**Theme 1: <u>Blast Furnace Ironmaking</u>**

**Title of the problem:** Enhancement of pig iron production using high alumina iron ore.

**Industry concerned:** Indian Iron and Steel plants

**Brief description of the problem:**

Generally, Indian iron ore has high alumina content. Due to the presence of high alumina in Indian iron ore, there are several operational difficulties during BF iron making such as (i). Higher operating temperature (ii). Higher liquidus temperature of BF slag. (iii). higher coke rate. (iv). high slag volume. In an integrated steel plant, molten iron from the blast furnace is transferred to the steel melting shop (SMS) after adopting external refining treatment i.e., either desulphurisation or desiliconisation. Adoption of desulphurisation or desiliconisation treatment to molten iron depends upon the acidic and/or basic gangue minerals present in the iron ore.

**Challenges faced primarily:**

Alumina is a refractory oxide (gangue mineral) in Indian iron ore that increases the liquidus temperature of the BF slag and consequently BF operating temperature goes up. Coke rate is also increased due to higher alumina in iron ore**.**

**Critical questions to be answered:**

1) While using high $Al_2O_3$ iron ore used as a raw material in BF, which of the following refining reaction is favored i) desulphurisation or ii) desiliconisation? and explain how?

2) While using high $Al_2O_3$ iron ore used as a raw material in BF, which external refining treatment needs to be adopted ? Explain why?

3) How to control the liquidus temperature of the BF slag and hot metal for smooth running of BF operation during usage of high $Al_2O_3$ iron ore as a raw material in BF?

4) Explain the basic burdening of a blast furnace with external desiliconisation and acid burdening of blast furnace with external desulphurization w.r.t to the presence of high alumina in Indian iron ore.

**Theme 2: Mineral Beneficiation and Fines Processing**

**Title of the problem:** Physical beneficiation of ores at fine to ultra-fine size range

**Industry concerned:** Mineral beneficiation industries

**Brief description of the problem:**

As the good grade ores are exhaustible, the dependence on low grade ores to meet the growing global demand in the mineral industry is increasing day by day. This usage of lean grade ores necessitates a decrease in liberation size which leads to generation of fines (with particles less than 20 to 5 microns size). These fines are often difficult to beneficiate using conventional techniques.

**Challenges faced primarily:**

Conventional gravity separation, flotation, magnetic separation can't be applied for this size range of beneficiation.

**Critical questions to be answered:**

1) What modifications can be done in the existing separation systems so that they can accommodate beneficiation in this fine to ultra-fine size range?
2) What types of forces are dominant in such fine size ranges?
3) What are the major factors which hinder in applying conventional separators to beneficiate the ultra-fine size particle beneficiation?
4) Any rough conceptual idea how a new system may work for beneficiation of ultra-fine particle beneficiation?
5) What makes ultra-fine particle behavior different in fluids than coarser size particle?

**Theme 3: Metallurgical Waste Handling**

**Title of the problem:** Red mud: Problem and solutions

**Industry concerned:** Alumina industries (NALCO, HINDALCO, JSW, VEDANTA)

**Brief description of the problem:**

Red mud is a byproduct of the Bayer process, an industrial procedure which extracts alumina from bauxite ore. Alumina, also known as aluminium oxide, is most often used in the industrial production of aluminium. The mud is given its characteristic red colour through its high concentration of iron oxide.

The Bayer process produces around twice as much red mud as alumina, and around 120 million tonnes of red mud are created each year around the world. More than 4 million tons of red mud is generated annually in India only. Red mud is highly alkaline, making it dangerous to handle, and difficult to dispose of. Instead, it is most often kept in large open-air holding ponds.

**Challenges faced primarily:**

Nowadays, the industrialists are getting more concerned about the production of cleaner residue in the aluminium industry. The main environmental risks associated with bauxite residue are related to high pH and alkalinity and minor and trace amounts of heavy metals and radionuclides. During monsoons, the waste may be carried by run-off to surface water courses and cause ground water contamination due to leaching. The disposal of red mud is a major problem in alumina plants throughout the world depending on the facilities available and the surroundings. Red mud is either stored as red mud ponds, or in dry landfills. A systematic effort has to be made to improve the present methods of disposal with the growing concern for environmental protection and land conservation.

**Critical questions to be answered:**

1) Methods of green utilization of red mud, so that alumina industries end up with no residue at all. Explain any procedures if possible.
2) Techniques/ways to reduce red mud generation.
3) What is carbonized red mud? How can it be used to treat water contaminated with metals such as copper and lead?
4) Has any Indian Aluminum industry commissioned any red mud processing unit? If yes, then how are they utilizing red mud?

**Theme 4: Advanced Functional Materials**

**Title of the problem:** Development of low core loss electrical steels

**Industry concerned:** Automation and Sensor Development Industry

**Brief description of the problem:**

The advent of IoT, automation, electric mobility has created huge demand for Electrical steels (both isotropic and anisotropic) having soft-magnetic properties. The soft magnetic property of a material increases with minimization of hysteresis and eddy current losses. The Fe-3 wt % Si steel is widely adopted in the form of CRGO and CRNO type steels. One of the major limitation of these Silicon Steels is their suitability for operation at high frequencies (500 Hz and above), due to large eddy current and anomalous core losses. The eddy current and anmolous lossess can be reduced by either reducing sheet thickness (presently 0.23 mm) or increasing electrical resistivity.

**Challenges faced primarily:**

The Silicon steels are usually susceptible to embrittlement during cold rolling for further thickness reduction and that is the primary reason behind the industrial limitation of an achievable thickness level of 0.23 mm. Also the entire processing schedule for development of silicon steel is highly precise and complicated.

**Critical questions to be answered:**

1) How can the thickness be further reduced through conventional thermo-mechanical route? State the major constraints and suggestions.
2) Suggest any other novel production/manufacturing techniques for a reduced thickness.
3) Can any other element replace Si without deteriorating soft-magnetic properties, If, so name it and state the basis on which the element has been chosen?

**Theme 5: <u>BOF Steelmaking</u>**

**Title of the problem: <u>Treatment and utilizing BOF/LD slag</u>**

**Industry concerned:** Steel plants (TATA, ESSAR, JSW, SAIL etc)

**Brief description of the problem:**

BOF steelmaking involves removal of impurities present in hot metal such as Si, Mn, P and C in oxide form in the presence of oxidation atmosphere. It generates huge amount of slag primarily consists of CaO, SiO2, Al2O3, MgO, FeO, and P2O5. Phosphorus removal during steelmaking requires both basic and oxidation atmosphere. Therefore, generation of basic and oxidizing slag is inevitable in the steelmaking process, to meet the need of low phosphorous steel (<0.015%) for critical application.

**Challenges faced primarily:**

Higher content of P along with iron limits its usage in metallurgical processes. It is presently used as land filling material, however due to its weathering expansion, it creates environmental problem. It is also not used in cement industry due to high iron content and weathering expansion. Therefore, it requires dephosphorization for effective utilization in metallurgical processes. Carbothermic reduction of BOF slag can remove P, but, almost all P goes to the produced metal which has no further use.

**Critical questions to be answered:**

1) Ways to reduce the generation of BOF/LD slag during steelmaking? Explain.

2) Can any novel process be developed for selective removal of P from BOF/LD slag? Explain.

3) Can it be used for other purpose? State How?

**Theme 6: <u>Advanced Engineering Materials</u>**

**Title of the problem: <u>Difficulty in joining ultrahigh strength steel – 'Raising the bar'</u>**

**Industry concerned:** Steel, Mining and Cement industries

**Brief description of the problem:**

A lot of attention has been paid on development of ultrahigh strength steel (UHSS) grades for different applications, viz., automotive, wear-resistant, aerospace etc. Some of these grades are quenched and tempered steels, TWIP and TRIP steels. However, any steel for its use in any component needs to be joined. Joining by spot welding and laser welding has been studied extensively for sheet metals but joining the UHSS plates by conventional MIG welding is much more complex due to the requirement of suitable filler wire. Most of the commercially available filler wires can not achieve the strength of the joint beyond 800-1000 MPa despite reducing the heat input of the process. This effectively limits the application of the joined component to stresses almost 50-70 % of the strength of the base metal.

**Challenges faced primarily:**

Lower strength of the joint can lead to the failures from the weld under static or cyclic loading. Furthermore, often, there is a reduction in the impact toughness of the heat-affected zone. Challenge is to come up with the joint strength similar to that of the UHSS, say 1500 MPa or greater.

**Critical questions to be answered:**

1) What is the maximum reported strength of the joint using conventional MIG welding process? Extensive literature review is expected.

2) What can be done to increase the strength level of the joint?

3) Does increasing the tensile strength guarantee a successful use under service condition?

4) Which is a better approach: to develop new welding filler wires or to optimize the welding parameters using the existing available electrode wires?

# General Rules of Industrial Problem Solving (IPS) Contest

The primary objective of the "Industrial Problem Solving (IPS) Contest" in BTTD 2019 is to inculcate industrial exposure as well as the multitasking ability such that the young engineers would meet the present industrial demand.

**Rules:**

1. Industrial problems are invited from several metallurgical industries and few potential industrial problems have been selected.
2. The problems statements are available online now at bttd.nmlindia.org, for the participants to work on it. These problem statements are with respect to the various themes which were decided and uploaded in the website earlier (under the 'BTTD 2019 Flyer for Industrial Problem Solving').
3. All the participants are requested to go through the problem statements thoroughly and prepare for any one of the given problems.
4. The participants will have to specify the problem which they will be attempting to address in the IPS contest, at the time of registration.
5. The attempt towards solution of the problem has to be undertaken individually or in a group of maximum two (as per the decision of Judges).
6. The contest will be evaluated based on depth of understanding about the particular problem, related basics, feasibility of the solution to adopt in industries, team work, communication/presentation skills and timing.
7. **The "BEST SOLUTION AWARD" for the IPS contest will be given to one student/group of two students.**

Student participants are requested to feel like they are employed in the industries and you are asked to solve the problem by your company top management.

**About the IPS contest on 6th September 2019:**

1. Contest will take place in NML auditorium from 14:30 to 16:30 Hrs on 6th September 2019.
2. Contest involves two rounds.

   i) Technical Group discussion (GD), which will be moderated by Scientists and Research Experts from NML and TATA Steel Ltd. Here the participants will have an opportunity to showcase and refine their ideas pertaining to the choice of industrial problem which they mention at the time of registration. The focus of the moderators will be on assessing the novelty, depth of understanding of the problem, presentation skills and conduct of the participants during the GD. From this round only one participant or a group of participants (maximum 2) will proceed to the final stage round depending upon the moderator's scores. The decision of the moderators will be the final decision of this round. **(Allotted Time: 25 minutes of GD + 5 minutes decision time for judges)**

   ii) Stage round where the winners from GD round will explain their solution in front of a senior expert panel from industry and R&D. The participants in this round have to give a brief description of their solution in a crisp and convincing manner. Here the assessment will be of the technical novelty, industrial aptitude, understanding of feasibility, presentation skills and sense of timing. Based upon the scores of judges from the expert panel, one winner of the stage round (out of all stage round participants) will be awarded **'The Best Solution award'** of IPS – 2k19 contest.

   **(Allotted Time for each stage round participant: 7 minutes of explanation + 3 minutes of questionnaire)**


Meet you at BTTD
2019