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Safety Precautions and Current Scenario: A perspective Approach for Indian Foundrymen

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Abstract

Metal Casting is the primary manufacturing process handled by foundrymen. Moulding, melting, Liquid metal pouring and fettling are the main jobs to perform. Generally, the temperature of the molten metal handled by the workers for nonferrous industry varies from 800-12000C and for ferrous it varies from 1600-20000C. So, safety precautions need

extensive care to perform such operations for ferrous and nonferrous both type of foundry need. Few fields visit was made to understand the working conditions of the skilled and unskilled foundrymen. Severities found in terms of process and manufacturing, health hazards and accidents during the production due to negligence of safety precautions and standards taken by the competent authority and also the socioeconomic background of the workers. The authors proposed and try to implement the basic safety requirement for the foundry industry.

Keywords: Safety Precautions, Foundry, Foundrymen, Metal Casting

Introduction

The foundry, steel, and metal casting industries are vital sectors in India, contributing significantly to economic growth. However, these industries are also associated with numerous risks, ranging from workplace accidents to environmental pollution. For the protection of both the environment and employees, safety laws and environmental requirements must be followed. Despite the presence of various laws and safety guidelines, compliance remains a challenge. Workers and employers often struggle to adhere to these rules due to factors such as lack of awareness, insufficient enforcement, or economic pressures. Therefore, it is imperative to not only enforce these rules but also make them widely popular and accessible to all stakeholders. This requires a combination of effective regulation, education, industry collaboration, and the creation of a safety-oriented culture that prioritizes the well-being of everyone involved [1].

Foundry clusters of India

India has several prominent foundry clusters spread across different states, catering to industries like automotive, railways, agriculture, and construction. These clusters are hubs for small, medium, and large-scale foundry units. Below is a list of major foundry clusters in India:

Coimbatore, Tamil Nadu

- **Specialization:** Automotive and pump castings.
- **Key Features:** Known as the "Pump City of India," Coimbatore houses around 1,500 foundries. It is a leading hub for precision castings and supplies extensively to the global market.

Rajkot, Gujarat

- **Specialization:** Diesel engine components, machine tools, and automotive parts.
- **Key Features:** Rajkot has a large concentration of small and medium foundries producing cast iron and ductile iron components.

Kolhapur and Sangli, Maharashtra

- **Specialization:** Automotive and tractor components.
- **Key Features:** Known for high-quality grey iron and ductile iron castings, Kolhapur is a major supplier to automobile manufacturers in India and abroad.

Belgaum (Belagavi), Karnataka

- **Specialization:** Automotive and industrial castings.
- **Key Features:** Known as the "Foundry Hub of Karnataka," Belgaum is home to numerous foundries catering to domestic and export markets.

Howrah, West Bengal

- **Specialization:** Engineering and industrial castings.
- **Key Features:** One of the oldest foundry clusters in India, Howrah specializes in cast iron products for railways and heavy engineering industries.

Ahmedabad and Bhavnagar, Gujarat

- **Specialization:** Ship-breaking yard castings, pumps, and valves.
- **Key Features:** Bhavnagar, known for ship recycling, also produces specialized castings for industrial applications.

Agra, Uttar Pradesh

- **Specialization:** Sanitary and agricultural castings.
- **Key Features:** Agra's foundries primarily produce cast iron components for agricultural equipment and infrastructure.

Ludhiana, Punjab

- **Specialization:** Bicycle components, machine tools, and auto parts.
- **Key Features:** Ludhiana is a key supplier of castings for engineering and automotive applications.

Jalandhar, Punjab

- **Specialization:** Hand tools, auto parts, and industrial castings.
- **Key Features:** Known for ductile iron and cast iron products.

Chennai, Tamil Nadu

- **Specialization:** Automotive and industrial castings.
- **Key Features:** Chennai’s proximity to major automobile manufacturers makes it a significant foundry hub.

Pune, Maharashtra

- **Specialization:** High-precision automotive and engineering components.
- **Key Features:** Pune is an emerging hub for advanced casting technologies.

Jaipur, Rajasthan

- **Specialization:** Sanitary and agricultural castings.
- **Key Features:** Jaipur's foundries cater to domestic and international markets.

Indore, Madhya Pradesh

- **Specialization:** Engineering and industrial castings.
- **Key Features:** Known for producing ferrous and non-ferrous castings.

Batala and Goraya, Punjab

- **Specialization:** Machine tools and industrial machinery.
- **Key Features:** These towns have a long history of foundry operations and are important suppliers for engineering industries.

Foundry Park, West Bengal

- **Specialization:** Modern casting technologies.

- **Key Features:** A government-backed initiative to develop a state-of-the-art foundry cluster near Kolkata.

India's Global Position

India is one of the largest producers of castings globally, exporting cast iron, ductile iron, and other metal castings to over 70 countries (Figure 1) [2, 3].

Fig.-1: Foundry Clusters in India

Understanding the problem: Field visit

A field visit was done at Howrah foundry cluster of both ferrous and no ferrous foundry to understand the problems regarding safety and precautions.The condition of workers and working conditions are shown in figures 2 and 3.

(a) (b)

Fig.-2: Current Scenario for Non-Ferrous Foundry (a) Pattern making with bare hand, (b) Liquid Metal Pouring without precaution

(a) (b)

Fig.-3: Current Scenario for Ferrous Foundry(a) Melting of CI in Furnace, (b) Liquid Metal Pouring

Accidents in Foundry Industry for last decade:

Over the past decade, India's foundry industries (including steel industry) have witnessed several significant accidents. Below is a list of notable incidents, along with their details and references:

Visakhapatnam Steel Plant Explosion (2012):

- **Date:** June 13, 2012
- **Location:** Visakhapatnam, Andhra Pradesh
- **Description:** A massive explosion during a trial run of a newly commissioned oxygen plant resulted in 19 fatalities.

Bhilai Steel Plant Gas Leak (2014):

- **Date:** June 12, 2014
- **Location:** Bhilai, Chhattisgarh
- **Description:** A gas leak resulted in the deaths of six individuals, including two senior officials, and affected over 50 others. The incident was attributed to a breakdown in the water pump house, causing carbon monoxide to leak into the premises.

Visakhapatnam Steel Plant Gas Leak (2014):

- **Date:** June 16, 2014
- **Location:** Visakhapatnam, Andhra Pradesh
- **Description:** Two engineers were fatally injured in a suspected case of carbon monoxide poisoning.

Visakhapatnam Steel Plant Explosion (2014):

- **Date:** November 7, 2014
- **Location:** Visakhapatnam, Andhra Pradesh
- **Description:** A minor explosion occurred in Blast Furnace II; fortunately, there were no casualties.

Visakhapatnam Steel Plant Accident (2015):

- **Date:** February 12, 2015

- **Location:** Visakhapatnam, Andhra Pradesh
- **Description:** An assistant general manager died after falling into a rotating drum.

Bhilai Steel Plant Blast (2018):

- **Date:** October 9, 2018
- **Location:** Bhilai, Chhattisgarh
- **Description:** An explosion in a pipeline near the coke oven section led to 13 deaths and injuries to 14 others.

Visakhapatnam Steel Plant Explosion (2019):

- **Date:** January 18, 2019
- **Location:** Visakhapatnam, Andhra Pradesh
- **Description:** A hot metal pipe exploded in Blast Furnace Number 3. There were no casualties.

Kutch Steel Mill Incident (2023):

- **Date:** January 2023
- **Location:** Kutch, Gujarat
- **Description:** A mechanical fault in the melting shop caused molten metal to fall on workers, resulting in one death and six injuries.

Ahmedabad Foundry Accident (2023):

- **Date:** February 2023
- **Location:** Ahmedabad, Gujarat
- **Description:** A 32-year-old laborer died after molten metal fell on him; his brother was critically injured in the same incident.

These incidents highlight the critical importance of stringent safety protocols and regular maintenance in industrial operations to safeguard workers' lives [4-6].

Health issue of Foundrymen

Workers in the foundry industry are exposed to various hazardous substances and conditions that can lead to occupational diseases [7, 8]. Some of the prevalent illnesses and ailments linked to foundry work are listed below:

Respiratory Diseases:

- **Silicosis:** Caused by prolonged inhalation of silica dust, common in sand molding and grinding operations.
- **Chronic Obstructive Pulmonary Disease (COPD):**caused at foundries by exposure to gases, fumes, and dust.
- **Asthma:** Triggered by inhalation of chemical fumes, metal dust, and other irritants.

Skin Diseases:

- **Contact Dermatitis:** Caused by exposure to chemicals, resins, or oils used in molds and casting processes.
- **Skin Burns:** Due to splashes of molten metal or contact with hot surfaces.

Hearing Loss:

- **Noise-Induced Hearing Loss (NIHL):** caused by extended exposure to loud mechanical, grinding, and molding equipment noise levels.

Musculoskeletal Disorders (MSDs):

- Conditions like back pain, repetitive strain injuries, and joint problems due to heavy lifting, repetitive movements, and awkward postures.

Eye Disorders:

- **Conjunctivitis and Corneal Damage:** From exposure to infrared radiation, flying particles, or sparks during metal pouring and grinding.

Metal Poisoning:

- **Lead Poisoning:** From exposure to lead fumes or dust in alloys and paints.
- **Manganism:** Caused by excessive exposure to manganese fumes during welding or casting.

Cancer Risks:

- **Lung Cancer:** Linked to prolonged exposure to carcinogenic substances like polycyclic aromatic hydrocarbons (PAHs) from furnace emissions.
- **Skin Cancer:** because of extended exposure to ultraviolet (UV) light.

Heat-Related Illnesses:

- **Heat Stress, Heat Exhaustion, and Heat Stroke:** Caused by working in high-temperature environments near furnaces.

Cardiovascular Diseases:

- Due to exposure to carbon monoxide and other toxic gases, which may impair oxygen transport in the blood.

Mental Health Issues:

- **Stress and Fatigue:** Resulting from high workloads, shift work, and hazardous working conditions.

Preventive Measures

Use of Personal Protective Equipment (PPE):

- Respirators to prevent inhalation of dust and fumes.
- Heat-resistant gloves, clothing, and face shields to avoid burns.
- Ear protection (earplugs or earmuffs) to reduce noise exposure.

Proper Ventilation Systems:

- Ensure adequate air circulation to reduce airborne contaminants.

Regular Health Monitoring:

- Routine medical checkups to detect early signs of occupational diseases.

Worker Training and Education:

- Train workers to identify hazards and use safety protocols effectively.

Ergonomic Work Practices:

- Promote proper lifting techniques and provide tools to reduce physical strain.

Hydration and Breaks:

- Ensure workers stay hydrated and take regular breaks in cool areas to prevent heat stress.

Lapses in responsibility by the foundry management

Foundry owners may sometimes be reluctant to fully comply with rules and regulations due to several underlying reasons. Here are some common factors:

Cost Implications

- **High Compliance Costs:** Implementing safety measures, pollution control equipment, and proper waste disposal systems often involves significant investment. Small and medium-sized foundries may find these costs burdensome.
- **Short-Term Focus:** Owners may prioritize immediate profits over long-term compliance benefits, viewing regulatory adherence as an unnecessary expense.

Lack of Awareness

- **Limited Knowledge:** Many foundry owners, especially in smaller units, may lack awareness of legal requirements or the consequences of non-compliance.
- **Inadequate Training:** A lack of training in modern safety practices and environmental standards can lead to unintentional violations.

Weak Enforcement Mechanisms

- **Inconsistent Inspections:** Regulatory inspections may be infrequent or not rigorous enough, leading to a sense of complacency among owners.
- **Corruption:** In some cases, owners may bypass compliance by paying bribes to inspectors or authorities.

Competitive Pressure

- **Cost Cutting:** In highly competitive markets, owners may cut corners on safety and environmental measures to keep production costs low and maintain competitive pricing.
- **Informal Sector Dominance:** In many regions, informal foundries operate outside the regulatory framework, creating an uneven playing field for compliant businesses.

Limited Resources

- **Small-Scale Operations:** Many foundries in India are small or medium-sized enterprises (SMEs) with limited financial and technical resources to invest in compliance.
- **Difficulty Accessing Technology:** Advanced pollution control and safety equipment may be expensive or unavailable in local markets.

Resistance to Change

- **Traditional Practices:** Owners may rely on outdated practices and resist adopting modern, safer, and more efficient methods.
- **Fear of Disruption:** Implementing changes to comply with regulations might disrupt production schedules, leading to hesitation [9].

Perceived Lack of Immediate Benefits

- **Low Priority for Safety:** Owners might not perceive an immediate benefit from compliance, especially in the absence of accidents or visible environmental impacts.
- **Short-Term Thinking:**The long-term benefits of following regulations are frequently overshadowed by a focus on short-term profitability.

Socioeconomic Factors

- **Worker Exploitation:** In areas with high unemployment, workers may not demand safer conditions, allowing owners to ignore regulations.
- **Community Tolerance:** Local communities may tolerate non-compliance if the foundry provides employment, reducing pressure on owners to comply.

Consequences of Non-Compliance

- Environmental degradation, occupational hazards, accidents, legal penalties, and reputational damage. Despite these risks, the factors above often outweigh the perceived benefits of compliance.

How to Encourage Compliance:

- **Awareness Programs:** Educating owners about the benefits of compliance and legal consequences of violations.
- **Subsidies and Incentives:** Providing financial support for pollution control equipment and safety measures.
- **Strict Enforcement:** Regular and transparent inspections with stringent penalties for violations.
- **Access to Technology:** Facilitating affordable access to modern equipment and best practices.

By addressing these challenges, governments and industry associations can work towards improving regulatory compliance in the foundry sector.

Lapses in attention to duty by the foundry worker

Foundry workers may sometimes be reluctant to follow safety rules and regulations for various reasons, including lack of awareness, economic pressures, and workplace culture. Below are some common factors:

Lack of Awareness

- **Insufficient Training:** Workers may not fully understand the importance of safety regulations or how to implement them.
- **Illiteracy or Language Barriers:** Some workers, particularly in smaller foundries, may not be able to read or understand safety manuals or guidelines.
- **Ignorance of Risks:** Workers may underestimate the dangers of exposure to hazardous materials, poor ventilation, or unsafe practices.

Economic Pressures

- **Daily Wage Dependency:** Many foundry workers are daily wage laborers who prioritize completing tasks quickly over following safety rules.
- **Fear of Losing Income:** Workers may avoid using protective gear or following time-consuming safety measures to avoid delays and maintain productivity.

Inadequate Safety Infrastructure

- **Poor Quality Equipment:** Employers may not provide adequate or functional personal protective equipment (PPE), such as gloves, masks, or helmets.
- **Lack of Proper Facilities:** Absence of proper ventilation, clean drinking water, or first-aid facilities discourages workers from following safety practices.

Workplace Culture

- **Lax Attitude:** In some foundries, safety rules are not enforced, creating a culture where unsafe practices are normalized.
- **Peer Pressure:** Workers may feel pressured to ignore rules to match the speed and efficiency of colleagues who do not follow them.
- **Negative Reinforcement:** If managers or supervisors overlook unsafe behavior or punish workers for slowing down due to safety precautions, compliance decreases.

Lack of Incentives

- **No Rewards for Compliance:** Workers may feel no tangible benefits from following rules, such as incentives or recognition.
- **Focus on Output:** Emphasis on meeting production targets often overshadows safety concerns.

Discomfort or Inconvenience

- **Uncomfortable PPE:** Workers may find protective gear uncomfortable, especially in the hot and humid conditions of a foundry.
- **Slows Down Work:** Following safety protocols can slow down operations, making workers less inclined to comply.

Fear and Mistrust

- **Mistrust of Management:** Workers may perceive safety rules as a way for management to impose more control rather than genuinely protect them.
- **Fear of Reporting Issues:** Workers may fear retaliation or job loss if they report unsafe conditions or refuse to work in hazardous environments.

Lack of Enforcement

- **Inconsistent Monitoring:** If supervisors do not strictly enforce rules or allow violations, workers are less likely to follow them.
- **No Consequences for Non-Compliance:** Without penalties for breaking rules, workers may not take them seriously.

Habitual Neglect

- **Resistance to Change:** Long-time workers may resist adopting new safety practices, preferring to stick to familiar methods.
- **Desensitization to Hazards:** Regular exposure to risky environments may lead workers to become complacent about potential dangers.

How to Improve Compliance among Workers:

- **Regular Training:** Conduct frequent and practical training sessions on safety practices and risks.
- **Improve Workplace Safety:** Provide high-quality PPE, proper facilities, and a safe working environment.
- **Incentivize Safety:** Introduce rewards or recognition programs for following safety protocols.
- **Foster a Safety Culture:** Promote a workplace culture where safety is a shared priority for both management and workers.
- **Strict Enforcement:** Supervisors should monitor compliance and enforce rules consistently.
- **Effective Communication:** Use clear and accessible language to explain rules and their importance to workers.

By addressing these issues, foundries can encourage workers to prioritize safety and adhere to the necessary rules.

Safety measures by Govt. of India

The Government of India has established comprehensive regulations and guidelines to ensure the safety, health, and environmental compliance of foundry and steel plants. Below is an overview of key regulations and guidelines governing these industries:

Safety Guidelines for the Iron & Steel Sector

The Ministry of Steel has formulated 25 safety guidelines addressing specific activities and hazards in both large and small steel industries. These guidelines aim to promote safe practices and mitigate risks associated with steel manufacturing processes.

Occupational Health and Safety Requirements for Foundries

Foundry operations are subject to stringent occupational health and safety standards, which include:

- **Cleanliness:** Maintaining a clean work environment to prevent accidents and health hazards.
- **Waste Disposal:** Proper disposal of waste and effluents to minimize environmental impact.
- **Ventilation:** Ensuring adequate ventilation to control heat, dust, and fumes, thereby safeguarding workers' respiratory health.
- **Lighting:** Providing sufficient lighting to facilitate safe operations.
- **Drinking Water:** Availability of clean drinking water for workers.
- **Overcrowding Prevention:** Avoiding overcrowding in workspaces to reduce the risk of accidents.
- **Artificial Humidification:** Implementing measures to control humidity levels, where necessary.

These measures are designed to protect workers from occupational hazards prevalent in foundry environments.

Environmental Regulations

The following environmental laws are enforced by the Central Pollution Control Board (CPCB) and State Pollution Control Boards (SPCBs) and apply to foundries and steel plants:

- In order to reduce air pollution, the **Air (Prevention and reduce of Pollution) Act** of 1981 regulates emissions.

- In order to combat water pollution, the **Water (Prevention and Control of Pollution) Act** of 1974 regulates effluent discharge.

- The **1986 Environment (Protection) Act** establishes a framework for hazardous material regulation and environmental protection.

Compliance with these acts ensures that foundry and steel operations minimize their environmental footprint [10].

Factories Act, 1948

This act lays down the legal framework for occupational safety, health, and welfare in manufacturing establishments, including foundries and steel plants. Key provisions include:

- **Safety Measures:** Mandates the installation of safety equipment and adherence to safe working practices.
- **Health Provisions:** Requires measures to prevent occupational diseases and maintain hygiene.
- **Welfare Provisions:** Ensures facilities like restrooms, canteens, and first-aid appliances are available to workers.

Adherence to the Factories Act is crucial for the lawful and ethical operation of foundry and steel plants.

Production Linked Incentive (PLI) Scheme for Specialty Steel

The Government has introduced the PLI Scheme to promote the domestic manufacturing of specialty steel and reduce imports. The scheme anticipates an additional investment of approximately ₹29,500 crores and aims to create around 25 million tonnes of specialty steel capacity.

Methodologies for optimizing rule implementation and dissemination

To effectively implement and popularize rules and regulations in the foundry, steel, and metal casting industries, a comprehensive approach is required. This involves creating awareness, ensuring enforcement, and fostering a culture of safety and compliance. Below are key strategies to achieve this:

Awareness Campaigns

- **Training Programs:**
  Conduct regular training sessions for workers, supervisors, and employers to ensure they understand the rules, their importance, and the consequences of non-compliance. These programs should cover safety standards, environmental laws, and workers' rights.
    - Use hands-on demonstrations to show the correct safety practices.

- Include information on how compliance can improve health, safety, and productivity.

- **Worker Education:**
  Implement education initiatives that target the workers directly, especially in regions where awareness is low. Use visual aids, posters, and signage in local languages to communicate safety protocols clearly.

- **Industry Workshops and Seminars:**
  Organize workshops with experts, including government representatives, environmentalists, and industry veterans, to educate foundry owners and workers about the latest regulations and best practices.

- **Digital Media Campaigns:**
  Use social media, websites, and apps to spread awareness of key safety rules, environmental compliance, and workers' rights. Interactive content like videos, infographics, and quizzes can engage the audience more effectively.

Government and Industry Collaboration

- **Government Initiatives:**
  The government should take the lead in creating awareness and pushing for compliance through media campaigns, advertisements, and outreach programs. They can also provide incentives for foundries that adopt safe and sustainable practices.

- **Industry Associations' Role:**
  Industry associations such as the Indian Foundry Association (IFA) can play a crucial role in disseminating information, providing guidelines, and offering training programs to its members.

- **Partnerships with NGOs and Educational Institutions:**
  Collaboration with NGOs and academic institutions can help spread awareness about the importance of compliance and its benefits, especially in rural or less developed areas.

Incentivizing Compliance

- **Certification Programs:**
  Introduce certifications for foundries and steel plants that comply with safety, environmental, and quality standards. These certifications can be used to promote businesses that follow best practices.
    - For example, the ISO certification for quality and safety standards can be a motivator.

- **Financial Incentives:**
  Offer subsidies, tax rebates, or funding support for businesses that invest in improving safety measures, pollution control equipment, or worker welfare.

- **Rewards and Recognition:**
  Implement programs that recognize and reward companies and workers who consistently adhere to rules and regulations. Annual awards, public recognition, and media exposure can encourage others to follow suit.

Strict Enforcement and Monitoring

- **Regular Inspections:**
  Ensure frequent inspections and audits by authorities to monitor compliance. Inspectors should be adequately trained and empowered to enforce the regulations and impose fines when necessary.

- **Use of Technology:**
  Implement digital tools such as sensors and monitoring systems in workplaces to track emissions, waste disposal, and worker safety in real-time. This data can be used to assess compliance and make informed decisions.

- **Transparency in Penalties:**
  Clearly communicate the consequences of non-compliance and ensure that penalties for violations are strictly imposed. Make sure there are no loopholes or leniency for violators.

- **Whistleblower Mechanisms:**
  Encourage workers to report unsafe practices or non-compliance anonymously by offering protection from retaliation. This can help uncover violations that are not visible to authorities.

Foster a Safety Culture

- **Leadership and Commitment from Employers:**
  Foundry owners and managers must set the tone by actively promoting safety and compliance. When leaders prioritize safety, it signals to workers that the rules are essential.

- **Worker Involvement:**
  Encourage workers to take ownership of safety practices by involving them in decision-making, safety audits, and suggesting improvements. Workers who are engaged in the process are more likely to follow the rules.

- **Continuous Improvement Culture:**

Establish a culture of continuous improvement where compliance is not seen as a one-time effort but an ongoing process. Regular feedback sessions and discussions about safety and regulations can keep the workforce engaged.

Simplify Regulations

- **Clear and Concise Rules:**
  Ensure that rules and regulations are easy to understand and do not overwhelm foundry owners or workers. They should be straightforward, using simple language and practical examples.

- **Localized Guidelines:**
  Adapt the rules to the local context, especially for smaller or informal foundries. Create region-specific guidelines to address local challenges and resources.

- **Online Resources and Help Desks:**
  Provide online portals or helplines where industry players can easily access information, ask questions, or get guidance on compliance. This will encourage better understanding and adherence.

Collaboration with Media

- **Media Partnerships:**
  Collaborate with news outlets, radio stations, and local TV channels to spread awareness about the importance of regulatory compliance in foundries and steel plants.

- **Public Service Announcements:**
  Broadcast PSAs that highlight the benefits of adhering to safety standards, environmental regulations, and worker welfare practices.

Continuous Research and Development

- **Innovation in Safety Measures:**
  Encourage the development of innovative technologies and safety practices that make compliance easier and more affordable for foundries and steel plants.

- **Collaboration for Best Practices:**
  Promote sharing of best practices through industry conferences, trade fairs, and collaborative platforms, so businesses can learn from each other.

By combining awareness, incentives, strong enforcement, and industry-wide collaboration, rules and regulations can be effectively implemented and popularized in the foundry, steel, and metal casting industries. Fostering a culture of safety and compliance requires a long-

term, multi-faceted approach involving both government action and active participation from industry stakeholders.

Conclusion

The implementation and popularization of safety and regulatory compliance in the foundry, steel, and metal casting industries in India require a multifaceted approach. It is not only about enforcing rules but also about creating an environment where awareness, responsibility, and a culture of safety thrive at all levels.

Key takeaways include:

Awareness and Education: Continuous training, clear communication, and awareness campaigns are vital for both employers and workers to understand the importance of compliance. When workers, supervisors, and owners are educated on the risks and benefits of adhering to regulations, the likelihood of compliance increases.

Government and Industry Collaboration: Effective collaboration between the government, regulatory bodies, and industry associations can create a strong framework for compliance. Government incentives and industry-led workshops can foster a collective effort toward ensuring safe and environmentally friendly practices.

Incentivization and Recognition: Offering financial incentives, rewards, and certifications for complying with safety and environmental standards can motivate industries to follow the rules. Positive reinforcement, alongside penalties, can drive better outcomes in the long run.

Strict Enforcement: Regular inspections, use of technology for monitoring compliance, and clear penalties for violations are crucial for holding industries accountable. Transparency and strict enforcement prevent complacency and make it clear that non-compliance has real consequences.

Fostering a Safety Culture: A culture of safety must be embedded into the daily operations of a foundry or steel plant, starting from leadership. In addition to protecting employees, employers who put safety and compliance first also increase long-term sustainability and overall productivity.Worker involvement in safety audits and decision-making processes ensures that safety is viewed as a shared responsibility.

Simplified Regulations and Support: To make compliance achievable, regulations must be clear, accessible, and tailored to the specific needs of foundries of all sizes. Simplified rules and online resources can help make compliance less burdensome.

The path to widespread regulatory adherence in India's foundry and steel industries lies in a combined effort of education, regulation, incentivization, and cultural change. If these elements are executed thoughtfully, the industry can move towards safer, more compliant, and environmentally responsible practices.

Reference:

1. Mgonja CT. A review on effects of hazards in foundries to workers and environment. Int J Innov Sci Eng Technol. 2017;4(6):326-34.
2. Santhipushan R. Hazard identification and risk assessment in foundry. *Int J Nov Res Dev*. [Internet]. [cited 2025 Mar 7].
3. Ulewicz R, Novy F, Dwornicka R. Quality and work safety in metal foundry. *Metal Conference Proceedings*. 2020 May 20-22; Brno, Czech Republic.
4. Khanpara K. Occupational health and safety requirements for foundry and construction workers in India. *Int J Dent Med Sci Res*. 2022;4(1):360-5.
5. Roy S, Debnath S, Datta PK, Pramanick AK. Investigation of Dhokra Casting in Light of Modern Engineering Technique. Journal of Mines, Metals and Fuels. 2023 Nov 30:2348-57.
6. Gokulakrishnan G, Balamurugan M. Workplace safety and health conditions in small-scale foundries. *Int J Res Publ Rev*. [Internet]. [cited 2025 Mar 7].
7. Rashtriya Ispat Nigam. *Wikipedia*. [Internet]. [cited 2025 Mar 7]. Available from: https://en.wikipedia.org/wiki/Rashtriya_Ispat_Nigam
8. Ministry of Steel, Government of India. Safety guidelines in the iron and steel sector. [Internet]. [cited 2025 Mar 7]. Available from: https://steel.gov.in/en/safety/safety-guidelines-iron-steel-sector
9. Press Information Bureau, Government of India. Safety measures in the steel industry. [Internet]. [cited 2025 Mar 7]. Available from: https://pib.gov.in/PressReleaseIframePage.aspx?PRID=2037429
10. iPleaders. Occupational health and safety requirements. *iPleaders Blog*. [Internet]. [cited 2025 Mar 7]. Available from: https://blog.ipleaders.in/occupational-health-safety-requirements/