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President's Message



Sikandar Mustafa Khan

President

Pakistan Foundry Association

9th International Foundry Congress & Exhibition (IFCE 2025), January 29-30, 2025, was a great success. It brought together industry leaders, experts, and businesses to explore new technologies and opportunities for the foundry sector.

I extend my sincere gratitude to our esteemed guests for their support and participation. Their presence reflects the strong collaboration between the foundry sector and key industrial stakeholders.

This event showcased the strength and potential of Pakistan's foundry industry. With insightful technical sessions, global participation, and valuable networking, IFCE 2025 has helped create new pathways for growth and innovation.

I would also like to highlight the importance of the **Commercial Sessions**, which have proven to be a

vital bridge between the foundry sector and key industries. These sessions created valuable business opportunities, helping foundry professionals connect with industrial sectors and secure new work.

I sincerely thank all our sponsors, exhibitors, speakers, and attendees for making this event impactful. **The Pakistan Foundry Association (PFA)** remains committed to supporting the industry's progress. Let's continue working together to drive innovation, strengthen global partnerships, and build a stronger future for Pakistan's foundry sector.

A special appreciation to **Mr. Asim Qadri**, General Secretary - PFA, and **Mr. Irfan Ahmad Qureshi**, Joint Secretary - PFA, for their dedicated efforts in organizing this wonderful exhibition. Their hard work and commitment have played a crucial role in making IFCE 2025 a success.

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When Scon Valves Pvt Ltd began in 1990, global confidence in Pakistani manufacturing was low and resources were scarce. Farhan N. Sheikh faced the uphill task of transforming a

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We stay committed to our customers and shall continue to play our role in driving country's economic progress.



Casting Defect Analysis Procedure and a Case History

A. Alagarsamy
Citation Corporation, Birmingham, Alabama

Abstract

Foundries are still using trial and error methods to solve casting problems. There are benefits to using a more disciplined approach to define, identify and determine the root cause of a defect. Use of international standard defect codes for classifying the defects is illustrated. Powerful techniques such as defect mapping, questioning to narrow down the root causes and design of experiments to identify and control the variables are explored. An actual case history in solving shrinkage porosity is described to illustrate these techniques in practical use.

Introduction

A tremendous amount of productivity is lost through defective castings. By employing a disciplined approach to understand the nature of defects and the mechanism of defect formation and controlling the key process variables we can significantly reduce the scrap both in-house and at the customer. Misidentification of defects leads to costly scrap, lost time and customer dissatisfaction. It is not uncommon to have different names for the same defect, making it difficult to compare the successes and failures of other foundries in solving the same problems. The AFS has published a book standardizing the names of almost all the defects seen in the industry, but the foundries have not yet adopted the standardized codes and names. Even if in-house names unique to the foundry are used they can be cross-referenced with the published codes to help disseminate the knowledge for solving casting defect problems.

Shrinkage porosity revealed during machining plagues the customers as well as foundries. Foundries are now increasingly required to pay for the machining expenses for scrapped castings. Shrinkage porosity occurs sporadically making it difficult to determine the root cause. It is very difficult to verify in the foundries by using NDT techniques due to complex shapes, and the cost or time required to test the castings.

Background

Ever since the start of production of ductile iron castings, foundries have been working on understanding the effect of process variables on the shrinkage formation and controlling these variables to minimize defects. The Ductile Iron Society undertook a study to do just that. It was determined that silicon level has a significant effect on the internal porosity in unfed sections of the castings.

Casting Defect Codes

The International Atlas of Casting Defects handbook divides the defects into seven major categories. The entire defect codes and their names are given in the appendix. New names were added shown in italics. In addition to the codes listed in the handbook, AFS committee 4E has added codes at the end of the current codes to further identify the material of the casting such as gray iron, aluminum, etc. and to identify the process by which the castings were made. Use of these codes, in addition to in-house names or codes, will enable foundrymen to use data from one foundry to another without any confusion.

Major Defect Codes

A – Metallic projections
B – Cavities
C – Discontinuities
D – Defective surface
E – Incomplete casting
F – Incorrect shape and dimension
G – Inclusions and structure

Alloy Categories

GI – Gray iron
DI – Ductile iron
CS – Carbon steel
SS – Stainless steel
OF – Other ferrous
AL – Aluminum
MG – Magnesium
CU – Copper
ZN – Zinc
OA – Other non ferrous

Process

GS – Green sand
BK – Baked sand
NB – No bake
CB – Cold box
HB – Hot box/shell
PM – Permanent mold
DC – Die casting

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LF – Lost foam
IV – Investment casting
VP – 'V' Process
CN – Centrifugal
IG – Ingot
CC – Continuous cast
OM – Other methods

A fully coded defect will appear as B214-DI-GS, which will be read as shrink at the riser contact in ductile iron castings made in green sand molding process. This information is available at the website given below. <http://www.castingsolutions.com>

As we have come up with new processes and new materials, we also have created new types of defects with new names not covered in the present atlas. Some of the new defect names that are considered, for the newer materials and processes and to classify them in more detail are listed here.

- Vermicular graphite
- Chunk graphite
- Mesh graphite
- Exploded graphite
- Inverse chill carbides
- Grain boundary carbides
- Gas voids with graphite layer
- Gas void with oxide layer
- Blister
- Doughnut (fisheye)
- Leaker
- Riser break-in
- Shrink at riser contact

Identification Of Defects

Most of the defects seen in the foundries are easy to recognize and identify by the correct defect name and code. There are a few defects that may appear to be similar but may be entirely different types. If we do not correctly diagnose these defects we may get into more problems trying to correct something or change something that may not be necessary. It may be better to keep the defect as neutral prior to classifying into a more specific defect. If distinction could not be made between gas defect and shrinkage defect, then it should be kept as porosity until it is clearly determined to be either shrink or gas defect. Ambiguous defects include inclusions (sand or slag). There are several places information is available to help determine the true defect name and code. Every foundry should have known defect standards that have been identified previously for reference and training new personnel. Defect handbooks, in-house manuals, and the internet are a few of the sources that are readily accessible.

Suppliers also have a lot of information collected through the years in helping solve foundry problems. It is important to have good knowledge of the mechanics of casting defect formation, probable locations and the nature of the defects. In some difficult cases, analytical tools such as the SEMs are used to pinpoint the nature and cause of the defects. One should use any and all tools available to make sure the defect is identified correctly.

Gathering Data – Information

In solving casting quality problems, we must start with reliable data for key process variables that affect the quality of the castings. Data gathered in the foundries should be reliable. Gage R and R for the measuring equipment should be in the acceptable range. For evaluating casting defects, instead of having two categories (acceptable castings and rejects), a range of quality standards should be established with a reproducible measuring system, e.g. 1 through 5, 1 denoting no defects and 5 representing worst case defect. Once a valid measurement system is established then any experimentation can be undertaken to study the effect of variables on the casting quality.

Routine documentation of all process data should be easily obtainable for analysis of conditions causing the defects. More frequent data gathering may be necessary to zero in on the causes of defects. Any data that are used for analysis should be dependable.

Defect Mapping

It is very important to analyze the defects by carefully cataloging details of the defects. It will be very informative when the defects are plotted on a pattern layout diagram. The details will indicate how many defects of one kind occur at a particular location of a cavity in the casting, cope or drag and relative location with respect to a gating schematic. Defects documentation should also contain the time the castings were

made, especially for persistent types of defect. From this kind of detailed mapping it is easy to see where the defects are mainly located, what type of defects and which cavities are prone to the defects under consideration. For shrink type of defects, information about the risers (how well it is functioning-piping) should also be documented. From the defect mapping information and process data during high scrap times and low scrap times, useful contrast information can be derived. By asking and answering questions listed below, one can remove processes not contributing to the defect. By eliminating a broad process, quite a few variables need not be considered thus simplifying the work ahead. One should

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be careful not to eliminate variables that may be influencing the defect formation. It should also be noted that there may be interaction between variables as well as design features.

| When the defect is: | Processes not contributing to the defect |
|---------------------------------|--|
| In only one of several cavities | Melt, molding, pouring core, |
| Shrink at riser connection | Sand, molding, core |
| Shrink at hot spot | Sand, molding, core |
| Tear-up, stickers | Core, melt, pouring |
| Crush at certain times | Core, tooling, melt, pouring |
| Misrun at start of a shift | Tooling, sand, molding, core |
| Sand at the bottom | Melt, pouring |

Table 1. Examples of elimination of processes not contributing to the defect

Prior to investigating casting defects, one should gain knowledge about the nature of defects, the appearance and possible location of the defects and the mechanism of defect formation. During the investigative phase, by asking and answering pertinent questions, more insight into the defects can be gained. Prior to investigating casting defects, one should gain knowledge about the nature of defects, the appearance and possible location of the defects and the mechanism of defect formation. During the investigative phase, by asking and answering pertinent questions, more insight into the defects can be gained.

Some of the questions for root cause analysis:

- Where are the defects?
 - o Drag, side walls, above or below core
 - o Closer to gates or farther away from gates
 - o At the surface, interior or sub surface
- Are the defects found at the same location?
- Are the defects occurring all the time?
- Are the defects people related?
- Are the defects time related?
- Are the defects cavity related?
- Do these defects occur in other similar jobs?

Further questions as to related defects can shed light as to the causes of defects. Are there related defects in the same castings?

- o Misrun, short pour, run-outs, laps
- o Rat tails, buckles, scabs
- o Rough surface, burn-in, penetration
- o Swells, erosion, stickers
- o Shrinkage, gas porosity, leakers

When related defects occur in the same castings, it may indicate a system related problem.

We are going to look at a case history of a porosity defect and the procedure that was followed to reduce the defect occurrence. The schematic view of a sectioned casting is shown in Figure 1. Porosity occurs sporadically in a heavier section not fed directly by a riser, at the location shown, Figure 2. shows two different locations

where a riser is attached for different cavities, due to layout of patterns for maximizing number of cavities in the mold.

What else is known:

- Porosity shows up after machining the casting.
- Porosity is three times more when the riser is at location 'B' than when the riser is at location 'A'.
- Occasionally in some heat codes there is a spike in the defect severity.
- Overall, the incidence of porosity is low.

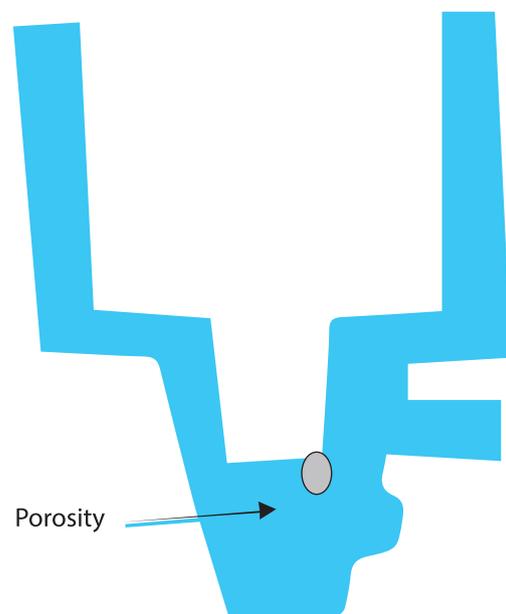


Figure 1. Schematic view of cut view of casting

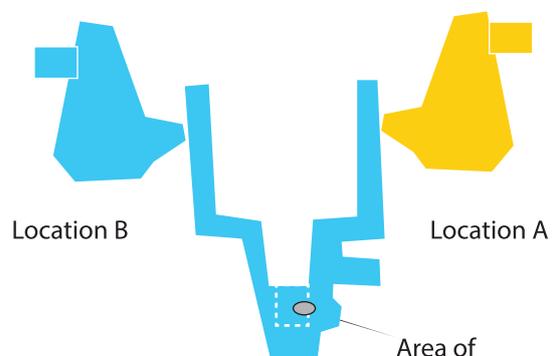


Figure 2. Alternate locations for riser

Analysis Of The Defect

By the appearance (dendritic) and the location (below the core) and in the center of the isolated heavy section, it was concluded this was a shrinkage defect. This defect is remote area (centerline) porosity. The international code for this defect is determined to be B222 - Centerline or axial shrinkage porosity. As the section where the defect occurs is isolated from the riser by a thinner section of the casting, the riser is not able to compensate for the shrinkage that occurs at the end of solidification of the isolated section. Solidification models predict there will be shrinkage at this location. Even then, over 98% of the time the castings are sound. Most of the time the expansion due to graphite precipitation compensates for the shrinkage occurring at this late stage of the solidification process.



Figure 3. Example of micro shrinkage in the center of unfed area of a casting

When there is microshrinkage, there has been insufficient graphite expansion at the end of solidification to compensate for shrinkage due to austenite formation.

Expansion And Shrinkage

Expansion and shrinkage occurs simultaneously during solidification of a casting. In many instances expansion due to graphite precipitation pushes liquid metal into the voids or into the free surface of a

riser. This can readily be seen by observing the piping behavior in the risers as shown in figures 4 and 5. There is absence of continuous piping in most cases, which indicates at different times expansion is greater than the shrinkage, pushing liquid metal into the riser. Process variations within mold and from mold to mold affect the rate and relative values of shrinkage and expansion. If the casting design and riser design is marginal, then shrinkage defects may exhibit different forms.



Figure 4. Riser piping behavior

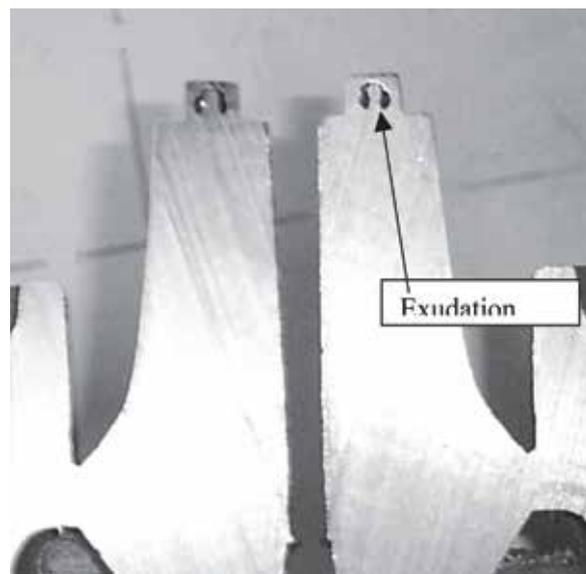


Figure 5. Exudation of metal is clearly seen into the riser piping cavity.

Evidence of exudation is clear in cases where the metal was semisolid and solidified very quickly maintaining its shape. There are some rare instances where the exudation is into a primary liquid shrinkage cavity inside a casting. One such instance is shown in figure 6.



Figure 5. Exudation of metal is clearly seen into the riser piping cavity.

In the case study under discussion here, the factors inherent in the design of both the casting and gating makes the casting susceptible to shrinkage porosity. Since a very small percentage of castings have defects and they occur in spikes, it suggests that there are some significant variables or combination of variables that influence the shrinkage porosity.

The fact that riser location 'A' figure 2. results in much less frequency of shrinkage defects than riser location 'B' suggests that casting design has a significant effect. By looking at the results of casting solidification simulation, we can detect that the feeding path is open for a slightly longer duration for the 'A' location than for the 'B' location. This means that when the feeding path is cut off, the remaining volume of liquid in the isolated area is slightly smaller with 'A' riser than with 'B' riser. This fact then leads us to conclude that the variables which influence the amount of liquid remaining in the isolated area have a direct effect on the shrinkage defects. The other set of variables that will affect the shrinkage are metallurgical variables which affect graphite precipitation especially at the end of solidification.

Variables

Prior to running design of experiments, a matrix study was done to determine the key variables that in this case will affect the

shrinkage porosity. Listed below are the variables considered to have effect on the shrinkage.

Metallurgical factors that affect the shrinkage:

- Carbon equivalent
- Cumulative level of forward segregating elements
- Magnesium and cerium residuals
- Level of base iron nucleation
- Silicon level
- Precipitation rate and timing of graphite nodules

Factors influencing the volume of liquid metal:

- Pouring temperature
- Green sand heat conductivity-density
- Core sand heat conductivity
- Mold quality – mold wall movement
- Pouring rate
- Design of casting
- Core length-affecting mass at hot spot

The top ranked factors listed in bold letters were thought to influence the shrink most, and warranted further study. The graphite precipitation rate and timing is an important variable but is not directly controlled like the other variables. Graphite nodule precipitation is influenced by several other variables listed and/or by inoculation effectiveness. For instance, over-inoculation or very high carbon equivalent can result in primary graphite precipitation, which results in duplex nodule size distribution. There is some evidence this type of graphite nodule distribution leads to increased shrinkage. A DIS research project at CANMET showed that excess inoculation increases shrinkage.

Also from this study and other experiences, we know that an increased magnesium residual level for the section thickness and final sulfur increases shrinkage.

Increased level of silicon contributes to increased shrinkage. Silicon level is also controlled to minimize carbide formation. There may be less freedom in some shops to lower the silicon level, due to common iron being poured for many jobs, some of which require higher silicon to control carbides and/or pearlite levels in the casting. In some cases a minimum silicon may be specified by the customer for operational benefits.

Design of Experiments

Considering all the above factors it was decided to conduct a design of experiment to determine the variable factors that influence shrinkage the most. The first set of variables considered for the study are:

1. Magnesium residual level
2. Core design
3. Pouring temperature

From the feedback from the customer and analyzing the internal process data, a strong correlation was found that pointed to the magnesium residual level contributing to an increase in shrinkage defects on some days.

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Core design was chosen as a factor that affects the volume of liquid metal in the hot spot area. By lengthening the core, liquid mass could be reduced. It was expected that the longer core will result in reduced shrinkage.

Pouring temperature was selected as another variable due to its influence on the volume of liquid metal remaining when the feed path is cut off. Generally in larger casting sections lower temperature seemed to help minimize shrinkage.

A full factorial design was used to determine if there were any interactions between the three variables selected. A set of 8 heats were poured as shown in Table 2, Numbers 1 through 8 show the sequence when the heats were poured.

Table 2. Three factor full factorial experiments

| | Short cores | | Long cores | |
|--------|-------------|-----------|------------|-----------|
| | Low temp | High temp | Low temp | High temp |
| Low Mg | 1 | 5 | 3 | 7 |
| Hi Mg | 2 | 6 | 4 | 8 |

Castings from these heats were radiographed and rated by two people as to the severity of shrinkage. Shrinkage was rated from 0 to 5, 0 being no shrinkage and 5 being the worst case observed. The points for each condition were totalled and used as a response from the experiments for analysis. See Table 3. and Figure 7.

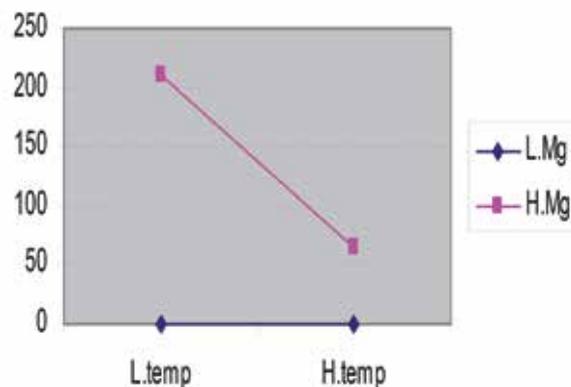


Figure 7 : Total shrinkage porosity at low and high levels of Mg and temperature

| | Short cores | | Long cores | |
|--------|-------------|-----------|------------|-----------|
| | Low temp | High temp | Low temp | High temp |
| Low Mg | 0.7 | 0 | 0 | 0 |
| Hi Mg | 110 | 35 | 101 | 31 |

Table 2. Three factor full factorial experiments

At lower magnesium levels there was no shrinkage seen. At higher magnesium levels, temperature has an effect, with higher temperature reducing the amount of shrinkage. Core design did not affect the shrink. The major effect is Mg, followed by temperature. Interaction between magnesium and temperature can be seen.

After the study the process variables for magnesium residual and pouring temperature were adjusted to a more

favorable range. This change resulted in a significant improvement in the level of defects found after machining. Even with the reduced defect severity, porosity still occurs at the same pattern/location as before. As we know, the silicon level also has an influence on shrinkage, so the silicon level is also adjusted lower, while monitoring for an increase in carbides.

We continue to audit the castings with radiography and are not seeing any defects in the radiographs. We are still investigating other variables such as green sand density and core sand density that affect the volume of liquid when the feed path is cut off.

Summary

A systematic approach to defect identification and analytical techniques to find root causes is explained in detail. One example of a defect case history is shown to explain the procedure that was followed to identify and resolve the problem.

Acknowledgments

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5. Sparkman, David., "Offsetting Macro-Shrinkage in Ductile Iron" DIS News, Issue 3, 2001

Appendix 1.

Defect Codes From International Atlas of Casting Defects Handbook

A - Metallic Projections

A 100 Metallic projections in the form of fins or flash
A 111 Joint flash or Finning
A 112 Veining or Finning
A 113 Heat Checked Mold or Die
A 114 Fillet Vein
A 121 Cope Raise, Raised Mold
A 122 Sag or Strain
A 123 Cracked or Broken Mold
A 200 Massive projections
A 211 Swells
A 212 Erosion, Cut, or Wash
A 213 Crush
A 221 Mold Drop or Sticker
A 222 Raised Core or Mold Element, Cutoff
A 223 Raised Sand
A 224 Mold Drop
A 225 Corner Scab
A 226 Broken or Crushed Core

B - Cavities

B 100 Cavities with generally rounded smooth walls detectable to the naked eye
B 111 Blowholes, Pinholes
B 112 Blowholes near inserts, chills, chaplets
B 113 Slag Blowholes
B 121 Surface or Subsurface Blowholes
B 122 Corner Blowholes, Draws
B 123 Surface Pinholes
B 124 Dispersed Shrinkage
B 200 Cavities with rough walls, shrinkage
B 211 Open or External Shrinkage
B 213 Core Shrinkage
B 214 Shrink at riser contact*
B 221 Internal or Blind Shrinkage
B 222 Centerline or Axial Shrinkage Porosity
B 223 Center line porosity at isolated hot spots*
B 300 Porous structures caused by many small cavities
B 311 Macro, Micro, shrinkage porosity-leakers

C - Discontinuities

C 100 Discontinuities caused by Mechanical effects
C 111 Breakage (Cold)
C 121 Hot Cracking
C 211 Cold Tearing
C 221 Hot Tearing
C 300 Discontinuities caused by lack of fusion.
C 311 Cold Shut or Cold Lap
C 321 Interrupted Pour
C 331 Cold Shut (At Chill or Insert) Unfused Chaplet
C 400 Discontinuities caused by metallurgical defects
C 411 Conchoidal or Rock-Candy Fracture
C 412 Intergranular Corrosion

D. Defective Surface

D 100 Casting surface Folds, Gas Runs
D 112 Cope Defect, Elephant Skin, Laps
D 113 Seams or Scars
D 114 Flow Marks
D 121 Rough Casting Surface
D 122 Severe Roughness, High-Pressure Molding
D 131 Buckle
D 132 Rat Tail
D 133 Flow Marks, Crow Feet
D 134 Metal-Mold Reaction, Orange Peel
D 135 Soldering, Die Erosion
D 141 Sink Marks, Draw, Suck-In
D 142 Slag Inclusions
D 200 Serious surface defects
D 211 Push-Up, Clamp Off
D 221 Burn On
D 222 Burn In
D 223 Metal Penetration
D 224 Dip Coat Spall, Scab
D 231 Scab, Expansion Scab
D 232 Cope Spall, Boil Scab, Erosion Scab
D 233 Blacking Scab
D 241 Oxide Scale
D 242 Adherent Packing Material
D 243 Scaling

E. Incomplete Casting

E 100 Missing portion of casting (no fracture)
E 111 Misrun
E 112 Defective Coating (Tear-Dropping) or Poor Mold Repair
E 121 Misrun (a)
E 122 Poured Short
E 123 Runout
E 124 Excessive Cleaning
E 125 Fusion or Melting during Heat Treatment
E 200 Missing portion of casting (with fracture)
E 211 Fractured Casting
E 221 Broken Casting (At Gate, Riser or Vent)
E 231 Early Shakeout

F. Incorrect Dimensions or Shape

F 100 Incorrect dimensions, correct shape
F 111 Improper Shrinkage Allowance
F 121 Hindered Contraction
F 122 Irregular Contraction
F 123 Excessive Rapping of Pattern
F 124 Mold Expansion during Baking
F 125 Mold wall Movement, Mold Cavity Enlargement
F 126 Distorted Casting
F 200 Casting shape incorrect or in certain locations
F 211 Pattern Error
F 212 Pattern Mounting Error
F 222 Shifted Core

F 223 Ramoff, Ramaway
F 231 Deformed Pattern
F 232 Mold Creep, Deformed Mold, Springback
F 233 Casting Distortion
F 234 Warped Casting

G. Inclusions

G 100 Inclusions or Structural Anomalies
G 111 Metallic Inclusions
G 112 Cold Shot
G 113 Internal Sweating, Phosphide Sweat
G 121 Inclusions of Slag, dross or Flux: Cerioxide
G 122 Slag-Blowhole Defect
G 131 Sand Inclusions
G 132 Blacking or Refractory Coating inclusions
G 141 Black Spots
G 142 Oxide Inclusions or Sinks, Seams
G 143 Lustrous Carbon Films, Kish Tracks
G 144 Hard Spots
G 200 Structural anomalies-macroscopic
G 211 Primary Chill, Chilled Spots or Edges
G 212 Unmottled Chill, Clear Chill
G 213 Inverse Chill*
G 214 Ferritic Skin*
G 221 Primary Graphite White Iron
G 222 Excessive Pearlite Layer
G 223 Localized Hard Spots, Inclusions
G 224 Flake Graphite*
G 225 Chunk graphite*
G 226 Exploded Graphite*
G 262 Kish Graphite Inclusions
G 263 Carbon Flootation
G 264 Faceted (Dendritic) Fracture

* additional codes

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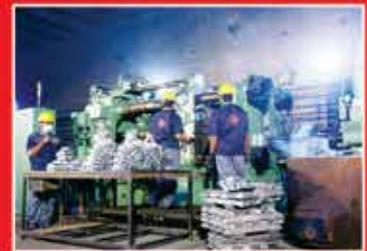


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Foundry Energy Optimization

Introduction

It is estimated that more than 48,300 foundries are registered globally. [1] The metal casting industry is one of the most energy-intensive manufacturing sectors with the melting process accounting for over half of its energy consumption. Although its high energy expenses have been a significant concern for metal casters, the industry continues to use melting technologies with poor energy efficiency. [2] Pakistan is facing energy crisis. The availability of the energy is far less than the demand. Striving to reduce energy consumption in melting metals shows a promising path to lowering operating costs in foundries and, in turn, cutting down the production costs for the entire manufacturing sector. The industry, especially foundry sector, needs to adopt smart energy consumption methods to handle the situation. The betterment can be expected through improvements in equipment design, process control and management techniques.

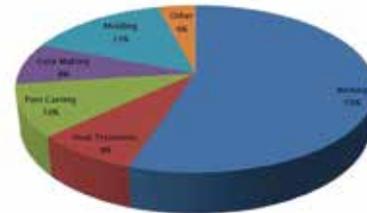
The Energy Sources:

A melting furnace derives its heat from solid fuels (coke and breeze), natural gas, electricity, or other sources of energy. To be smart user of energy we need find the ways to maximize the output by minimum input of the energy in each respect. Coreless Induction Furnace and Cupola Furnaces are more popular than other types of furnaces for cast iron production.

The Energy Consumption:

As per study of Metal casting technology station University of Johannesburg, the highest electrical energy in the foundry is consumed by the melting unit. [9]

METAL CASTING TECHNOLOGY STATION
UNIVERSITY OF JOHANNESBURG



Energy consumption in the metal casting facility
Source: MODERN CASTING APRIL 2011

The runner ups in energy consuming equipments in a foundry is utility of compressors that supply high pressure air to other departments.

The Equipment and Machinery:

The energy can be saved through investing in energy efficient equipment over standard efficiency equipment. Cupola furnaces are most common furnace for cast iron melting. The most energy-efficient cupola, found by Teri, use 13.6% charge coke (coke:metal ratio of 1:7.5). The figure for the least energy-efficient cupola was found to be as high as 26.5% (coke:metal ratio of 1:4). [3]

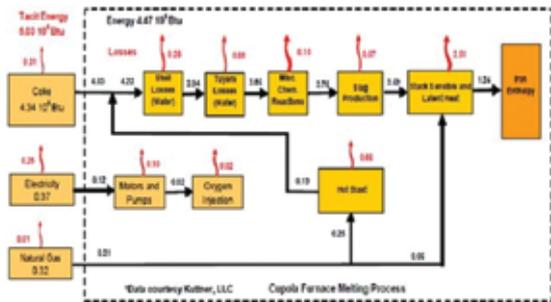
Energy efficient designs have been developed that include oxygen enriched blast cupola, divided blast cupola, hot blast cupola, long campaign cupola, plasma fired cupola, and coke-less cupola (gas cupola). Different designs claim 12 to 40% reduction in coke consumption as compared to conventional single tuyers cold blast cupola.

The new possibility of sparing managing the energy by melting cast iron includes a Brazilian cupola type FAR. A dramatically reduction of the coke: metal ratio, namely to the level 6~7 kg/100 kg of metal is expected with this design.

Computer-aided control of the cupola process may also lead to the best calculated output of the energy input.[4] Recently, computer models have become available, including neural network models, to provide

rapid estimates of process variables for use in automated control schemes. Computer control of the cupola process lowers material and processing costs, reduces scrap and improves quality.[5]

Low-Efficiency Cupola Melting Process Energy Balance (106 Btu/Ton Iron Melt)* (Water-Cooled Bare Shell) [6]

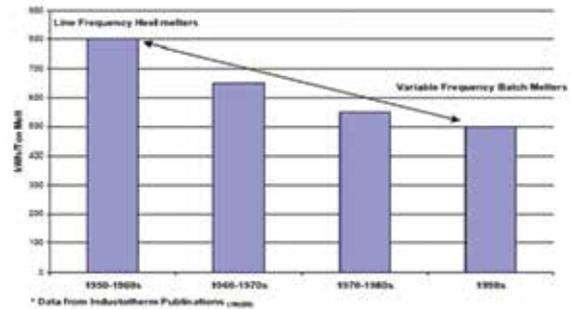


A 10 ton coreless induction furnace operating at 60 Hz can melt its capacity in two hours. At 275 Hz, the same furnace can melt the full 10 ton charge in 26 minutes, or four times faster. [5]

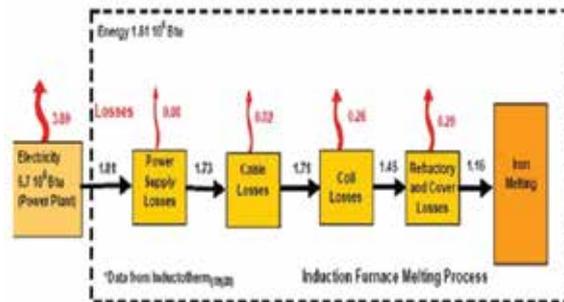
Better harmonics control can lead to the better efficiency of the coreless induction furnace. Harmonics problem, or feedback of electrical equipment on the power source, can be caused by the high power of the furnace power supplies. These power interface problems include low-power factor, high-frequency harmonics, line voltage notching, and inter-harmonic distortions. Special technologies and equipments have been developed to minimize the negative influence of induction furnaces on the power supply. Computerized controls and diagnostic systems are available to provide close control of the melting operation and reduce the chances of accidental overheating. A typical control system uses information from load cells for the weight of the furnace charge and thermocouple readings for melt control optimization. Multiple-Output Power Supplies have also been developed. Dual-output or “butterfly” operations utilize a single power supply and two furnaces with mechanized or electronic switching. This results in continuous and completely controllable power to two furnaces at the same time. Recently, multiple-output power

units with three or more outputs have been developed. These new systems are designed with capacitive furnace isolation and include one or two AC rectifiers. Such systems are capable of achieving the high volumes of metal production previously possible only with cupolas. [5]

Historical Induction Melting Furnace Energy* (Delivered) [6]

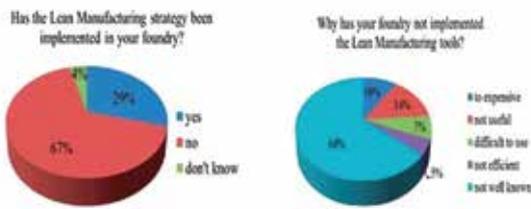


Modern Induction Melting Process Energy Balance (106 Btu/Ton Melt)* [6]



The verbal meaning of “lean” is “thin”. The Rockford Consulting USA defines it as, “Lean Manufacturing is an operational strategy oriented towards achieving the shortest possible cycle time by eliminating waste”. It is the philosophy of continually reducing waste in all areas and in all forms.

Also known as Toyota Production System (TPS), presently, Lean manufacturing techniques are not widely adopted in foundry sector. In 2013 J.Jezierski and K. Janerka of Poland conducted a survey.[8] Three hundred (300) Polish foundries responded the questionnaire. The results showed that the lean was not implemented widely and properly in the foundry sector.



Implementation of Lean in foundries Reasons to not implement lean tools

Types of Waste:

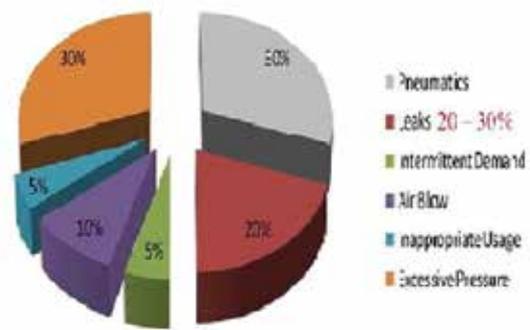
The soul of lean manufacturing is to eliminate waste in the process through various tools. Anything that adds cost to the product without adding value is defined as waste. After the value stream mapping it is important to know the waste. Lean defines eight types of Waste:

1. Defects
2. Over production
3. Waiting time
4. Non-utilized people
5. Transportation
6. Inventory
7. Motion
8. Excess processing

If we join first letter of each type, we get the word 'downtime'!

Among all the eight some types of waste are frequently observed in the foundries that ultimately cause the waste of energy. The defective castings or rejections simply mean that all the energy in any form we consumed to manufacture a rejection, gone in vain. The over-production leads to spend energy only to build up finished stock inventory which is not only the over-production waste but also the inventory waste. Controlling the defects and over production will reduce the energy consumption per ton shipped to the customer. Among all other waiting times, the most

drastic in the foundry is furnace waiting. Each minute of holding the furnace, for any reason, will cost units of energy for which the customer will not pay for. The over heating of the melt is an example of excess processing that consumes energy. Sometimes the metal is even cooled down before pouring at the desired temperature. This excess processing is a waste of energy adding cost to the end product. The heat is dissipated through radiation from the induction furnaces without lids hence wasting the energy. It is estimated that only 30% of the compressed air is utilized for production, rest of the valuable air is wasted due to leakages, artificial over demands, and poor distribution designs. [10]



The 1989 British survey of cupola foundries showed the average specific coke consumption (SCC) of 158 kg/t liquid iron. A U.K. cupola foundry lowered the SCC of their cold-blast cupolas to 113 kg/t, a savings of 28%. They achieved this through improved production planning to reduce variations in composition, temperature and melted metal demand, accurate weighing of coke and charge, and other process improvements. [7]

The following are some general recommendations that apply to both ferrous and nonferrous melting: [6]

1. Use clean scrap - one pound of sand charged means two pounds of iron or steel not melted and increases the slag generated. Do not waste energy to heat the sand!
2. Maintain minimum tapping temperatures that ensure quality castings. Streamline temperature measurement - automated furnace temperature and power controls prevent overshooting temperature settings.

Do not waste energy for extra processing!

3. Optimized scheduling – minimizes excessive holding power. Do not waste energy in wait!

4. Refractory – maintain refractory thickness to factory recommendations. There should not be over thickness. Do not waste energy to heat extra refractory!

5. Reduce the time the lid is open for all purposes while melting or holding iron. A 12-ton capacity furnace (storage tons) loses 14 kWh for each minute the lid is open. Do not waste energy to heat the surroundings!

The Energy Audits:

Energy audits indicate the ways in which different forms of energy are being used and quantify energy use according to discrete functions. An energy audit does not provide the final answer to the problem; it identifies where the potential for improvement lies, and therefore, where energy management efforts must be directed. [7] The entire audit exercise can be divided into three steps. Step one identifies the quantity and cost of the various energy forms used in the plant. Step two identifies energy consumption at the department/process level. The study involves detailed mass and energy balance of major energy consuming equipments. Step three relates energy input to production (output), thereby highlighting energy wastage in major equipment/processes. The system efficiencies are evaluated and measures are identified for improving the end-use energy efficiency. The energy audits can be performed internally by a competent individual with suitable technical training and good overall knowledge of the foundry's operations and also externally by the energy audit firms.

Incentives on Energy Savings:

Energy management is a cost reduction strategy that can have an immediate impact on profitability. Successful energy management is more than just turning off the

lights.[11] It takes a champion, a commitment, and a holistic, comprehensive program. It is not a quick fix, but a long term commitment with a program. It does not necessarily require capital investment but a change in company culture. Any individual or collective effort to minimize the energy consumption should be highlighted and praised with appreciation certificates, awards and cash prizes. The energy saving competition among the various departments in terms of %age reduction in input for more output can be held on monthly basis. The incentives offered to the direct consumers may make them think to find more effective ways to further saving of energy than standard usage.

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Strengthening the Foundry Industry: PFA's Year in Review

The Pakistan Foundry Association (PFA) continues to lead from the front in advancing the national foundry sector by promoting innovation, forging key industrial linkages, and enabling global exposure. In line with its mission to elevate Pakistan's casting capabilities, PFA recently undertook a series of impactful initiatives.

Visit from the Acting Consul General of Türkiye

The Acting Consul General of Türkiye, Mr. Ali Erbaş, along with the Turkish Commercial Counsellor Mr. Nurettin Demir, visited the PFA office. Discussions focused on enhancing industrial and technological cooperation between Pakistan and Türkiye.



Participation Opportunities in Metal China & Thailand 2024

PFA facilitated international exposure for its members by securing free stalls at the Thailand Foundry Exhibition 2024 and Metal China 2025 and arrange visa invitation letter for our members. This initiative enabled member foundries to showcase their capabilities to a global audience without incurring booth charges.

These strategic efforts reflect PFA's unwavering commitment to strengthening Pakistan's foundry ecosystem through technical excellence, market development, and international collaboration.

Engagement with Zhongfu Huixin Industrial Technology Co. Ltd. (China)

A session with Zhongfu Huixin, specialists in raw materials for cast iron production. The company expressed interest in supplying key inputs to the Pakistani foundry sector, paving the way for stronger material sourcing channels.



Collaboration with Caterpillar Inc.

Caterpillar reached out to the Pakistan Foundry Association (PFA) to identify potential iron casting suppliers from Pakistan. In response, PFA has initiated the registration of its members on Caterpillar's vendor list.

Executive Members Meetings

20th May 2024 – PFA Head Office

PFA Executive Members meeting, led by Mr. Asim Qadri (General Secretary) and Mr. Irfan Ahmad Qurashi, discussed key development points of PFA and focused on the initial planning for the 9th IFCE 2025.

26th January 2025 – Flatties Hotel, Lahore

The meeting reviewed the final preparations, including stall arrangements, technical sessions, and international participation, to ensure everything was in place for a successful IFCE 2025. Mr. Asim Qadri briefed the members on all the work completed so far and assigned tasks to the Executive Members to actively contribute to the event.



Business Development Sessions

PFA organized Business Development (BD) sessions with the supply chain and technical teams of key industrial sectors, providing PFA members with direct interaction and the opportunity to get work by becoming part of their vendor network. Notable participants included:

1. Ittehad Chemicals Ltd.
2. Dandot Cement
3. Nimir Chemicals
4. Maple Leaf Cement
5. Peoples Steel Mills
6. Pioneer Cement
7. Pakarab Fertilizers Ltd.
8. DG Cement
9. Zhongfu Huixin Industrial Technology Co. (China)
10. Pakistan Railways

These sessions aimed to link foundries with large-scale industries for potential contract manufacturing, localization of components, and long-term collaboration. Through these efforts, PFA is actively supporting local manufacturing, promoting import substitution, and contributing to national industrial growth.



Ittehad Chemicals Ltd.



Dandot Cement



Nimir Chemicals



Maple Leaf Cement



Peoples Steel Mills



Pioneer Cement



Pakarab Fertilizers Limited



DG Cement



Zhongfu Huixin Industrial Technology Co. (China)



Pakistan Railways

These sessions aimed to link foundries with large-scale industries for potential contract manufacturing, localization of components, and long-term collaboration. Through these efforts, PFA is actively supporting local manufacturing, promoting import substitution, and contributing to national industrial growth.

9th International Foundry Congress & Exhibition (IFCE 2025)

The 9th IFCE was successfully held on 29–30 January 2025 at PC Hotel, Lahore. The event brought together foundry professionals, industrial buyers, and international participants under one roof.

Key Highlights:

- Over 65 plus stalls and 6,000+ visitors
- Technical sessions with international and local experts
- Participation from international companies like Mega, Çukurova Kimya, RKB Europe SA, and Zhongfu Huixin (China)
- Promotional sessions conducted in Gujranwala, DarogaWala, Paspeeda and Faisabad.
- Extensive media and marketing campaigns executed
- The event strengthened industry networking, promoted local manufacturing, and encouraged global partnerships.



Technical Knowledge Sharing Webinars

PFA organized multiple technical webinars during the year to enhance industry knowledge and support capacity building among foundry professionals.

Influence of Correct Coating Selection & Application on Casting Quality

Conducted by Metko Hüttenes-Albertus, this session emphasized the role of proper coating selection in producing defect-free castings. Attended by QA teams and engineers nationwide.

Casting Simulation Solutions

Delivered by PoligonSoft, the session focused on digital tools for casting defect reduction, design optimization, and improving first-shot casting success.

How to Earn Money from Metallurgical Waste Recycling

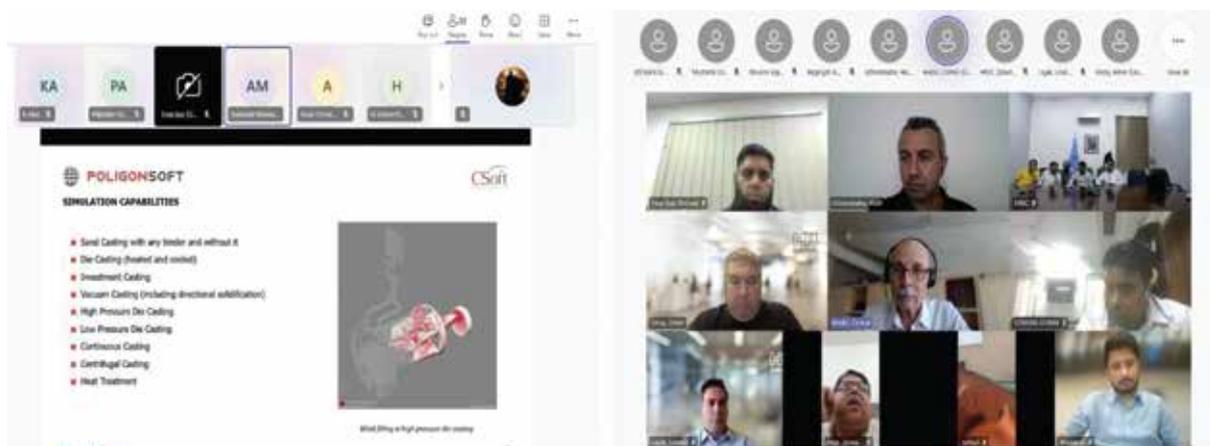
Held on December 17, 2024, presented by Andrey Korablin (CEO, SmartScrap Ltd.), focused on profit potential from waste recycling.

Optimizing EAF Production – Particle Case Study

Conducted on December 24, 2024 by Andrey Korablin, this webinar covered practical strategies to enhance electric arc furnace productivity.

4th CPD Lecture – HMC

Organized by Heavy Mechanical Complex, the session contributed to professional development in the foundry sector.



Global Outreach – Metal China 2025

PFA also played a pivotal role in forming a delegation for Metal China 2025, one of the world's largest and most influential foundry exhibitions. By enabling Pakistani foundries to participate, PFA aims to connect them with global buyers, explore technological innovations, and benchmark local practices with international standards.

21st Trade and Industrial Fair

PFA secured a free stall at the 21st Trade and Industrial Fair, which was offered to a member company for promotional use. The PFA logo was prominently displayed, recognizing the association as an event supporter. This participation helped enhance the visibility of PFA and its members within broader industrial circles.



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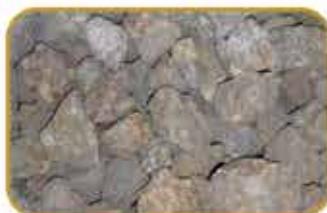
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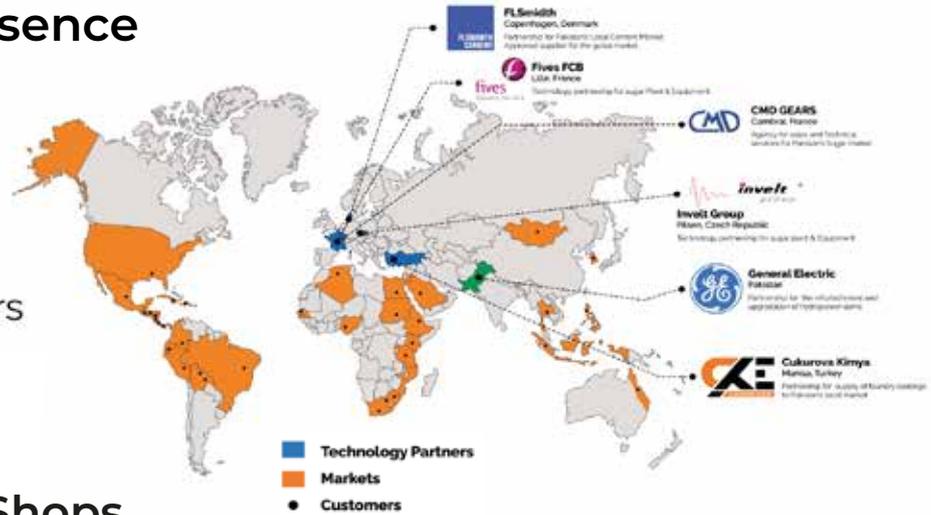
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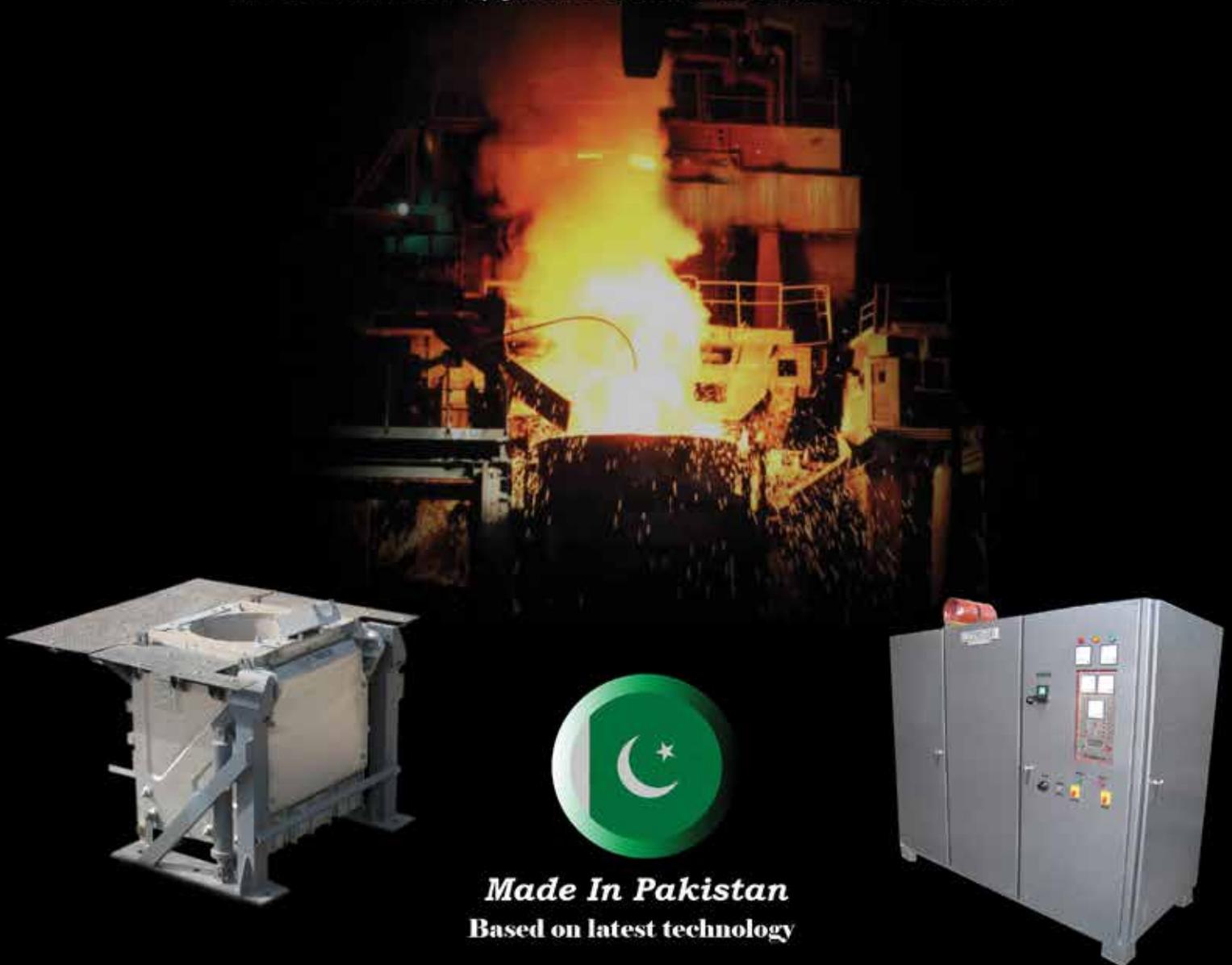
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Based on latest technology

Melting Capacity

Steel Frame Crucible: 10MT to 50MT

Yokeless Aluminum Crucible: 50kg to 10MT

Power Pack

Series Inverter: 50 kW to 900 kW

Parallel Inverter: 50 kW to 14000 kW

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Among our prestigious customers:

Bolan Castings Ltd, Karachi

Chenab Engineering Works and Foundries (Pvt) Ltd, Faisalabad

Friends Foundry (Pvt) Ltd, Islamabad

Qadri Brother (Pvt) Ltd, Lahore

