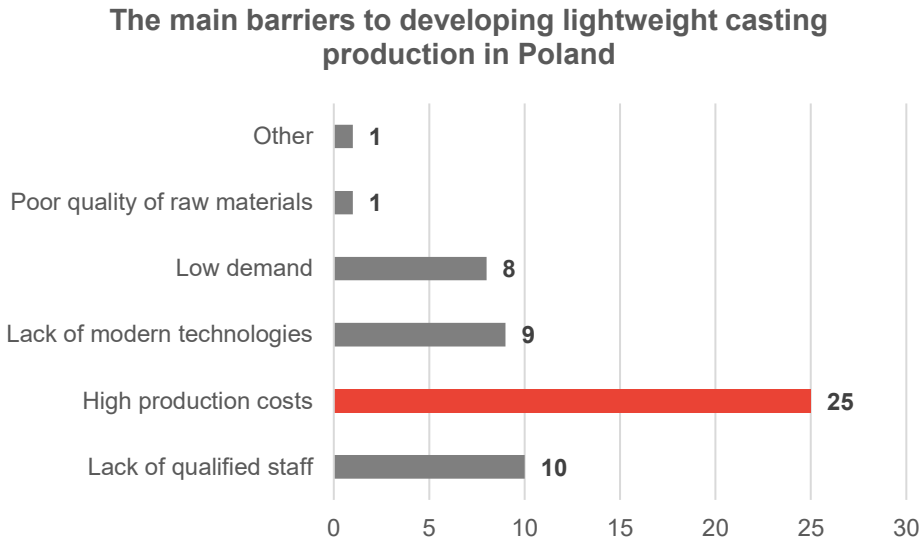
Thin-walled castings are demanding. The most sought-after properties among respondents are dimensional precision (21 respondents) and mechanical strength (21 respondents). Lightness of the castings appears to be important, as indicated by 16 respondents. Other properties of thin-walled castings include price and tightness.



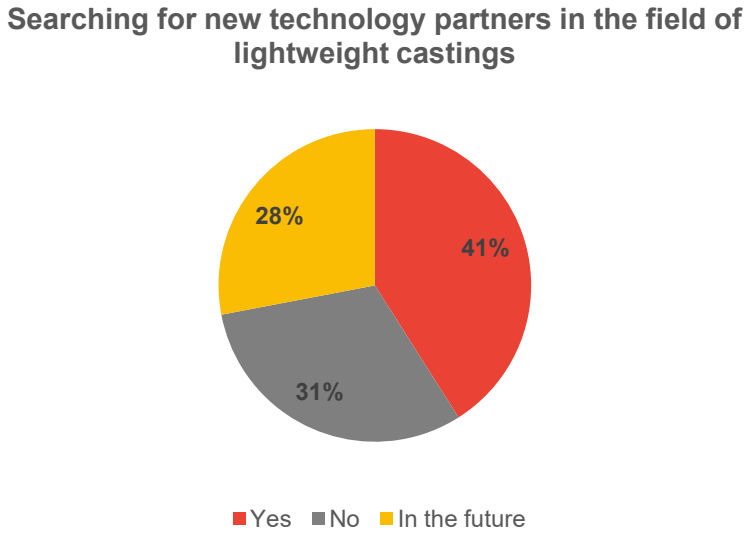
The survey respondents included foundries specializing in cast iron, steel, and non-ferrous metals. Consequently, respondents have no shortage of casting suppliers specializing in lightweight castings (81% of respondents).



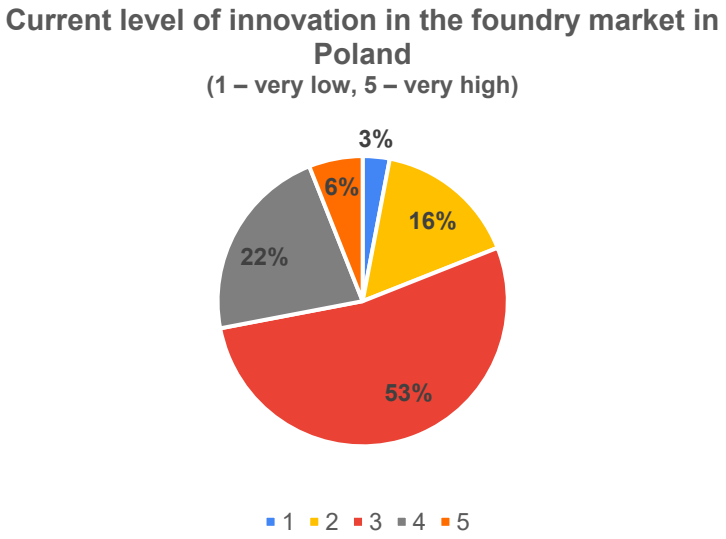
According to respondents, the main barriers hindering the development of lightweight casting production in Poland are primarily high production costs. This was confirmed by 25 respondents. 9 respondents also cited the lack of modern technologies and the persistently low demand for this type of casting (8 respondents). Other barriers identified by respondents included energy costs generated during th e production process.



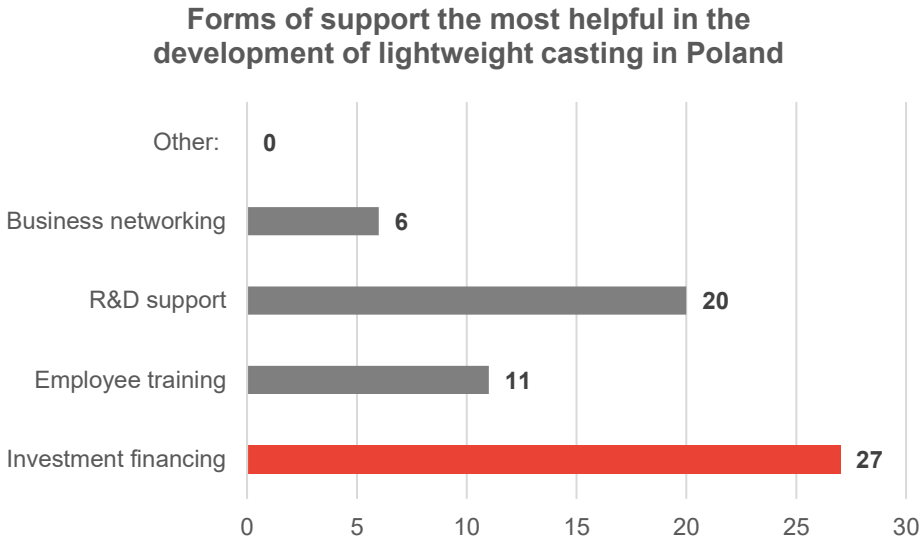
69% of respondents confirm that they are looking for new technology partners in the field of lightweight casting. 48% of them see this need only in the future. 31% of respondents confirmed that they are not looking for support from technology partners.



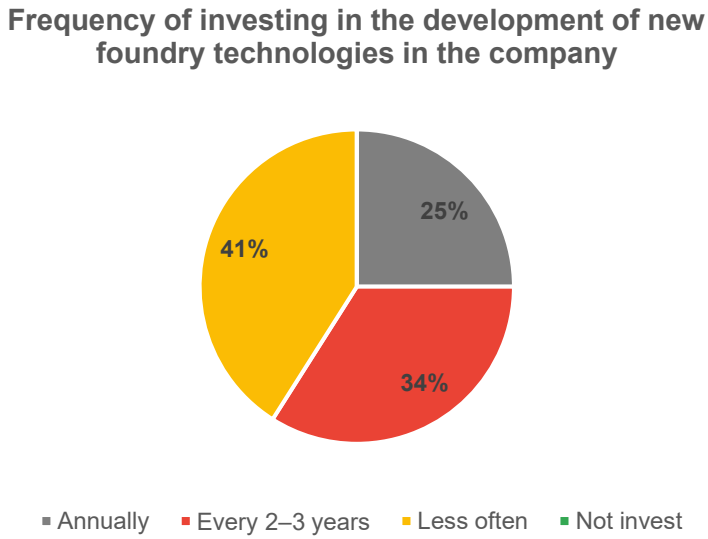
Over 80% of respondents positively assessed the current level of innovation in the foundry market. 53% of respondents rated this level as average, and 22% as high. Only 3% of respondents considered the level of innovation in the foundry market to be very low.



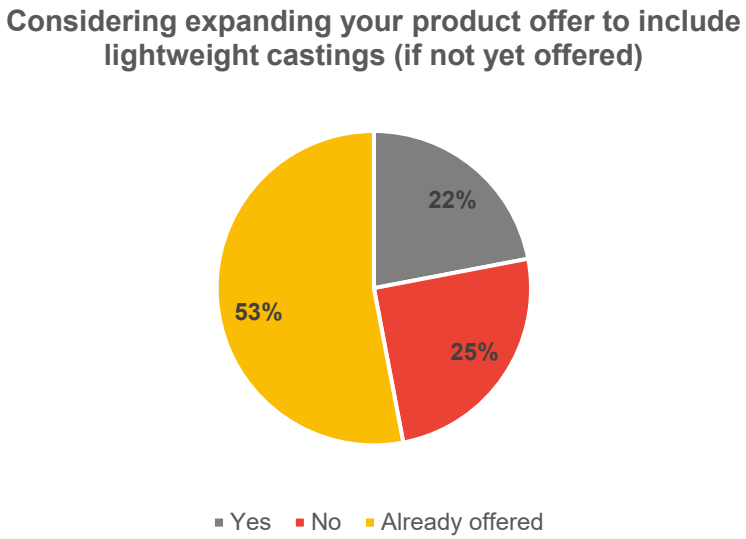
Among the forms of support that would contribute to the development of lightweight castings in Poland, respondents indicated the most important option as the possibility of investment financing – 27 respondents. Research and development (R&D) support is also an important aspect for the development of lightweight castings in Poland, as highlighted by 20 respondents.



Nearly 60% of foundry respondents invest in the development of new foundry technologies – 25% of respondents invest annually and 34% every 2-3 years. 41% of respondents invest in the development of new foundry technologies less frequently than every 2-3 years.



53% percent of the surveyed foundries offer lightweight castings, and 22% are considering expanding their existing offerings to include this type of casting. These results indicate an increase in demand for, and importance of, lightweight castings in the market.



The process of selecting a casting supplier is highly responsible. It requires analysis and evaluation of the offer. Suppliers consider many aspects, currently primarily environmental aspects.

62% believe that the supplier's environmental certifications and standards (e.g., ISO 14001) are an important criterion for selecting a casting supplier.

An equally important aspect is the carbon footprint. Reducing it is crucial for environmental protection and combating climate change. Reducing the carbon footprint allows companies to reduce operating costs, improve their reputation, and contribute to sustainable development. With the introduction of the requirement to calculate and report carbon footprints, foundries are paying close attention to this aspect.

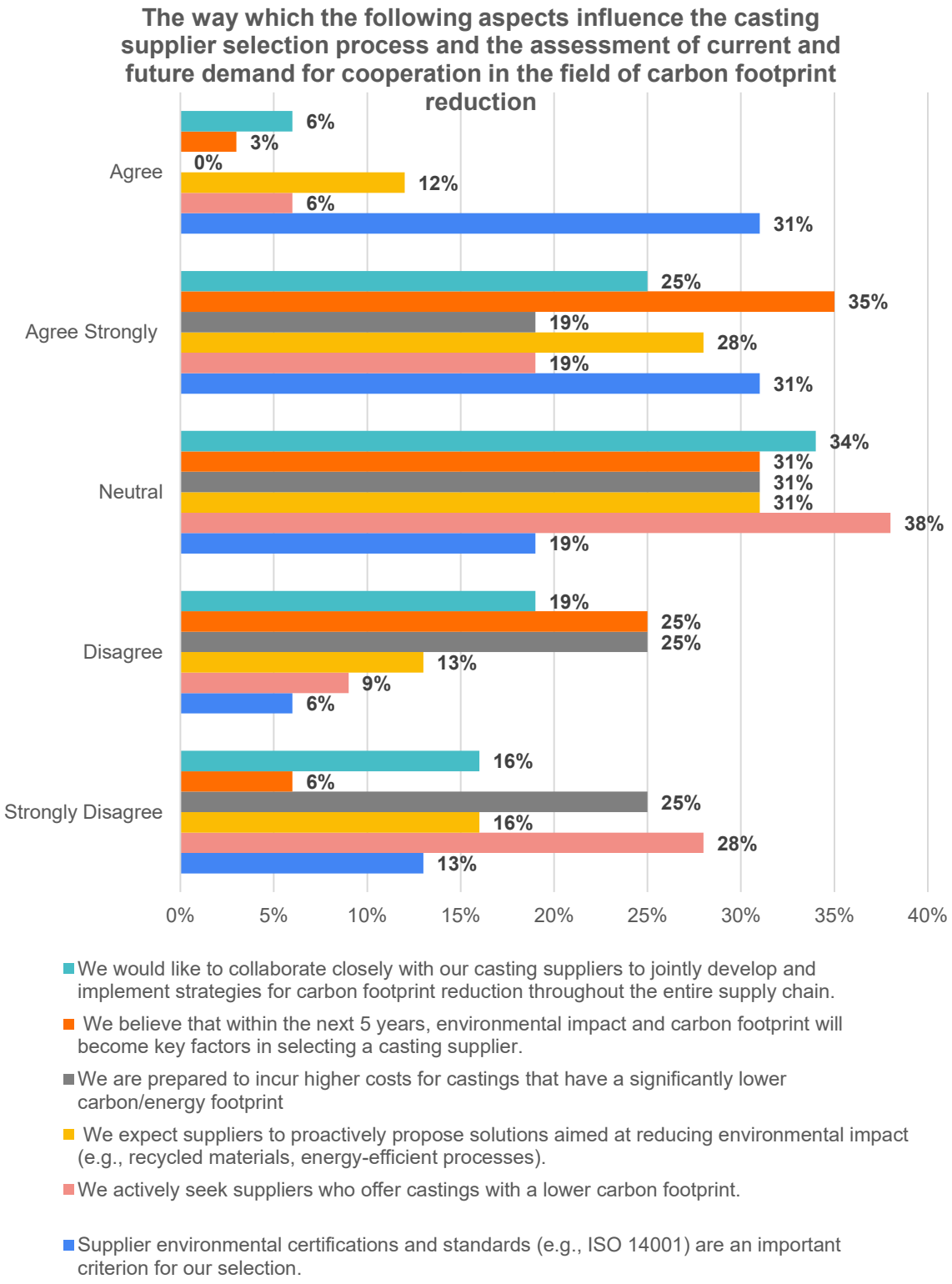
38% of respondents confirmed this, indicating that within the next five years, environmental impact and carbon footprint will become key factors in selecting a casting supplier. 31% of respondents had no opinion on this matter.

Currently, 28% of respondents do not consider the size of their carbon footprint when purchasing castings. 38% of respondents find it difficult to comment on this issue.

35% of respondents do not see the need to collaborate with casting suppliers to jointly develop and implement carbon footprint reduction strategies throughout the supply chain. Approximately 29% of them believe the opposite.

At the same time, approximately 40% of respondents expect suppliers to proactively propose solutions to reduce environmental impact, such as using recycled materials or energy-efficient processes.

Currently, nearly 50% of respondents are not willing to pay higher prices for castings with a lower carbon footprint.


The way which the following aspects influence the casting supplier selection process and the assessment of current and future demand for cooperation in the field of carbon footprint reduction
Agree
Agree Strongly
Neutral
Disagree
Strongly Disagree
6%
3%
0%
12%
6%
31%
25%
35%
19%
28%
19%
31%
34%
31%
31%
31%
38%
19%
19%
25%
25%
13%
9%
6%
16%
6%
25%
16%
28%
13%
0%
5%
10%
15%
20%
25%
30%
35%
40%
We would like to collaborate closely with our casting suppliers to jointly develop and implement strategies for carbon footprint reduction throughout the entire supply chain.
We believe that within the next 5 years, environmental impact and carbon footprint will become key factors in selecting a casting supplier.
We are prepared to incur higher costs for castings that have a significantly lower carbon/energy footprint
We expect suppliers to proactively propose solutions aimed at reducing environmental impact (e.g., recycled materials, energy-efficient processes).
We actively seek suppliers who offer castings with a lower carbon footprint.
Supplier environmental certifications and standards (e.g., ISO 14001) are an important criterion for our selection.

4.2. Foundry 4.0 and Digital technologies

The fourth industrial revolution, commonly known as Industry 4.0, has been underway for several years, but in many industries it is still in its early stages. The concept of Industry 4.0 integrates information and communication technologies with production processes, and its goal is to increase the efficiency, flexibility, and productivity of enterprises by integrating people, machines, and systems into a single network. 97% of respondents admit to being familiar with the concepts of the new trend, Industry 4.0, although 53% of them emphasize that they are only partially familiar with the concept.

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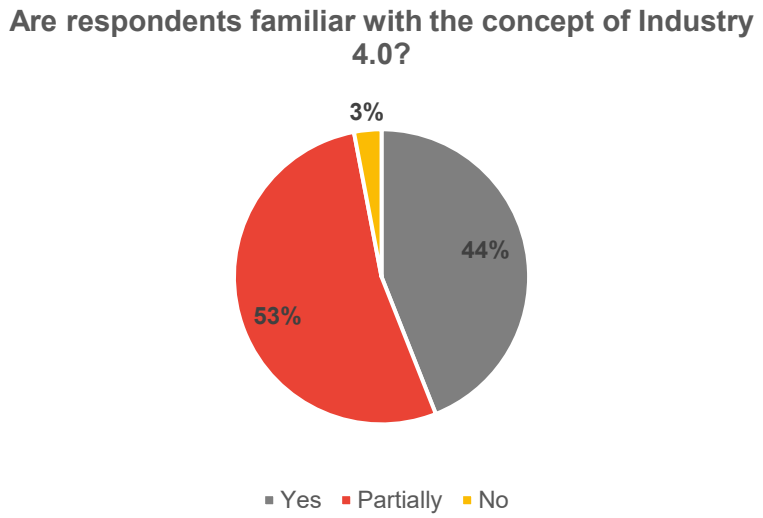
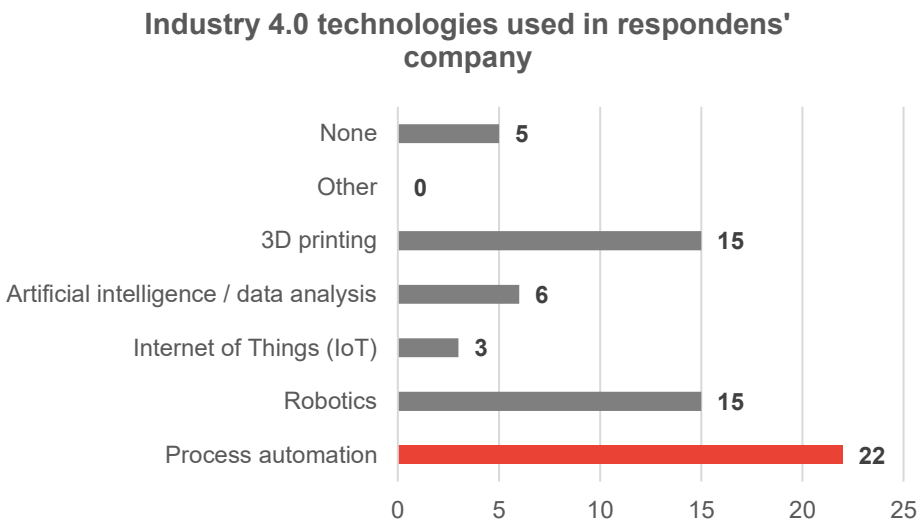
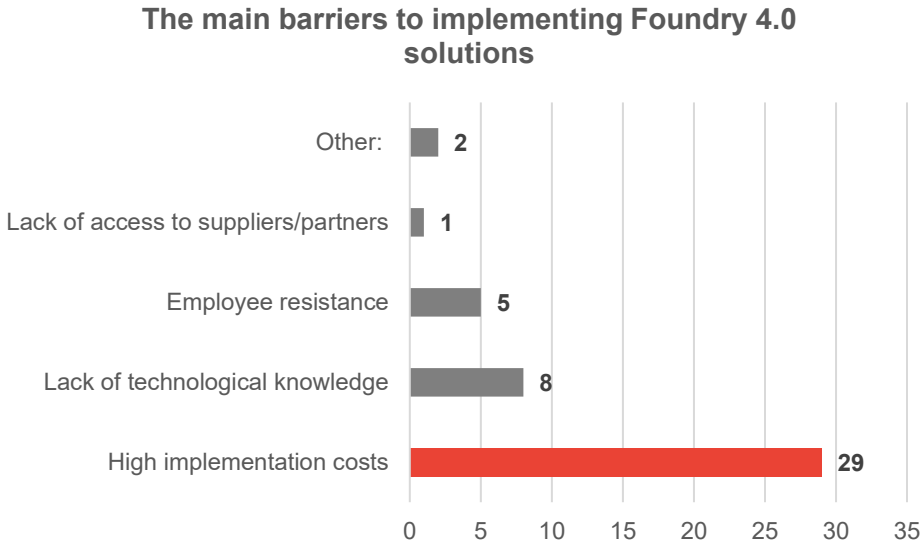


Among the Industry 4.0 technologies used by respondents, process automation was most frequently mentioned (22 respondents). Over 50% of respondents also use robotics and 3D printing in their production processes. The least popular technologies are the Internet of Things (IoT) (3 respondents) and artificial intelligence (6 respondents). It is worth emphasizing that technologies such as the Internet of Things and artificial intelligence are used in large foundries with modern production systems.

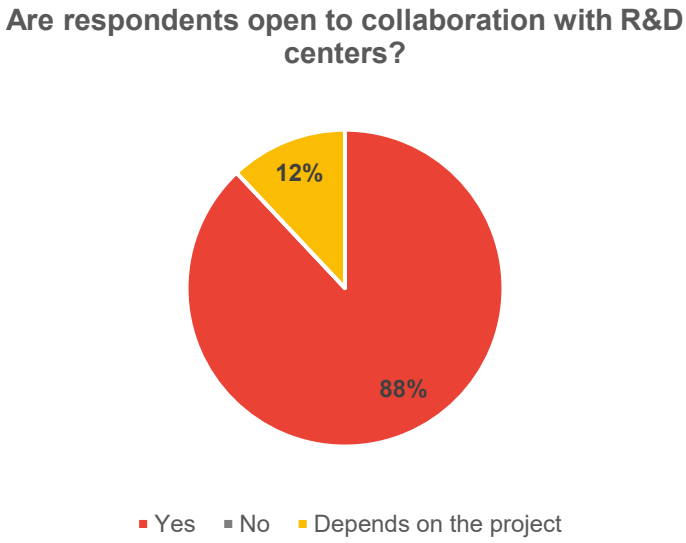
5 respondents, representing 15% of the total, do not use any of the technologies implemented within the Industry 4.0 concept.



The main barrier to implementing the Foundry 4.0 concept is high cost, as confirmed by 29 respondents (90%). Another obstacle to implementing this trend is the lack of appropriate technological knowledge among foundry employees (8 respondents) and employee resistance (5 respondents), likely related to the need to improve competence or the risk of job loss. Other barriers include the correct operation of implemented technologies and technological limitations related to the shape of the casting being produced, as noted by two respondents.

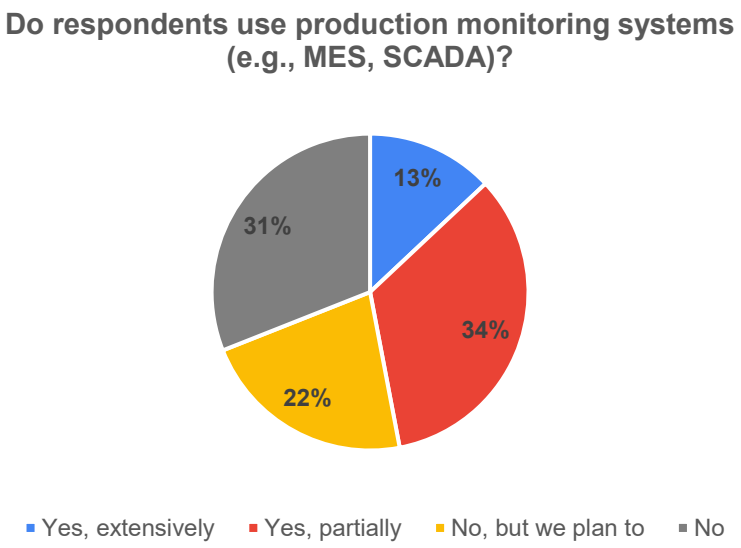


The Industry 4.0 concept necessitates collaboration with internal or external research and development centers. All respondents declared their willingness to collaborate with these entities, with 12% stating that such collaboration depends solely on the nature of the project.

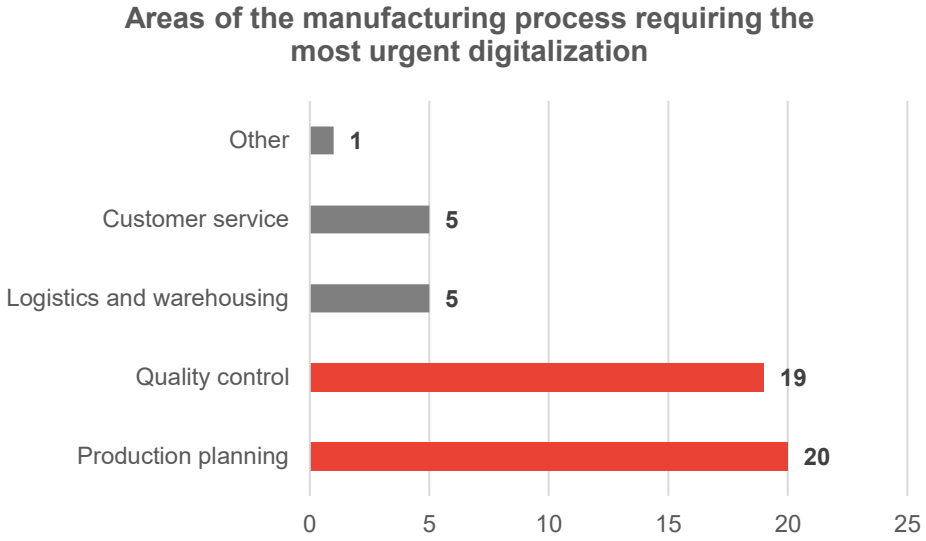


Nearly 50% of respondents use production monitoring systems, such as MES or SCADA. The extent of their use varies – 13% of respondents use them extensively, while 34% use them only partially. Among foundries that do not use a monitoring system, 22% plan to implement it in the future.

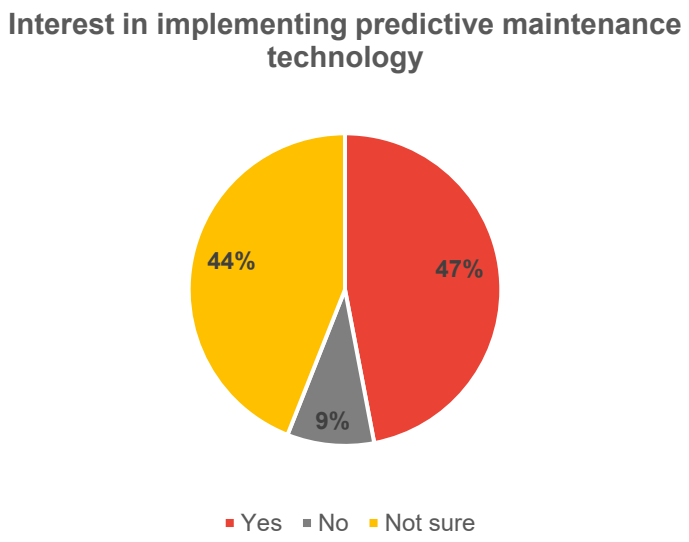
31% of respondents do not use any production management system and do not intend to implement one in the future.



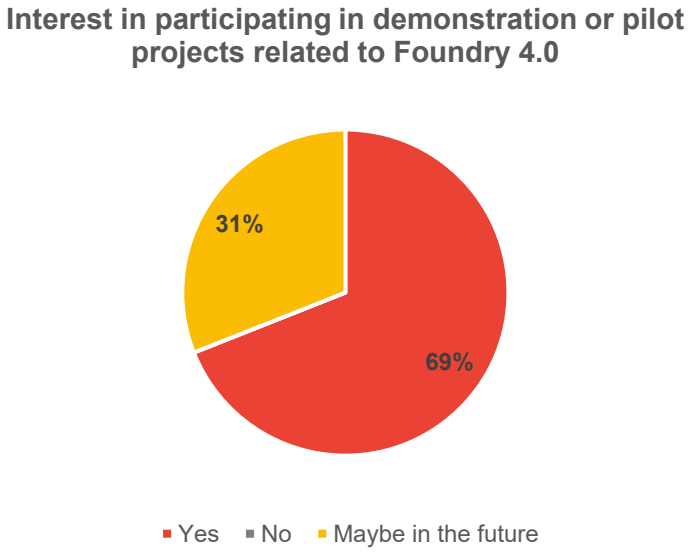
Among the production areas requiring the most urgent digitization, 20 respondents (over 62% of those surveyed) indicate the production planning process, 19 respondents (nearly 60%) – the quality control process.



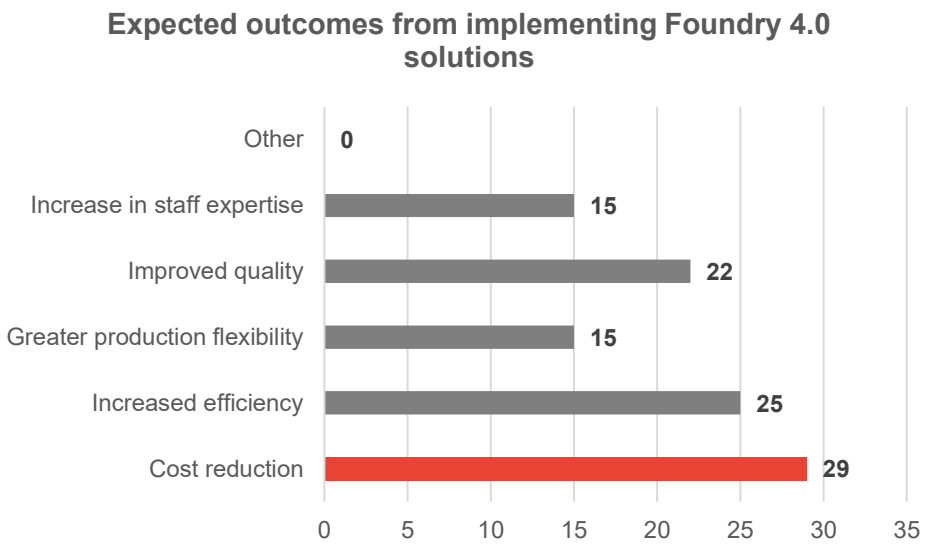
47% of respondents are interested in implementing predictive maintenance technology. 44% of respondents are not interested in implementing this technology, likely due to the fact that it utilizes advanced monitoring techniques, IoT, data analysis, and artificial intelligence, which have not yet been implemented in the enterprise.



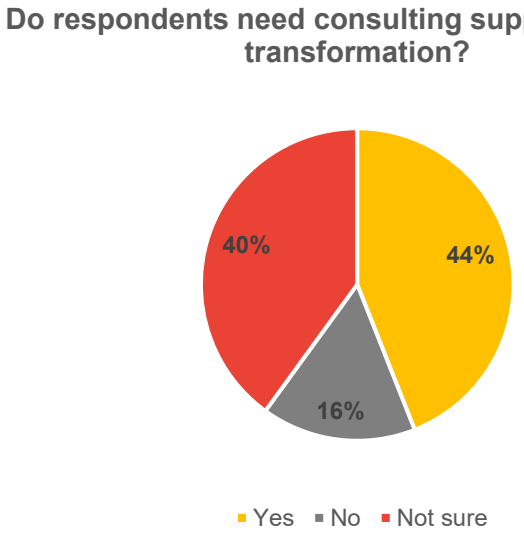
The interest in the Industry 4.0 concept is visible among the respondents, with 69% of them already declaring their willingness to participate in the Foundry 4.0 demonstration and pilot projects, and 31% are interested in participating in the future.



The most frequently cited expectations related to the implementation of Odlewnia 4.0 solutions include cost reduction (29 respondents, 91% of respondents), increasing efficiency (25 respondents, 78% of respondents), and improving the quality of manufactured castings (22 respondents, 69% of respondents). Equally important to respondents are increasing production flexibility and increasing employee expertise (15 respondents, 47% of respondents).

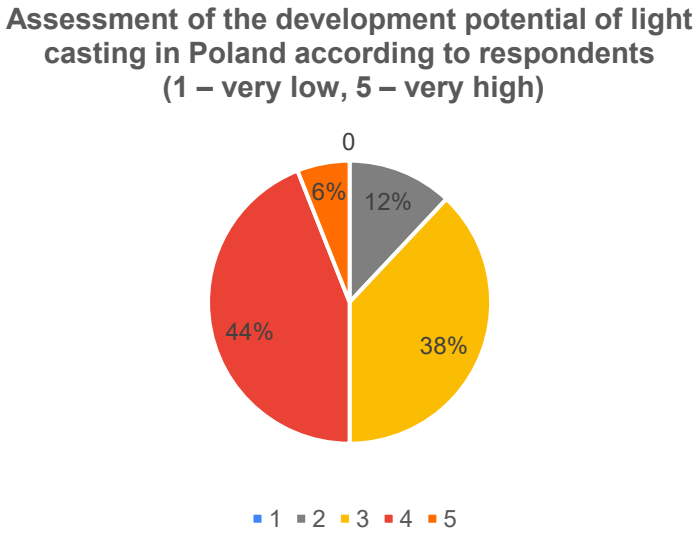


44% of respondents report a need for advisory support in digital transformation. 40% are undecided in this regard, and only 16% definitely do not require support.

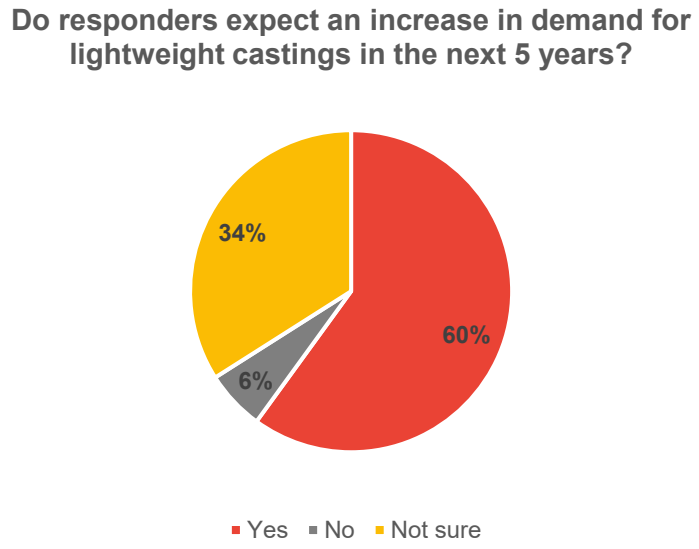


4.3. Market assessment and future outlook

Respondents rated the domestic development potential for lightweight castings as high (44% of respondents) and medium (38% of respondents). This represents a very positive assessment and bodes well for future market development.



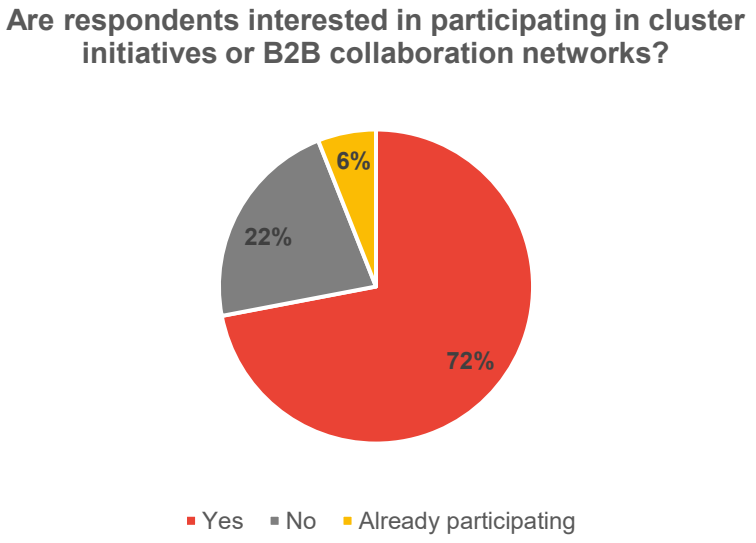
Therefore, respondents expect demand for lightweight castings to increase over the next five years. This was confirmed by 60% of respondents. 34% of respondents had no opinion on this matter.



Respondents indicated actions that should be taken at the national level to support the light casting industry. The most frequently mentioned included:

- reducing energy prices for energy-intensive industries,
- introducing subsidies for foundries and supporting investments in new technologies and automation,
- training staff (management, sales, and technical designers of finished products), including expanding knowledge on the impact of alloying elements on wall thickness,
- systemic changes supporting operations in heavy industry, including changes in raw materials and energy policies, reducing tax burdens and interest rates, halting increases in the minimum wage, and introducing customs duties on castings from Asia,
- collaboration with research institutions.

The vast majority of respondents (72%) are interested in participating in cluster initiatives or B2B collaboration networks. Twenty-two percent of respondents do not plan to engage in this type of collaboration.



5. Summary of Key Findings

Rising Demand for Lightweight Castings

Over 50% of respondents observed a growing demand for lightweight castings in the last five years. The highest demand is in the automotive (66%) and machinery (50%) sectors. Dimensional accuracy and mechanical strength are top priorities for customers.

High Production Costs Are a Major Barrier

78% of respondents identified high production costs as the most significant barrier to the development of lightweight casting production. Other challenges include lack of modern technologies and high energy costs.

Industry 4.0 Awareness vs Implementation

97% are aware of Industry 4.0, but only ~30% fully implement its tools (e.g., robotics, 3D printing). Internet of Things (IoT) and Artificial Intelligence are rarely used, mostly by large enterprises. Main barriers: cost (90%), lack of expertise, and employee resistance.

Digital Transformation Interest

About 60% believe production planning and quality control are most in need of digital transformation. 47% are interested in predictive maintenance technologies. 44% seek advisory support in digital transformation.

Sustainability and Environmental Criteria

Environmental certifications (e.g., ISO 14001) and carbon footprint are increasingly important in supplier selection. 38% foresee carbon footprint as a decisive factor in supplier evaluation within 5 years. Only 40% expect suppliers to proactively reduce environmental impact.

Future Market Outlook

82% of respondents rate the development potential of lightweight casting in Poland as medium or high. 72% are interested in participating in clusters and B2B initiatives.

6. Attachments

- Survey questionnaire
- Full result tables and charts

Market and Needs Analysis for Light Castings in Polish Foundry 4.0

This task involves a comprehensive market analysis of light castings, focusing on identifying needs and trends for the Foundry 4.0 sector in Poland. The study will be based on a survey conducted among at least 30 entities within the foundry industry. The analysis will be carried out by the Association of Polish Foundry Technicians, using data gathered from industrial plants associated with the foundry sector. The goal is to provide strategic information crucial for market development and positioning, which is a key element for achieving the objectives of the European project NetCastPL4.0.

	Analizy rynku i potrzeb rynkowych w obszarze lekkich odlewów dla Odlewni 4.0 w Polsce	**Market and Market Needs Analysis in the Area of Lightweight Castings for Foundry 4.0 in Poland**
	Europejska i globalna strategia redukcji emisji CO_2 prowadzi do rosnącego zapotrzebowania na lekkie komponenty w różnych gałęziach przemysłu. Wymaga to opracowania materiałów, które charakteryzują się wyższym stosunkiem wytrzymałości do masy niż obecnie stosowane i są możliwe do wyprodukowania przy rozsądnych kosztach. Przykładami takich materiałów ze stopów metali nieżelaznych są wysokowytrzymałe stopy aluminium i miedzi (AlCu), a w przypadku stopów żelaza różne odmiany żeliwa sferoidalnego (ADI). W zakresie niniejszego kwestionariusza, lekkość obejmuje podejścia, w których cieńsze ścianki są osiągalne dzięki wyższemu stosunkowi wytrzymałości do masy.	The European and global strategy toward reducing CO_2 emissions is leading to a growing demand for *lightweighting* components across different industries. This requires development of materials that have a *higher strength-to-weight ratios* than ones currently used and be producible with reasonable costs. Examples of these in non-ferrous metals are aluminium-copper (AlCu) high strength alloys, and on the ferrous cast metals the different forms of Austempered Ductile Irons (ADI). In the scope of this questionnaire, lightweighting covers approaches in where thinner walls are achievable through higher strength-to-weight ratios.
I	**Informacje ogólne o firmie (8 pytań)**	**General Company Information (8 questions)**
1	Jak długo Państwa firma działa na rynku odlewniczym? • Mniej niż 5 lat • 5–10 lat • 11–20 lat • Ponad 20 lat	How long has your company been operating in the foundry market? • Less than 5 years • 5–10 years • 11–20 years • More than 20 years

2	Jakiej wielkości jest Państwa przedsiębiorstwo? • Mikroprzedsiębiorstwo (do 10 pracowników) • Małe przedsiębiorstwo (11–50 pracowników) • Średnie przedsiębiorstwo (51–250 pracowników) • Duże przedsiębiorstwo (powyżej 250 pracowników)	What is the size of your company? • Micro (up to 10 employees) • Small (11–50 employees) • Medium (51–250 employees) • Large (over 250 employees)
3	Jakie metale nieżelazne lub ich stopy są najczęściej stosowane w Państwa produkcji? • Aluminium • Magnez • Cynk • Inne (proszę podać jakie): _____	What non-ferrous metals or their alloys are most commonly used in your production? • Aluminium • Magnesium • Zinc • Other (please specify): _____
4	Jakie stopy żelaza są najczęściej stosowane w Państwa produkcji? • Stal węglowa (np. stal konstrukcyjna, stal narzędziowa węglowa) • Stal stopowa (np. stal nierdzewna, stal narzędziowa stopowa, stal szybkotnąca) • Żeliwo szare • Żeliwo sferoidalne • Żeliwo białe • Inne (proszę podać jakie): _____	Which ferrous alloys are most commonly used in your production? • Carbon steel (e.g. structural steel, carbon tool steel) • Alloy steel (e.g. stainless steel, alloy tool steel, high-speed steel) • Grey cast iron • Ductile iron • White cast iron • Other (please specify): _____

5	Z jakich technologii odlewniczych korzystasz lub są one uwzględnione w Twoim łańcuchu dostaw? • Odlewanie ciśnieniowe • Odlewanie piaskowe • Odlewanie kokilowe • Odlewanie precyzyjne • Inne: _____	What casting technologies do you use or are included in your supply chain? • Die casting • Sand casting • Permanent mold casting • Investment casting • Other: _____
6	Czy Państwa firma prowadzi działalność eksportową? • Tak • Nie	Does your company export its products? • Yes • No
7	Jaka jest wielkość produkcji odlewów cienkościennych w Państwa odlewni, wyrażona w tonach, z podziałem na poszczególne materiały? *Prosimy o wpisanie szacunkowych wartości w odpowiednie pola:* • Aluminium: _____ tony • Magnez: _____ tony • Cynk: _____ tony • Stal węglowa: _____ tony • Stal stopowa: _____ tony • Żeliwo szare: _____ tony • Żeliwo sferoidalne: _____ tony • Żeliwo białe: _____ tony • Inne (proszę sprecyzować): _____ tony	What is the volume of thin-walled casting production at your foundry, expressed in tons, broken down by material? *Please enter the estimated values in the appropriate fields:* • Aluminum: _____ tons • Magnesium: _____ tons • Zinc: _____ tons • Carbon steel: _____ tons • Alloy steel: _____ tons • Gray cast iron: _____ tons • Ductile cast iron: _____ tons • White cast iron: _____ tons • Other (please specify): _____ tons

8	Prosimy o wskazanie, które branże są głównymi odbiorcami odlewów cienkościennych produkowanych w Państwa odlewni. Mogą Państwo wybrać jedną lub więcej opcji. • Motoryzacja • Lotnictwo • Energetyka • Przemysł (ogólny, np. maszynowy, narzędziowy, rolniczy) • Inne (proszę sprecyzować): _____	Please indicate which industries are the main recipients of thin-walled castings produced at your foundry. You may select one or more options. • Automotive • Aerospace • Energy • General Industry (e.g., machinery, tooling, agricultural) • Other (please specify): _____
II	**Potrzeby rynkowe i oczekiwania (11 pytań)**	**Market Needs and Expectations (11 questions)**
9	Czy zauważają Państwo wzrost zapotrzebowania na odlewy lekkie w ostatnich 5 latach? • Tak • Nie • Trudno powiedzieć	Have you noticed an increase in demand for lightweight castings over the past 5 years? • Yes • No • Not sure
10	W jakich sektorach obserwujecie Państwo największe zapotrzebowanie na odlewy lekkie? • Motoryzacja • Lotnictwo • Elektronika • Energetyka • Przemysł maszynowy • Inne: _____	In which sectors do you observe the highest demand for lightweight castings? • Automotive • Aerospace • Electronics • Energy • Machinery and equipment • Other: _____

11	Jakie właściwości odlewów są obecnie najbardziej poszukiwane? *(można wybrać więcej niż jedną opcję)* • Wytrzymałość mechaniczna • Lekkość • Odporność na korozję • Precyzja wymiarowa • Możliwość obróbki • Recykling materiału • Inne: _____	What properties of castings are most in demand at the moment? *(You may select more than one)* • Mechanical strength • Lightweight • Corrosion resistance • Dimensional precision • Machinability • Recyclability • Other: _____
12	Czy brakuje Państwu dostawców specjalizujących się w odlewach lekkich? • Tak • Nie	Do you experience a shortage of suppliers specializing in lightweight castings? • Yes • No
13	Jakie bariery utrudniają rozwój produkcji odlewów lekkich w Polsce? • Brak wykwalifikowanej kadry • Wysokie koszty produkcji • Brak nowoczesnych technologii • Niski popyt • Problemy z jakością surowców • Inne: _____	What are the main barriers to developing lightweight casting production in Poland? • Lack of qualified staff • High production costs • Lack of modern technologies • Low demand • Poor quality of raw materials • Other: _____

14	Czy poszukują Państwo nowych partnerów technologicznych w zakresie odlewów lekkich? • Tak • Nie • W przyszłości	Are you looking for new technological partners in the field of lightweight castings? • Yes • No • In the future
15	Jak oceniacie Państwo aktualny poziom innowacyjności rynku odlewniczego w Polsce? • Skala 1–5 (1 – bardzo niski, 5 – bardzo wysoki)	How would you rate the current level of innovation in the foundry market in Poland? • Scale 1–5 (1 – very low, 5 – very high)
16	Jakie rodzaje wsparcia byłyby najbardziej pomocne w rozwoju odlewów lekkich w Polsce? • Finansowanie inwestycji • Szkolenia dla pracowników • Wsparcie badawczo-rozwojowe • Sieciowanie z innymi firmami • Inne: _____	What forms of support would be most helpful in the development of lightweight casting in Poland? • Investment financing • Employee training • R&D support • Business networking • Other: _____
17	Jak często Państwa firma inwestuje w rozwój nowych technologii odlewniczych? • Co roku • Co 2–3 lata • Rzadziej • Nie inwestujemy	How often does your company invest in the development of new casting technologies? • Annually • Every 2–3 years • Less often • We do not invest

18	Czy rozważają Państwo rozszerzenie oferty o odlewy lekkie (jeśli jeszcze ich nie oferujecie)? • Tak • Nie • Już oferujemy	Are you considering expanding your product offer to include lightweight castings (if not yet offered)? • Yes • No • Already offered
19	W jaki sposób poniższe aspekty wpływają na Państwa proces wyboru dostawcy odlewów oraz jak oceniają Państwo obecne i przyszłe zapotrzebowanie na współpracę w zakresie redukcji śladu węglowego? *(Proszę zaznaczyć jedną opcję dla każdego stwierdzenia)* 1 - Zdecydowanie się nie zgadzam; 2 - Raczej się nie zgadzam; 3 - Trudno powiedzieć; 4 - Raczej się zgadzam; 5 - Zdecydowanie się zgadzam. • Certyfikaty i standardy środowiskowe dostawcy (np. ISO 14001) są dla nas istotnym kryterium wyboru. • Aktywnie poszukujemy dostawców, którzy oferują odlewy z niższym śladem węglowym. • Oczekujemy, że dostawcy będą proaktywnie proponować rozwiązania mające na celu zmniejszenie wpływu na środowisko (np. materiały z recyklingu, procesy energooszczędne). • Jesteśmy gotowi ponieść wyższe koszty za odlewy charakteryzujące się znacząco niższym śladem węglowym/energetycznym.	How do the following aspects influence your process of selecting a casting supplier, and how do you assess the current and future demand for collaboration in reducing the carbon footprint? *(Please select one option for each statement)* 1 - Strongly Disagree 2 – Disagree; 3 – Neutral; 4 – AgreeStrongly; 5 – Agree. • Supplier environmental certifications and standards (e.g., ISO 14001) are an important criterion for our selection. • We actively seek suppliers who offer castings with a lower carbon footprint. • We expect suppliers to proactively propose solutions aimed at reducing environmental impact (e.g., recycled materials, energy-efficient processes). • We are prepared to incur higher costs for castings that have a significantly lower carbon/energy footprint.

	• Wierzymy, że w ciągu najbliższych 5 lat wpływ na środowisko i ślad węglowy staną się kluczowymi czynnikami decydującymi o wyborze dostawcy odlewów. • Chcielibyśmy ściśle współpracować z naszymi dostawcami odlewów w celu wspólnego opracowywania i wdrażania strategii redukcji śladu węglowego w całym łańcuchu dostaw.	• We believe that within the next 5 years, environmental impact and carbon footprint will become key factors in selecting a casting supplier. • We would like to collaborate closely with our casting suppliers to jointly develop and implement strategies for carbon footprint reduction throughout the entire supply chain.
III	**Odlewnia 4.0 i technologie cyfrowe (10 pytań)**	**Foundry 4.0 and Digital Technologies (10 questions)**
20	Czy są Państwo zaznajomieni z koncepcją Przemysłu 4.0? • Tak • Częściowo • Nie	Are you familiar with the concept of Industry 4.0? • Yes • Partially • No
21	Jakie technologie Przemysłu 4.0 są wykorzystywane w Państwa firmie? • Automatyzacja procesów • Robotyzacja • Internet Rzeczy (IoT) • Sztuczna inteligencja / analiza danych • Druk 3D • Inne: _____ • Nie stosujemy	Which Industry 4.0 technologies are used in your company? • Process automation • Robotics • Internet of Things (IoT) • Artificial intelligence / data analysis • 3D printing • Other: _____ • None
22	Jakie są główne przeszkody w wdrażaniu Odlewni 4.0? • Koszty wdrożenia • Brak wiedzy technologicznej • Opór pracowników • Brak dostępu do dostawców/partnerów • Inne: _____	What are the main barriers to implementing Foundry 4.0 solutions? • High implementation costs • Lack of technological knowledge • Employee resistance • Lack of access to suppliers/partners • Other: _____

23	Czy są Państwo otwarci na współpracę z centrami badawczo-rozwojowymi? • Tak • Nie • Zależy od projektu	Are you open to collaboration with R&D centers? • Yes • No • Depends on the project
24	Czy korzystają Państwo z systemów monitoringu produkcji (MES, SCADA)? • Tak, na szeroką skalę • Tak, częściowo • Nie, ale planujemy • Nie	Do you use production monitoring systems (e.g., MES, SCADA)? • Yes, extensively • Yes, partially • No, but we plan to • No
25	Jakie obszary Państwa procesu produkcji wymagają najpilniejszej cyfryzacji? • Planowanie produkcji • Kontrola jakości • Logistyka i magazynowanie • Obsługa klienta • Inne: _____	Which areas of your manufacturing process require the most urgent digitalization? • Production planning • Quality control • Logistics and warehousing • Customer service • Other: _____
26	Czy interesuje Państwa wdrożenie technologii predykcyjnego utrzymania ruchu? • Tak • Nie • Nie wiem	Are you interested in implementing predictive maintenance technology? • Yes • No • Not sure

27	Czy są Państwo zainteresowani udziałem w projektach demonstracyjnych/ pilotażowych Odlewni 4.0? • Tak • Nie • Może w przyszłości	Are you interested in participating in demonstration or pilot projects related to Foundry 4.0? • Yes • No • Maybe in the future
28	Jakie efekty Państwo oczekują po wdrożeniu rozwiązań Odlewni 4.0? • Obniżenie kosztów • Zwiększenie wydajności • Zwiększenie elastyczności produkcji • Poprawa jakości • Zwiększenie wiedzy specjalistycznej pracowników • Inne: _____	What outcomes do you expect from implementing Foundry 4.0 solutions? • Cost reduction • Increased efficiency • Greater production flexibility • Improved quality • Increase in staff expertise • Other: _____
29	Czy potrzebujecie Państwo wsparcia doradczego w zakresie transformacji cyfrowej? • Tak • Nie • Nie jesteśmy pewni	Do you need consulting support in digital transformation? • Yes • No • Not sure

IV	Ocena rynku i przyszłość branży (5 pytań)	Market Assessment and Future Outlook (5 questions)
30	Jak oceniacie Państwo potencjał rozwoju odlewów lekkich w Polsce? • Skala 1–5 (1 – bardzo niski, 5 – bardzo wysoki)	How would you rate the development potential of lightweight casting in Poland? • Scale 1–5 (1 – very low, 5 – very high)
31	Czy spodziewają się Państwo wzrostu zapotrzebowania na odlewy lekkie w ciągu najbliższych 5 lat? • Tak • Nie • Trudno powiedzieć	Do you expect an increase in demand for lightweight castings in the next 5 years? • Yes • No • Not sure
32	Jakie działania powinny zostać podjęte na poziomie krajowym, by wspierać branżę odlewów lekkich? (pytanie otwarte)	What actions should be taken at the national level to support the lightweight casting industry? *(Open-ended question)*
33	Czy są Państwo zainteresowani udziałem w inicjatywach klastrowych lub sieciach współpracy B2B? • Tak • Nie • Już uczestniczymy	Are you interested in participating in cluster initiatives or B2B collaboration networks? • Yes • No • Already participating
34	Czy chcieliby Państwo otrzymać raport z wynikami niniejszej ankiety? • Tak (proszę podać e-mail): _____ • Nie	Would you like to receive a report summarizing the results of this survey? • Yes (please provide your e-mail): _____ • No