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Çukurova Kimya Endüstrisi, which was established in 1974 and is located in an industrial zone in Manisa, Turkey, has been a leading manufacturer of high-quality foundry consumables in the Turkish market since its inception. With over half a century of experience, extensive know-how, and engineering expertise, Çukurova Kimya ensures customer satisfaction. Moreover, our commitment to excellence extends globally, as we export our products to over forty countries on four continents, emphasizing our significant presence in international markets.

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President's Message



Sikandar Mustafa Khan

President

Pakistan Foundry Association

I am delighted to observe a very productive interaction of various Industrial sectors and our member foundries in PFA's Business Development Sessions. Our primary objective is to introduce our members to customers directly to get work. Till date, we have conducted nine sessions. These Business Sessions are designed to connect foundries with key industry players and offer insights that will help our members to thrive in an increasingly competitive market. We have already seen positive results, and we are determined to continue to support our members.

We have reshaped Pakistan Foundry Association (PFA) with a renewed focus on the success of our members.

Our upcoming 9th International Foundry Congress and Exhibition (IFCE) 2025, on January 29th and 30th, will have one of the highest number of industrial visitors from various sectors.

I strongly encourage all our members to take part in this event as exhibitors. You will have the chance to connect with representatives from both local and international industries, opening doors to new technological advancements and business relationships that can lead to tangible work opportunities, both within Pakistan and on the global stage.

Your active participation is crucial to your own success and to the success of foundry industry. Let's work together to make the 9th IFCE 2025 a landmark event that drives our collective progress and enhances your business prospects.



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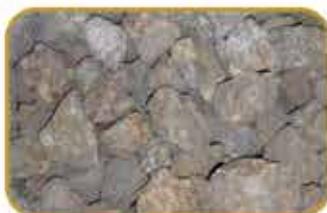
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Success Story

Asli Punjab Industries (Pvt.) Limited

Founded in 1966 by Haji Muhammad Basheer, Asli Punjab Industries (Pvt.) Limited (API) has established itself as a leading manufacturer of water pumps in Pakistan. For over five decades, API has delivered top-quality products and services, earning the trust and loyalty of its customers. From its early days to today, the company's journey has been marked by innovation, resilience, and a commitment to excellence.

Pioneering Innovation in Water Pumps and Polymer Products

In the 1980s, API began casting iron in-house for its water pump production, ensuring a steady supply of high-quality raw materials. This capability gave the company a competitive edge, allowing it to deliver superior products even when materials were scarce. The company's ability to adapt and innovate helped it weather economic challenges, such as the 1990s recession, when local copper wire prices plummeted, and impurities were discovered in local copper supplies. API responded by producing pure copper wire in-house, which increased the lifespan of its water pumps and reduced electricity consumption for its customers—demonstrating API's dedication to both product quality and customer satisfaction.

Expansion and International Reach

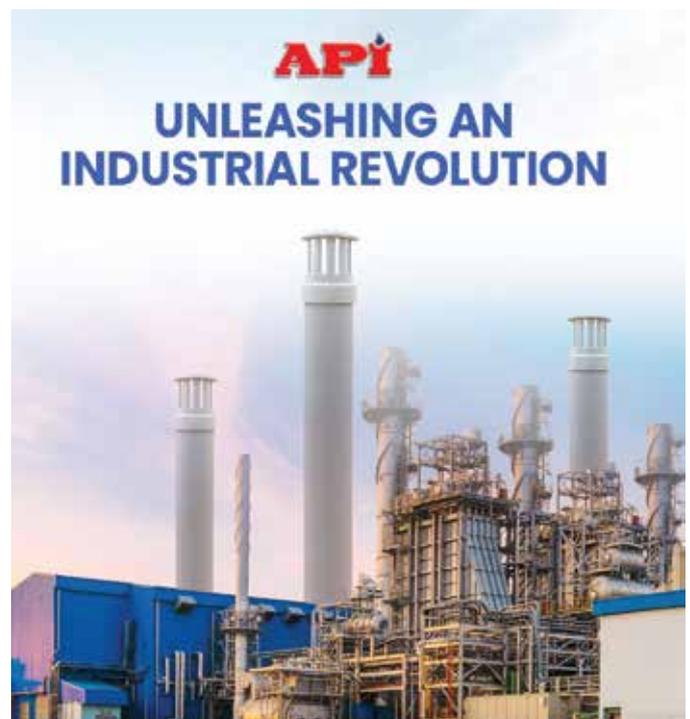
API's growth continued into the new millennium. In 2000, the company expanded its operations globally, trading water pumps and other products with Turkey, China, Europe, Korea, and the United States. It also made significant investments in advanced technology, importing state-of-the-art machinery to produce PPR-C and uPVC pipes and fittings. Under the guidance of international polymer experts, API ventured into polymer product manufacturing, further broadening its product portfolio and strengthening its position in the market.

Protecting Innovation and Customer Trust

As a leading manufacturer, API has faced the challenge of imitators trying to profit from substandard and counterfeit products. The company has taken decisive legal action to protect its intellectual property and ensure that only genuine API products reach the market. API's designs, patents, and brands are fully approved and protected by the Government of Pakistan, safeguarding the company's innovations and preserving customer trust.

Looking Ahead

With its state-of-the-art machinery, expert workforce, and unwavering focus on quality, Asli Punjab Industries continues to set industry standards in water pumps and polymer products. The company's rich history of innovation, integrity, and customer care ensures that it will remain a trusted name in the industry for years to come.





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GLOBAL EXPERTISE MEETS LOCAL INDUSTRY

Çukurova Kimya in Pakistan

In an unprecedented endeavor to enhance Pakistan's foundry practices, a four-member technical team from Çukurova Kimya embarked on a comprehensive tour across Pakistan. This strategic visit, aimed at fostering knowledge exchange and technical proficiency, saw the team visiting over 30 foundries in Lahore, Islamabad, Faisalabad, and Karachi.

THE JOURNEY OF KNOWLEDGE

Çukurova Kimya, a Turkish leader in the foundry chemical industry known for its innovation and expertise, dispatched

its top technical experts to Pakistan. Throughout their visit, the team provided invaluable technical guidance, offering insights and solutions tailored to the specific needs of each foundry.



The technical team engaged with local experts and foundry workers through interactive discussions, practical demonstrations, and customized solutions addressing specific challenges



IMPORTANCE OF TURKISH EXPERTISE

The expertise brought by Çukurova Kimya's technical team was pivotal in addressing the unique challenges faced by Pakistani foundries. Their in-depth knowledge of advanced foundry practices and cutting-edge technologies proved to be a game-changer. By sharing their extensive experience and technical know-how, the Turkish experts helped local foundries enhance their production processes, improve product quality, and adopt more efficient and sustainable practices.



HIGHLIGHTS OF THE TOUR

One of the tour's highlights was a dedicated technical guidance session with Daroghawala Foundries at the Pakistan Foundry Association's office. This session underscored the collaborative spirit and commitment to enhancing the local industry's capabilities. The Çukurova Kimya team, renowned for their technical acumen, shared keynotes on the intricacies of Gating and Feeding System Design, providing valuable insights that were eagerly absorbed by the local participants.



ÇUKUROVA KIMYA'S IMPACT ON PAKISTAN'S FOUNDRIES

Çukurova Kimya's visit to Pakistan marks a significant step towards bridging the technological gap and fostering a

culture of continuous improvement in foundry practices. The technical team's efforts, backed by Çukurova Kimya's wide range of foundry resins, coatings, and feeder sleeves, have provided immediate solutions and laid the groundwork for sustained collaboration and growth.

ENHANCING COMPETITIVENESS FOR EXPORT MARKETS

A crucial aspect of this visit was its focus on enhancing the competitiveness of Pakistani foundries in export markets. The Turkish experts worked closely with local foundries to identify opportunities for improvement that could lead to higher quality products meeting international standards. By implementing the advanced techniques and technologies shared by Çukurova Kimya, Pakistani foundries are better positioned to compete in global markets, potentially increasing their export potential and contributing to the country's economic growth.

FUTURE PROSPECTS

As the Pakistani foundries integrate the insights and techniques shared by Çukurova Kimya, the future of Pakistan's industrial landscape looks brighter and more resilient. This visit underscores the power of international cooperation in driving progress and innovation across borders, heralding a new era of excellence in the foundry industry.

Çukurova Kimya's commitment to fostering long-term relationships and continued support ensures that Pakistani foundries will have ongoing access to world-class expertise and resources. This partnership not only enhances local industry capabilities but also sets the stage for future collaborations and advancements.



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Unlocking Global Opportunities The Path to Success in Exporting Castings

In the rapidly evolving world of manufacturing, the export of castings stands as a beacon of economic opportunity and global engagement. The global market for castings is not just vast; it is a dynamic landscape filled with potential for those who are prepared to navigate its complexities. For manufacturers who dare to venture beyond their borders, the export of castings can lead to new growth, diversification, and unprecedented success. But how does one turn this vision into reality? The answer lies in a blend of strategic planning, quality control, and a deep understanding of market demands.

The Journey Begins with Research



The first step in this journey is to conduct thorough research on the type of castings you intend to export. The global market is diverse, with varying demands for different types of castings—whether it be iron, steel, aluminum, or

more specialized alloys like magnesium and bronze. Understanding which type of casting is in demand is crucial. This involves not only identifying potential buyers and suppliers but also understanding their specific requirements, such as quality standards, certifications, and logistical preferences.

Once you have a clear picture of what is needed, the next step is to align your production capabilities with these demands. This means ensuring that your castings meet the stringent quality requirements of international markets. The importance of quality control cannot be overstated; it is the foundation upon which trust and long-term business relationships are built.

Navigating the Export Process

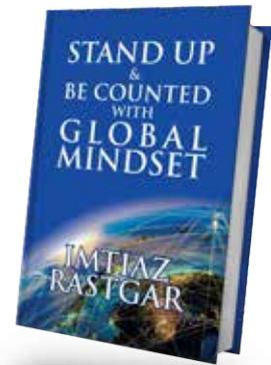
Exporting castings is not just about producing quality products; it is also about mastering the export process itself. This involves a series of critical steps: from understanding export laws and regulations to handling logistics and paperwork. Each step must be meticulously planned and executed to avoid costly delays or legal complications.



A key component of this process is finding an experienced freight forwarder who can manage the complexities of international shipping. This partner will help ensure that your castings reach their destination on time and in perfect condition, which is essential for maintaining customer satisfaction and securing repeat business.

Adding Value to Your Castings

In the competitive global market, simply meeting the basic requirements is not enough. To stand out, you must add value to your castings. This can be achieved through various methods, such as machining, alloying, and heat treatment. Machining, for instance, can improve the surface finish and dimensional accuracy of your castings, making them more appealing to high-end buyers. Alloying can enhance properties like strength and corrosion resistance, allowing you to tailor your products to specific applications. Heat treatment, on the other hand, can increase the durability and longevity of your castings, providing a competitive edge in markets where performance is a key consideration. Cultivating a Global Mindset.



Success in exporting castings requires more than just technical expertise; it demands a global mindset. This means being ambitious, adaptable, and willing to learn from the global leaders in the industry. The ability to think big and act strategically is what sets successful exporters apart. They are not just selling products; they are building global brands, creating value for their customers, and continuously seeking new opportunities for growth.

Conclusion: The Path to Global Success

The export of castings offers a pathway to global success for those who are willing to put in the hard work and develop the necessary expertise. By focusing on quality, mastering the export process, and continuously adding value to their products, manufacturers can not only survive but thrive in the global market. The journey may be challenging, but the rewards—greater market share, increased revenues, and the satisfaction of seeing your products used around the world—are well worth the effort. As the saying goes, "Success is a vehicle that moves on wheels named hard work, but the journey is impossible without the fuel named self-confidence." With the right approach, the world is yours to conquer.

Imtiaz Rastgar is a serial entrepreneur, now working as Coach & Consultant at www.pmx.com.pk. He is author of "Standup & Be Counted With Global Mindset", Available at Daraz: <https://www.daraz.pk/products/-i384331113.html> LinkedIn; <https://www.linkedin.com/in/irastgar/> . Reach out for specific advice and guidance on business challenges.

PFA Hosts Successful Business Development Sessions with Key Local Industries

Muzamil Niaz, Association Manager
Pakistan Foundry Association

Pakistan Foundry Association (PFA) has taken a significant stride towards strengthening the ties between its member foundries and local industries through a series of Business Development Sessions. These sessions, held at the PFA Lahore office, have brought together procurement and technical teams from key players in the industrial sector, including **Ittehad Chemicals Limited, Dandot Cement Company Limited, DG Cement Company Limited, and Maple Leaf Cement Limited, Pioneer Cement, and Nimir Chemicals Limited.**

The primary objective of these sessions is to provide a platform for foundries to engage directly with local industries, facilitating business growth and fostering a collaborative environment. By showcasing their capabilities and understanding the specific needs of the industries, foundries are better positioned to secure more business from local partners.

Highlighting PFA's Initiative for Foundries

PFA's initiative is a commendable effort to enhance the visibility and reach of its member foundries. These sessions offer a unique opportunity for foundries to demonstrate their production capacities, casting materials, and molding techniques to potential clients. The interactive format of the sessions ensures a thorough exchange of information, paving the way for fruitful partnerships. Each session begins with representatives from participating foundries introducing their companies. They provide detailed insights into their production capabilities, the variety of casting materials they utilize, and the advanced molding techniques they employ. This information is crucial for the industrial teams to assess the potential of these foundries to meet their specific requirements.

Acknowledging Local Industries' Participation

PFA extends its heartfelt thanks to the teams from

Ittehad Chemicals Limited, Dandot Cement Company Limited, DG Cement Company Limited, and Maple Leaf Cement Limited for their enthusiastic participation. Their presence and active engagement underscore the local industries' commitment to supporting the domestic foundry sector.

During the sessions, industrial teams outlined their specific casting requirements and expressed a strong interest in shifting from imported castings to locally produced ones. This transition not only promises cost savings but also strengthens the local supply chain. The willingness of these companies to explore local options highlights the growing confidence in the capabilities of Pakistani foundries.

Exploring Future Collaborations

A significant outcome of these sessions is the invitation extended by the industrial teams for foundries to visit their plants. These visits will allow foundry representatives to analyze the types of castings being used and understand the operational context better. Such hands-on insights are invaluable for customizing solutions that meet the exact needs of the industries, thereby enhancing the prospects for successful collaborations. The enthusiasm displayed by both foundries and local industries in these sessions is a promising indicator of future growth. By fostering direct communication and collaboration, PFA is playing a pivotal role in boosting the local foundry sector and reducing reliance on imported castings.

Moving Forward

The success of these initial sessions sets a strong precedent for future engagements. PFA plans to organize similar sessions regularly, involving a broader range of industries and foundries. This ongoing dialogue is expected to create a robust network of local suppliers and buyers, driving industrial growth and self-reliance in the casting

PFA's business development sessions are a vital initiative that benefits both foundries and local industries. They provide a platform for knowledge exchange, foster partnerships, and ultimately contribute to the growth of Pakistan's industrial sector. PFA remains committed to supporting its members and facilitating opportunities that drive Progress and innovation in the foundry industry.

By organizing these sessions, Pakistan Foundry Association has demonstrated its proactive approach to promoting local foundries and strengthening the industrial base. PFA looks forward to witnessing the positive impacts of these collaborations and the continued growth of the foundry sector in Pakistan.

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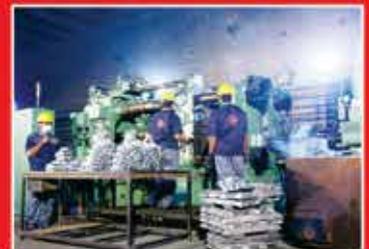


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Introduction to mold coatings – A Review

Introduction

Foundry or mould coatings are a mixture of very fine refractory (high temperature resistant) minerals and special additives in suspension with a liquid carrier and show the characteristics specified as follows

- Enhancing casting strip
- Enhancing metallurgical properties
- Increasing the temperature stability of the mould material
- Preventing metal-mould reactions (penetration, veining, erosion etc.)
- Optimising surface finish

Common liquid carriers for coatings are fresh water or organic solvents like isopropanol. Coatings can be supplied either ready-mixed, requiring only a small adjustment of carrier liquid, or in powder form, which must be mixed on-site. Proper mixing of powder coatings is sensitive to equipment, timing, and the operator's skill, leading most foundries to prefer ready-mixed coatings where additives are pre-activated. Additionally, some additives cannot be supplied in powder form, limiting the use of powder coatings.

Coating composition

Apart from the carrier liquid, the main components of mould coatings can be grouped as follows:

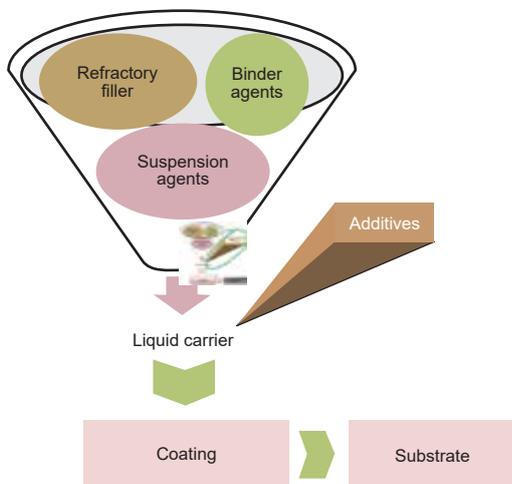


Figure 1 The components in the coating.

- Refractory fillers (inert and stable towards formation of intermediate compounds)

- Binding agents (ensure wear resistance at room temperature)
- Ceramic agents (sustain suspension and ensure wear resistance during casting)
- Additives (control colour, foaming, preservation, penetration etc.)

Some common Refractory fillers

The main refractory fillers of a coating are silicate minerals and oxides. The general characteristics of all common refractory minerals are discussed following:

Graphite

Graphite, a crystalline polymorph of carbon, is mined from geological deposits and has a melting point similar to coke (around 3,000°C). Its more rounded grains and higher fine particle content result in much smoother casting surfaces. However, its high thermal conductivity and heat absorption can cause surface defects, especially when casting large pieces.

Alumina

High alumina, containing about 98% Corundum (Al₂O₃), has a high melting point (around 2,000°C) and density. It is mainly used in mold coatings as an alternative to Zircon for applications requiring high thermal resistance.

Magnesia

High refractory grade magnesia, containing about 98% Periclase (MgO), has a high density (> 3 g/cm³) and a melting point around 2,800°C. Its primary benefit is protecting acidic molds (silica) from alkaline melts (with Mn, Ni, etc.). Due to its high refractoriness, magnesia coatings are often used in the production of manganese steel casting.

Zircon

Zircon, a zirconium silicate (ZrSiO₄) with about 66% ZrO₂ and 33% SiO₂, has a high density (> 4 g/cm³) and a melting point of around 2,200°C. Its isometric grain shape, like a football, allows high packing density, reducing the need for binding agents in mold

coatings and forming a strong, stable wet film. Zircon coatings can be applied by brushing, flow coating, or dipping. With excellent thermal shock resistance and minimal expansion, Zircon is non-reactive with non-alkaline alloys but, due to its high cost, is mainly used in steel casting where extreme refractory conditions are required.

Mullite

Calcining clay minerals (alumino-silicates) at temperatures up to 1,500°C removes crystal water and transforms them into Mullite, an aluminum silicate with 72% Al₂O₃ and 28% SiO₂. The resulting product, called fireclay, contains silicate glass and Cristobalite, a high-temperature quartz variant. Its grains are irregular with sharp edges, and refractoriness varies with the calcination process and composition. Though the theoretical melting point is around 1,700°C, high-quality fireclay coatings can still be used for steel castings.

Choice of the right coating Casting Type

The type of casting is key in determining basic properties such as dry or wet supply, carrier liquid, and refractory type (carbon, oxides, or silicates). Die castings have different needs than permanent mold castings, which in turn differ from sand castings. Sand casting requires consideration of factors like mold material, binder type and amount, new or reclaimed sand, and settling type, all of which influence the choice of coating system.

Casted alloy

The casted alloy and casting temperatures typically influence the composition of refractory fillers. Key factors like particle size, density, thermal conductivity, expansion, sintering, and melting points help assess potential reactions between the refractories, alloy, and mold. Ideally, the refractory filler should not be wettable by molten metal. Cost also plays a role, often leading to a trade-off between technical performance and savings, which can sometimes be achieved through a better coating-dilution ratio.

Table Approximate melting points of

Refractory	Refractoriness
Mullite	1700 °C
Alumina	2000 °C
Zircon	2200 °C
Magnesia	2800 °C
Carbon	3000 °C

Table Common casting temperature

Alloy	Temperature Range
Zinc	420 - 580 °C
Aluminum	620 - 740 °C
Magnesium	620 - 740 °C
Copper	1150 - 1290 °C
Iron	1340 - 1480 °C
Steel	1500 - 1700 °C
Titanium	1700 - 1800 °C

Application Methods

Several factors influence the choice of application method, including the complexity and size of molds or core packages, desired coating finish, and production rate. Transfer efficiency, the ratio of consumed coating to the amount that adheres to the substrate, is crucial; higher efficiency indicates better performance. This section discusses various application methods and their transfer efficiency potential.

Brushing

Brushing effectively fills the large pores between the quartz grains of a silicate mold, making it suitable for coating pockets and hard-to-reach areas. However, it relies heavily on the operator's skill and can result in uneven wet film thicknesses, with potential brush marks visible on the casting surface. Hot spots are typically pre-coated by brushing, allowing easy control of coating consumption and achieving good transfer efficiency.

Dipping

Dipping is ideal for core packages with low complexity (few cavities) and is well-suited for automated applications, especially in automotive foundries where high production rates and transfer efficiencies (up to 99%) are essential. Coatings designed for dipping have short flow characteristics, minimizing drips and runs. The special additive system requires high dilution rates, necessitating constant monitoring of the application. For manual dipping, faster withdrawal speeds can reduce material flow back, increasing wet film thickness.

Flow Coating

Flow coating is a rapid and reliable method for large and complex molds that cannot be dipped. The piece is tilted at an angle of approximately 20 to 40° (relative to vertical), and the coating is applied using lateral movements from top to bottom. This method

requires a medium-flow coating system, necessitating multiple rotations of the coated piece to remove excess material. Compressed air may be used to eliminate drips and runs. While flow coating is quick and easy, it requires a flow tank and a closed circuit to enhance transfer efficiency. Coatings optimized for flow application also penetrate the mold surface, providing additional protection against metal penetration.

Spraying

Spraying is effective for flat surfaces and requires specially designed guns to convert thick coatings into a fine spray. However, this method often results in low transfer efficiencies since much of the coating does not reach the substrate. Additionally, coatings with organic solvents can create hazardous spray mists, and deep cavities are difficult to coat with conventional spray guns. If not properly maintained, spray gun nozzles may clog. To mitigate the issues associated with air pressure backflow, airless spraying instruments have emerged as a solution.

Some Parameters of refractory coatings

Viscosity

Viscosity is a crucial property of the coating that needs to be controlled during application. Baumé measurement, as shown in Figure 2, is the most effective method for evaluating coatings because it has a high correlation with the dried residual layer on the core.



Figure 2 Baume method.

Solid substance

Coating solids must be measured as they are the refractory materials that protect the core or form. A higher percentage of solids translates to greater protection. Solid content also influences other important coating parameters, such as density, viscosity, thickness, and coverage. Therefore, understanding the amount of solids in the coating is crucial for ensuring the reproducibility of these parameters. The percent solids content can be calculated by dividing the weight of the dried coating by the initial weight and multiplying by 100.

Coating thickness

Coating thickness is typically measured using a destructive test. Measuring a thick dry coating layer can be challenging, so the most practical method is to assess the thickness of the wet coating layer with a wet film "comb," as shown in Figure 10. These combs can be used according to the following standards: ISO 2808-7B, ASTM D 4414-A, BS 3900-C5-7B, and NF T30-125. These standards specify that the wet film comb should be held perpendicular to the substrate, and the coating thickness is determined by the difference between the largest wet tooth value and the smallest dry tooth value.



Figure 3 Coating thickness.

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Analysis of the Requirements for Foundry Coke

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Abstract

Foundry coke is part of the mixture for melting of cast irons in coke oven and coke oven gas furnaces, which make up more than 37% of the domestic fleet of cast iron furnaces. It is obtained by sieving coal coke. Performing the function of fuel and providing the necessary heat, foundry coke has a significant impact on the stability of the melting process and the temperature of the cast iron. The share of energy and fuel in the cost of iron casting is 55-60%, so the reduction in coke consumption is of great importance for the energy efficiency of melting and the cost of castings. The requirements for foundry coke are currently set in the standard GOST 3340-88 "Foundry coke. Technical specifications", in which five indicators are normalized: mass fraction of total moisture, W_{tr} , %; ash content of analytical sample, Ad , %; mass fraction of total sulfur, S_t^d , %; strength according to MIKUM, M_{40} , %; fraction of pieces, less than 40 mm.

Introduction

Foundry coke is part of the mixture for melting of cast irons in coke oven and coke oven gas furnaces, which make up more than 37% of the domestic fleet of cast iron furnaces. It is obtained by sieving coal coke. Performing the function of fuel and providing the necessary heat, foundry coke has a significant impact on the stability of the melting process and the temperature of the cast iron. The share of energy and fuel in the cost of iron casting is 55-60%, so the reduction in coke consumption is of great importance for the energy efficiency of melting and the cost of castings.

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Literature overview

In the literature, the requirements for coke include: reactivity [1-3]; ash content [1, 4-7]; humidity [8-10]; strength [1-6]; porosity, density [1-6]; combustibility [5]; sulfur content [1-6]; the size of the pieces [1]; uniformity in size of pieces [2]. For example, it is believed that high-quality coke should have a piece size 10-12 times smaller than the cupola diameter [2]. As a rule, foundry coke has a piece size of more than 40 mm, and for cupolas with a diameter of more than 1.2 m - more than 80 mm to 150 mm [1,8-10]. Abroad, the requirements for the size of foundry coke are almost the same.

Two methods are currently used to assess the reactivity of coke: according to GOST R 54250-2010 "Coke. Determination of coke reactivity index (CRI) and coke strength after reaction (CSR)" and according to GOST 10089-89 "Coal coke. The method of determining the reactivity" (Table 1). Coke reactivity index (%) (NSC method of Nippon Steel Corporation) is used in foreign practice and currently in Russia.

Table 1: Comparative characteristics of methods for assessing the reactivity of coke

Distinction	Methods for determining reactivity	
	GOST P 54250-2010	GOST 10089-89
Indicator designation, units	CRI, %	K, cm ³ /g·s
Formula for calculating an indicator	$CRI = 100 \cdot \frac{m_0 - m_1}{m_0}$, where m ₀ – sample weight before reaction, g; m ₁ – sample weight after reaction, g.	$K = \frac{V \cdot T}{m \cdot T_1} \cdot R$, where V – carbon dioxide feed rate, cm ³ /s; T – test temperature according to test thermocouple, K; T ₁ – carbon dioxide temperature, K; m – mass of carbon in a sample of coke, g; R – reagent gas conversion.
Indicator values	20-35 [11], 45,8; 38,0; 38,6; 36,8; 30,3 (ERCI)	0,51-0,76 [12]
Sample requirements for analysis	Weight 200±2 g with a particle size of 19,0-22,4 mm	Weight 7-10 g with a particle size of 1-3 mm
Analysis conditions	Temperature 1100±3 0C; carbon dioxide feed rate 10±0,25 dm ³ /min; test time 120 min	Temperature 1000±5 0C; heating rate not less than 100 0C/min; carbon dioxide feed rate 3 cm ³ /s; test time 15 min

Reactivity determines the efficiency of coke use in the cupola [11-12]. The gasification reaction contributes to coke overspending and cupola cooling, besides, the formed carbon oxide cannot be used [13], which generally reduces the melting efficiency. Therefore, coke with the lowest possible reactivity (< 0,5 cm³/(g·s) is required for foundry [14]. The best varieties of domestic foundry coke have a reactivity of 0,4-0,5 cm³/(g·s) [2].

The ash content (Aa, %) is an indicator of the quality of foundry coke according to the requirements of GOST 3340-88 and depends on the brand of foundry coke. The ash content should not exceed 12.0% for coke of the KL-1 brand, 11.0% - for coke of the KL-2 brand, and 11.5% - for coke of the KL-3 brand. The composition of ash in coke is determined according to GOST 10538-87 "Solid fuel. Methods for determining the chemical composition of ash" and GOST R 54237-2010 "Solid mineral fuel. Determination of the chemical composition of ash by the method of atomic emission spectrometry with inductively coupled plasma", ash content according to GOST R 55661-2013 "Solid mineral fuel. Ash determination".

Main part

The coke ash in Russian plants is significantly higher than in European ones. This is explained by an increase in the ash content of coal concentrates from 9.6 to 10.5% according to GOST R 51588-2000 "Coals and anthracites of the Kuznetsk and Gorlovsky basins for technological purposes. Technical specifications", as well as the lack of price differentiation depending on the ash content of coal [15-18]. Hence, the ash content in coke for foundry is in the range of 11-12%, and in some cases even higher (13-14%) [2].

The moisture content according to the requirements of GOST 3340-88 is also an indicator of the quality of foundry coke. The share of total moisture in the working condition of the fuel (Wp, %) does not depend on the brand of coke and should not exceed 5.0%. The moisture content in coke is determined

according to the requirements of GOST 27588-91 "Coal coke. Method for determination of total moisture", GOST 27589-91 "Coke. Method for determination of moisture in an analytical sample".

Humidity of coke in the plants of the European Union varies in a significant range (7.0-3.5%). Particularly high humidity is in some varieties of coke imported from China (9.5%). Minimum (9.5%). Minimum humidity (0.1-0.5%) is obtained by dry quenching of coke [4, 16, 19-21]. In Russia, the moisture content in coke is from 0.14-1.26 to 4.3-5.0%. The sulfur content according to the requirements of GOST 3340-88 is an indicator of the quality of foundry coke and depends on the brand of foundry coke. The mass fraction of total sulfur should not exceed 0.6% in the KL-1 brand foundry coke, not more than 1.0% - in the KL-2 brand coke, and not more than 1.4% - in the KL-3 brand coke. In the supplied domestic foundry coke, the total sulfur content (S_t^a , %) is on average 0.46-0.56%. Sulfur in coke passes from coal during coking. Methods for determining the forms of sulfur are presented in GOST 30404-2013 "Solid mineral fuel. Determination of sulfur forms", the total sulfur content in coke - GOST 2059-95 "Solid mineral fuel.

Method for determination of total sulfur by burning at high temperature", GOST 8606-2015 "Solid mineral fuel. Determination of total sulfur. Ash's Method". Phosphorus enters coke from a coal charge and is determined according to the requirements of GOST 1932-93 "Solid fuel. Methods for the determination of phosphorus". The phosphorus content in coke is very different and depends on the phosphorus content in the initial coals [4]. Mass fraction of phosphorus in coke ash at various metallurgical enterprises is presented in Table 2 [17, 21, 24-26].

Table 2: Mass fraction of phosphorus in coke ash at various metallurgical enterprises (P2O5), percent (17)

Nizhny Tagil	Chelyabinsk	Magnitogorsk	Orsk-Khalilovsky	Kuznetsk	West Siberian	Cherepovetsky	Novolipetsk number 1-4	Novolipetsk number 5-6	Kemerovo coking coal plant	Kaliningrad coke plant
0,35	0,65	1,00	0,70	1,10	0,65	0,25	0,60	0,60	0,31	0,55

Volatile substances are substances formed during the decomposition of coal under heating without access to air [18]. Volatile substances consist of adsorbed gases, especially air oxygen and carbon oxide [13, 27-28]. The content of volatile substances in coke is determined according to the requirements of GOST R 55660-2013 "Solid mineral fuel. Determination of the yield of volatile substances".

The amount of volatile substances of foundry coke (Vdaf, %) is from 0.5 to 1.5% [2, 16]. According to [20, 21, 29], the recommended amount of volatiles in foundry coke should not exceed 1.2%. The content of volatile substances in the supply of foundry coke according to GOST 3340-88 is not indicated. However, when technical specifications (TS) are developed, the developer usually adds the value of

this indicator to the quality indicators for foundry coke. For example, according to the requirements of TS 0761-027-00187852-10 "Foundry coke. Specifications" the yield of volatile substances is normalized by a value of not more than 1.0%, and according to the requirements of TS 0761-028-00187852-10 "Foundry coal, coke produced by PAO "Mechel". Specifications" for coke with a grain size of 40 mm or more - not more than 1.2%. Foundry coke strength is of great importance for the effectiveness of melting iron in a cupola furnace. For cupola melting, the strength of foundry coke against abrasion, discharge, shock loads, and also strength at high temperatures is of interest. The following values of strength indicators are characteristic of domestic coke: M40 – 69-77 %; M25 – 83.7-92.3 %; M10 – 6.0-11.0 %; CSR – 32.6-58.2 %. For foundry coke, the strength value (M40, %) is established in GOST 3340-88 and ranges from 73 to 78% depending on the size class. The size of the coke provides charge permeability to gases and liquid melting products. The size of foundry coke according to the requirements of GOST 3340-88 is regulated by an indicator that limits the proportion of pieces smaller than 40 mm. The size of the coke provides charge permeability to gases and liquid melting products. The size of foundry coke according to the requirements of GOST 3340-88 is regulated by an indicator that limits the proportion of pieces smaller than 40 mm.

Coke porosity is determined by various methods and it is characterized by the parameters of porosity (P_r , %), apparent porosity (P_a , %) and bulk density in a large container (Z , t/m³). Bulk mass in a large

container according to the requirements of GOST ISO 1013-95 "Coke. Method for determination of bulk density in a large container" (Z , t/m³) is defined as the mass of coke per container volume. The bulk density depends on both the actual density and the apparent density and porosity. For cokes from Donetsk coals, the bulk density is 0.43-0.45 [16, 20], and 0.46-0.48 t/m³ - for cokes from eastern coals [20].

For foundry coke, the value of apparent porosity (P_a , %) according to various sources, ranges from 35 to 45% [2, 4]. The degree of completeness of the molecular and supramolecular structure of coke determines its properties as a semiconductor, characterized by a certain amount of electrical resistance. The value of electrical resistance can serve as an indirect characteristic of a number of properties of coke [22, 31]. For example, in [23], the relationship was established between the number of volatile substances characterizing the degree of "readiness" of coke and the completeness of thermomechanical transformations during coking, and the coke electrical resistance (ρ , $\Omega \cdot m$). The reactivity of coke is known to be reflected in the value of electrical resistivity: the smaller the ρ value of coke samples, the lower the reactivity index K [12, 24]. The data presented in [25] indicate the presence of a connection between the specific electrical resistivity and the valid density of coke (the correlation coefficient was -0.82). The analysis of data on the rationing of requirements for foundry coke (Table 4) indicates the following: - foundry coke has a large number of properties that affect each other;

Table 3: Foundry coke standardization

Number	Requirement	Designation	Units	Optimum values
1	2 Reactivity	3 K	4 cm ³ /g·s	5 < 0,4-0,5
1	Reactivity after reaction with carbon dioxide	CRI	%	Not established
2	Ash content	Aa	%	< 12,0
3	Moisture of analytical test	Wp	%	< 5,0
4	Total sulfur content	S _t ^a	%	< 0,6
5	Phosphorus content	P	%	< 1,2
6	Devolatilization	Vdaf	%	< 1,2
	Abrasion of coke after reaction with carbon dioxide	AV	%	Not established
	Coke strength after reaction with carbon dioxide	CSR	%	Not established
7	The strength of coke according to MIKUM	M40	%	≥ 73 ≥ 78
	Strength dropping	Shl	mm	Not established
8	Mass fraction of pieces less than 40 mm	-	%	≤ 5
	Porosity	P_r ,	%	Not established
9	Apparent porosity	P_a	%	< 45
	Bulk density in a large container	Z	t/m ³	Not established
10	Electrical resistivity	ρ	$\Omega \cdot m$	Not established

Conclusion

Insufficient attention to foundry coke indicates the absence of standardized requirements for foundry coke indicators such as reactivity, strength and abrasion of coke after reaction with carbon dioxide, dropping strength, porosity, bulk density in a large container, electrical resistivity.

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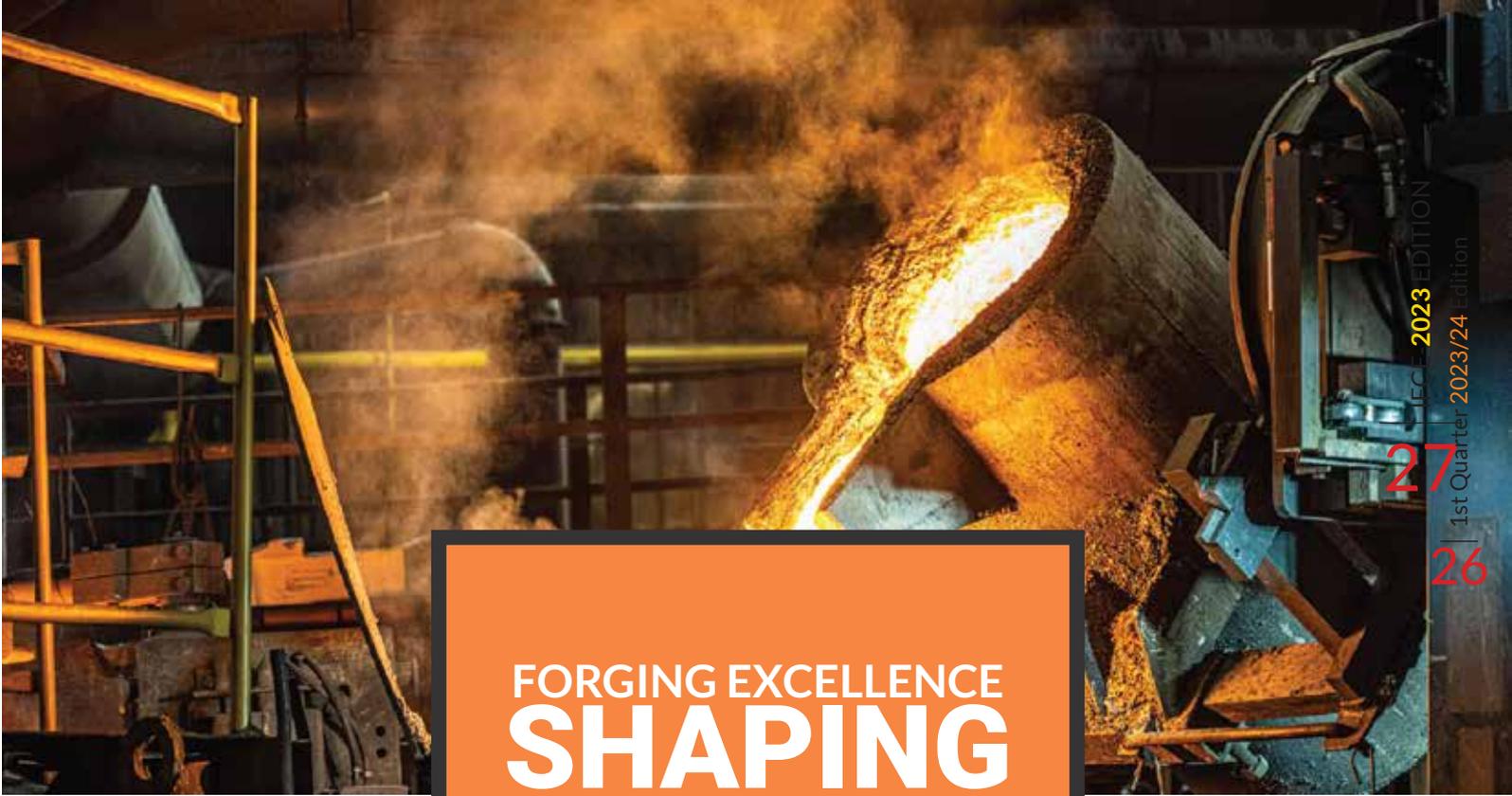
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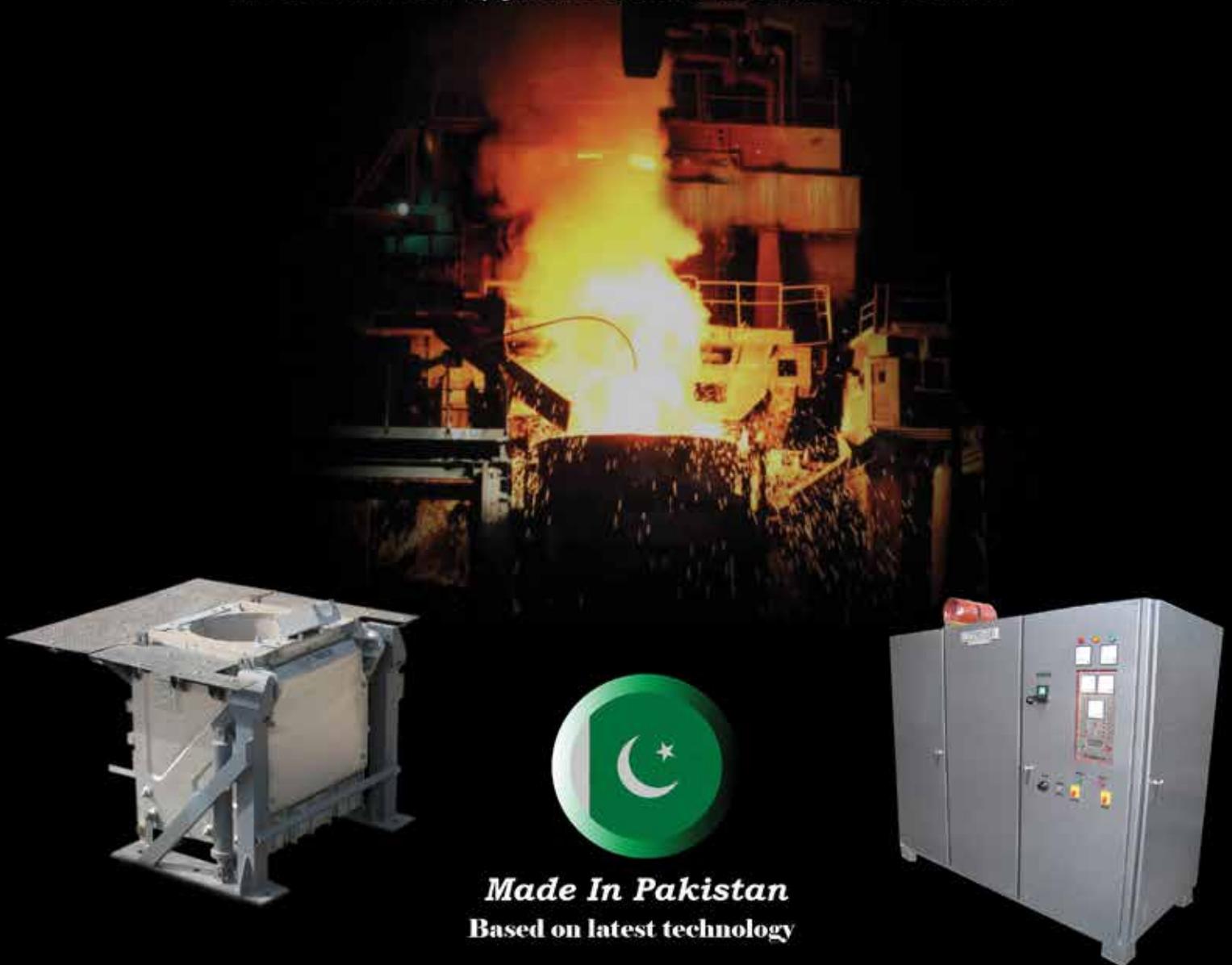
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