Project Based Report on

OPTIMIZING INVENTORY MANAGEMENT IN FOUNDRY

A report submitted as a part of the vocational training in foundry (ES&F), Rashtriya Ispat Nigam Limited, Visakhapatnam Steel Plant

By:

DEEP NARAYAN: 100022187

Under the esteemed guidance of
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Rashtriya Ispat Nigam Limited (RINL)
(Duration: 5th June 2023 to 1st July 2023)

Certificate

This is to certify that the following student of **National Institute of Technology Durgapur**, *was actively engaged in the project work titled* **Optimizing Inventory Management in Foundry**.

DEEP NARAYAN: 10022187

In partial fulfillment of the degree of **Bachelor of Technology** *in* **Department of Metallurgical and Materials Engineering** *in* **National Institute of Technology Durgapur, West Bengal**. *This is a record of bonafide work carried out by him under my guidance and supervision during the period from 5th June 2023 to 1st July 2023.*

Date: 1st July 2023
Place: Visakhapatnam

30/06/23
Mr. K. KRISHNA PRASAD
Deputy General Manager (DGM)
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RINL-VSP

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Company Profile

Rashtriya Ispat Nigam Ltd (RINL), commonly known as Vizag Steel, is a central public sector undertaking owned by the Ministry of Steel, Government of India, and located in Visakhapatnam, India. RINL represents the government entity of Visakhapatnam Steel Plant (VSP), which is India's first shore-based integrated steel plant built with advanced technology. VSP has a production capacity of 7.3 million tons per annum (MTPA). Originally commissioned in 1992 with a capacity of 3.0 MTPA, the company subsequently completed capacity expansions to 6.3 MTPA in April 2015 and 7.3 MTPA in December 2017.

RINL is a government-owned entity, fully controlled by the Government of India. In recognition of its achievements, the company was granted Navratna status by the Government of India in November 2010.

The steel plant operated by RINL has a capacity of 7.3 million tons per annum in Visakhapatnam. Although the company initially faced substantial losses, it has since witnessed a significant improvement in profitability, with profits increasing by 200%. This remarkable growth sets it apart as the only steel industry to achieve such a target. By the year 2020, RINL's annual capacity reached nearly 7.5 million tons. As part of its future plans, RINL aims to invest ₹60,000 crore (US$7.5 billion) to further expand its capacity to 20 million tons by 2027.

The Plant is an epitome of technological marvel crafted in nature’s lap, where environment sustenance comes first and a tree is grown for every metric ton of production capacity added. The residential township is unique of its kind with dense foliage, beautiful parks, wide roads and provides all modern amenities within the vicinity.

Departments:

- Raw material handling plant (RMHP)
- Coke Oven & Coal Chemical Department (C & CCD)
- Sinter Plant (SP)
- Calcining & Refractory Material Plant (CRMP)
- Blast Furnace (BF)
- Steel Melting Shop (SMS)
- Light and Medium Merchant Mill (LMMM)
- Medium Merchant and Structural Mill (MMSM)

- Wire Rod Mill (WRM)
- Special Bar Mill (SBM)
- Roll Shop & Repair Shop (RS & R Ss)
- Power Generation and Distribution
- Water Treatment Department
- Traffic Department
- Engineering Shops & Foundry
- Utilities Department

Engineering Shops & Foundry

Engineering Shops & Foundry department is set up to meet the requirements of spares, repair of assemblies and reclamation of various jobs of different departments. This complex consists of:

- Central Machine Shop (CMS)
- Steel Structural Shop (SSS)
- Foundry
- Forge Shop (FS)
- Utility Equipment Repair Shop (UERS).

CENTRAL MACHINE SHOP (CMS):

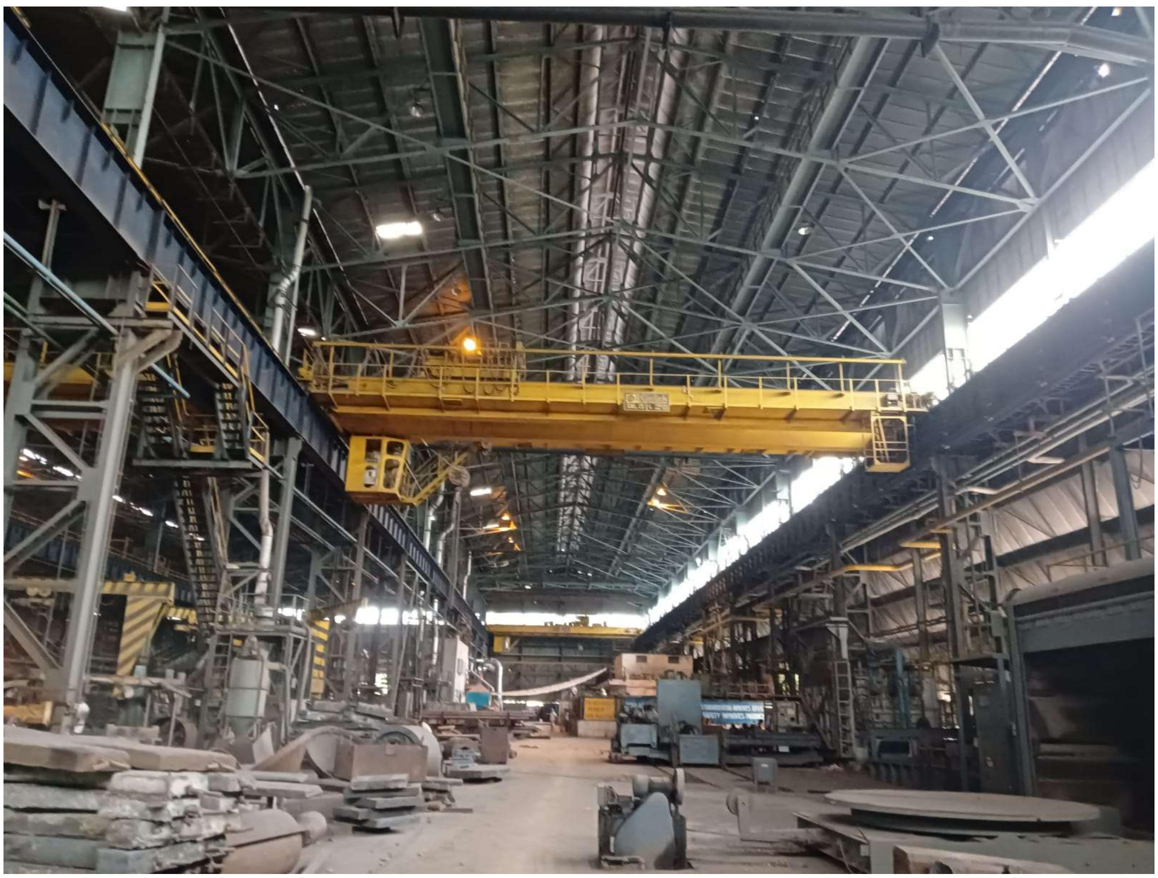
In Central machine shop, various spares like Gears, Shafts, Crusher liners, hammers, machined castings and fabricated jobs are made. In addition to the manufacturing spares, assembly and repair jobs like gear boxes, Crusher, bearing housings, stands of SMS are taken up. Over 100 major machines including lathes, milling, Plano milling, boring, slotting, shaping, grinding etc. are available to take up machining of spares. 2 presses of 630-ton, 315 ton and dynamic balancing machine of 25-ton capacity, are provided at CMS for repair of assemblies.

STEEL STRUCTURAL SHOP (SSS):

At Structural shop of ES&F, structural jobs of various departments like coke bucket, ladle, SRC body, Wagons, Shells, ducts etc. are being fabricated or repaired as per the requirement of departments. The equipment available are Bending machine-25mm capacity, shearing machine - 25mm capacity, CNC profile gas cutting machine, welding machines, gas cutting sets, other tools and tackles.

FOUNDRY:

In Foundry, castings of Iron, steel and non-ferrous are produced based on the projection of customer departments. 8-ton Arc furnace, 2nos of 5ton Induction furnaces and 1 ton crucible furnace for non-ferrous jobs and sand plant for preparation of sand for molds are available for making castings. Major jobs likeHot metal runners of 10 tons weight, Bottom funnel (5 ton), Emergency containers (7 ton), lower mantle and Bowl liners (3 tons each) etc. are produced.



FORGE SHOP (FS):

In Forge shop, preparation of raw materials for shafts, coupling flanges, gears etc. and also, of forge shapes such as crusher hammer heads, V - hooks, drill rods with the help of 0.5-ton, 2 ton, 3 ton pneumatic hammers, manipulators, heating furnaces is carried out.

UTILITY EQUIPMENT REPAIR SHOP (UERS):

In Utility Equipment Repair Shop, repair of ventilation equipment, valves, fans and impellers is carried out.

Foundry

PATTERN MAKING

Its primary purpose of a pattern is to facilitate the meticulous preparation of a well-defined cavity, within which molten material is subsequently poured during the casting process. Patterns employed in the realm of sand casting exhibit a diverse range of compositions, encompassing materials such as wood, metal, plastics, and various other suitable mediums, all carefully chosen to meet the specific requirements of the casting operation. This comprehensive array of pattern materials enables the casting industry to achieve exceptional precision and flexibility, ensuring optimal outcomes in the creation of cast components.

Functions of Pattern:

- To produce the mold cavity of correct size and shape.
- To produce seats for cores in the molds.
- To establish the parting surfaces and lines in the mold.
- To establish distinct locating points in the molds.
- To minimize defects in castings.
- To minimize the cost of castings.

Types Of Patterns

- Single piece or solid pattern: A pattern made from a single solid piece of material for creating a mold in foundry.
- Split pattern: A pattern divided into two or more parts to facilitate mold removal and accommodate complex shapes.
- Multi-piece pattern: A pattern composed of several separate pieces assembled together to form the desired shape for casting.
- Match plate pattern: A pattern mounted on a plate with an additional cope or drag pattern to create both mold halves simultaneously.
- Cope and drag pattern: A pattern split into two halves, the cope and drag, to create the upper and lower parts of the mold separately.
- Loose-piece pattern: A pattern designed with removable parts to allow for the creation of complex or intricate castings.
- Sweep pattern: A pattern used for creating long, slender castings with a uniform cross-section by sweeping it along a curved path.

Types Of Pattern Allowances:

1. Shrinkage Allowance: All the metals used for castings contract and shrink in size after solidification and cooling. To compensate for this, a pattern is made larger than the finished casting by means of a shrinkage on contraction allowance. In laying measurements for the pattern, the pattern-maker allows for this by using shrink or contraction rule. This rule is slightly longer than the ordinary rule of the same length. Different metals have different shrinkages. Therefore, there is a shrink rule for each type of metal used in casting.

2. Draft allowance or taper allowance: When the pattern is drawn from a mold, there is a possibility of damaging the edges of the mold. This possibility is decreased if the vertical surfaces of a pattern are tapered slightly inward. This slight taper inside on the vertical surfaces of a pattern is known as the draft. Draft is expressed in mm/meter on a side in degrees. Amount of draft needed depends upon:
   - The shape of the casting.
   - Depth of casting.
   - Molding method.
   - Mold material.

3. Finish or machining allowance: rough surfaces of castings, that have to be machined, are made to dimensions somewhat over those indicated on the finished working drawings. The extra amount of metal to be machined is called finish or machine allowance. Their allowance varies from 1.5 to 16 mm but 3 mm allowance is common for small and medium-size castings. The edges of these surfaces are shown by a finish mark V or f.

MOLD MAKING

Materials Used for Mold Making:

The main constituents of molding sand involve silica sand, binder, moisture content and additives.

- **Silica Sand:** Silica sand (SiO_2) is essential for its high melting point and low thermal expansion, making it suitable for sandcasting.
- **Binder:** Binders can be inorganic (e.g., clay, sodium silicate) or organic (e.g., resins), providing cohesion and strength to the mold.
- **Moisture Content:** Moisture (2-8%) is added to the clay-silica sand mixture to facilitate bonding without compromising permeability.
- **Additives:** Additional materials called "additives" are included to enhance specific properties and optimize the molding process.

Additives Used in Molding Sand Mixing

- **Coal Dust:** Coal dust is primarily added to create a reducing atmosphere during the casting process. This atmosphere prevents oxygen in the molds from oxidizing the metal. It is commonly used in molding sands for the production of grey iron and malleable cast iron castings.
- **Wood Flour:** Wood flour, a fibrous material, is mixed with granular materials like sand. Its elongated and thin fibers serve to prevent direct contact between the sand grains. This inclusion of wood flour enhances mold wall movement and reduces expansion defects. Additionally, it improves the collapsibility of both the mold and core.
- **Sodium Silicate:** Commonly used as a binder in sand molds and cores
- **Bentonite:** Bentonite is used as an additive in mold making for foundries to provide binding, moisture control, thermal stability, dimensional accuracy, and improved casting finish

Mold making processes:

1. **Carbon Dioxide (CO_2) Molding:** This is most commonly used in VSP. Carbon dioxide molding, also called the "CO_2 process," is a sand-casting technique that uses carbon dioxide gas to harden the sand mold or core. The process involves the following steps:

    - Pattern Creation: A pattern of the desired object is made, typically from wood, metal, or plastic. This pattern is a replica of the final product and is used to create the mold.

- Sand Mixture: A sand mixture, often consisting of silica sand and a binder, is prepared. The binder helps hold the sand particles together and provides strength to the mold or core.
- Molding: The pattern is placed in a flask (a frame-like container) and surrounded by the prepared sand mixture. The sand is then compacted around the pattern to create the mold cavity.
- Gassing: Once the mold is ready, carbon dioxide gas is introduced into the mold cavity. The CO2 gas rapidly reacts with the binder in the sand mixture, causing it to harden and solidify the mold or core.
- Mold Removal: After the CO2 gas has been applied, the mold is allowed to set and harden. Once hardened, the mold is removed from the flask, and the pattern is extracted from the mold cavity, leaving behind a precise negative impression of the desired object.

2. **Oil Core Molding (No-Bake Sand Molding):** Oil core molding, also known as no-bake sand molding, is another technique for creating molds and cores in the foundry. It involves the use of sand mixed with a liquid resin binder instead of carbon dioxide gas. Here's how the process works:

- Sand Preparation: Silica sand is mixed with a liquid resin binder, which may be a thermosetting resin like phenolic or furan. The binder coats the sand particles, providing strength and binding properties.
- Core Formation: The sand and resin mixture is shaped or packed around a core box, which is a pattern or template for the core. The core box helps create the desired shape and size of the core.
- Curing: The packed sand-resin mixture is allowed to cure and harden. This can be achieved by ambient air drying or by heating the core at a controlled temperature.
- **Core Removal:** Once the core has hardened, it is removed from the core box, leaving behind a hollow space. This core is then placed inside the mold cavity, which is created using the same sand-resin mixture or a different sand mixture.
- **Molding:** The mold is created by packing the sand-resin mixture around the core and any additional patterns. The sand is compacted and shaped to ensure a proper mold cavity.
- **Casting:** Molten metal is poured into the mold, filling the cavity. The metal is allowed to cool and solidify, after which the mold is broken away to reveal the cast metal object.

Properties of molding sands:

A molding sand should possess the following 6 properties

- Porosity
- Flowability
- Collapsibility
- Adhesiveness
- Cohesiveness or strength
- Refractoriness

MELTING

Melting in the VSP foundry, is carried by mainly two furnaces:

1. **Electric Arc Furnaces (EAFs):** In comparison to basic oxygen furnaces, EAFs have a lower capacity. The specific capacity of the electric arc furnace at VSP Foundry is 8-10 tons. While EAFs can be used with pig iron, they are predominantly utilized for processing 100% scrap iron and scrap steel obtained from other manufacturing processes. The scrap materials are introduced into the electric arc furnace, and lime is added as a fluxing agent. The furnaces are equipped with a removable roof to prevent excessive slag formation on the molten material. Additionally, necessary alloying elements are incorporated into the molten material. The tapping of the produced steel is achieved by tilting the entire furnace.

2. **Induction Furnaces**: As the name suggests, induction furnaces utilize induction technology and alternating electric currents to generate the required heat for melting metal. Induction furnaces are commonly used in global foundries instead of cupolas for melting materials like brass or cast iron. Moreover, these furnaces are versatile and can efficiently melt a variety of metals, including steel, iron, aluminum, and copper. The induction-based heating mechanism leads to optimal thermal energy utilization, resulting in cost savings for die casters. The capacity of an induction furnace can range from less than 1 kg up to 100 tons. At VSP Foundry, the capacity of the induction furnace is 5 tons.

FETTLING

Fettling is an essential process in the manufacturing of castings, aimed at removing excess material that often forms along the parting lines of the die during the casting process. This occurs when molten material is injected into the die or mold. To achieve precise removal of these undesired materials, robots are commonly employed for accurate positioning.

Fettling encompasses various operations, including the removal of risers and excess material, as well as the linishing process, which involves grinding or sanding the component to enhance its surface flatness.

The fettling operation can be categorized into distinct stages:

1. **Removal of Dry Sand:** The elimination of dry sand cores is accomplished by knocking them out using an iron bar. Pneumatic or hydraulic devices are sometimes employed for quicker knocking, particularly for small to medium-sized workpieces. For larger castings, the hydro blast process is predominantly utilized.

2. **Removal of Gates and Risers:** Chipping with a hammer, flame cutting, lancing, gas cutting and abrasive cut-off machines are the techniques employed for the removal of gates and risers.

3. **Removal of Fins and Unwanted Projections:** After the gates have been removed, the casting surface may still exhibit rough surfaces and fused sand residues. Additionally, there might be fins and other projections along the surface near the parting line. Thorough cleaning of these imperfections is necessary before the casting can be put to use.

4. **Removal of hydroblasts**: The castings are transferred to a shakeout machine. Shakeout machines are large, vibrating devices designed to separate the remaining sand and debris from the castings.

By following these stages of fettling operations, castings can be refined and prepared for their intended applications, ensuring high-quality and precise end products.

HEAT TREATMENT

One of the main purposes of heat treatment is to change a mechanical property or combination of mechanical properties so that the metal will be more useful serviceable, and safe for a definite purpose by heating a metal can be made harder, stronger, and more resistant to impact, heat treatment can also make a metal softer and more ductile.

Principles Of Heat Treatment

Heat treating changes metal properties by heating the metal to a specific temperature, holding it at that temperature for a certain length of time and then using one of several methods to control the cooling of the metal. A metal's properties are determined by the shape and alignment of its atoms.

Heat Treatment Techniques

- **Annealing:** Annealing consists of heating of steel parts to a temperature at or near the critical temperature 900-degree Celsius hold it at that temperature for a suitable time and cooled slowly in the Furnace itself.

- **Normalizing:** Normalizing is a heat treatment process similar to annealing in which the Steel is heated to about 50 degrees Celsius above the upper critical temperature followed by air cooling.

- **Hardening:** Hardening is a heat treatment process carried out to increase the hardness of Steel by water quenching.

- **Tempering:** To increase ductility and toughness of hardened steel.

Stages In Heat Treatment

- **Heating:** First stage in which any structure of an alloy is heated at a specified temperature.
- **Soaking:** A second stage in which the heated metal completely changes its structure due to soaking.
- **Cooling:** The third stage is cooling where the structure of the soaked metal is cooled either by quenching or by still air.

Importance of foundry in an integrated steel plant like RINL Visakhapatnam

In an integrated steel plant like RINL (Rashtriya Ispat Nigam Limited) in Visakhapatnam, a foundry plays a crucial role in the steelmaking process. The importance of a foundry lies in its ability to produce castings, which are essential components used in various industries, including automotive, construction, machinery, and more. Here are some key reasons why a foundry is important in an integrated steel plant:

1. Casting Production: The foundry is responsible for producing castings, which are solid metal objects formed by pouring molten metal into molds and allowing it to solidify. Castings are widely used in different sectors and industries to create complex shapes and structures.

2. Raw Material Utilization: A foundry enables efficient utilization of raw materials in the steelmaking process. It allows the recycling and reprocessing of scrap metal and other metallic waste, reducing the overall cost of production and minimizing environmental impact. The foundry converts these materials into usable castings, contributing to sustainable practices and resource conservation.

3. Component Manufacturing: The castings produced in the foundry serve as crucial components in the manufacturing of machinery, equipment, and infrastructure. These components can include engine blocks, gears, valves, pumps, pipes, and more. The foundry ensures the production of high-quality castings that meet specific requirements, such as strength, durability, and dimensional accuracy.

4. Process Integration: In an integrated steel plant, the foundry works in coordination with other departments and units to ensure a seamless production process. For instance, the castings produced in the foundry might be used in the plant's steelmaking operations or for the maintenance and repair of plant equipment. This integration streamlines the overall production and reduces dependence on external suppliers.

In summary, the presence of a foundry in an integrated steel plant like RINL Visakhapatnam is vital for the production of castings, efficient utilization of raw materials, manufacturing of components, process integration, and employment generation. It plays a significant role in the overall steelmaking process and facilitates the supply of high-quality castings for various industries.

Importance of availability of raw materials in foundry

Having all raw materials available in a foundry is crucial for maintaining smooth operations and achieving consistent product quality. The availability of raw materials ensures uninterrupted production and minimizes the risk of delays or disruptions in the manufacturing process. Here are some key reasons why it is important:

1. Continuous Production: Raw materials are the building blocks of the foundry process. Having all the necessary materials on hand allows for continuous production without interruptions. It ensures that the foundry can meet customer demands and deliver products on time.

2. Cost Efficiency: Procuring raw materials in bulk or from reliable suppliers often offers cost advantages. Having all the required materials readily available allows for better inventory management, reduces the need for expedited orders or emergency purchases, and minimizes associated costs.

3. Process Optimization: Foundries often have established processes and workflows designed for specific raw materials. Availability of all necessary materials allows the foundry to optimize its operations, implement efficient production techniques, and minimize downtime.

On the other hand, if a raw material is not available, several losses or negative impacts may occur:

1. Production Delays: The unavailability of a critical raw material can lead to production delays or even temporary shutdowns. This can result in missed delivery deadlines, dissatisfied customers, and potential financial penalties.

2. Increased Costs: Urgent sourcing of alternative or substitute materials may be necessary if a primary raw material is unavailable. These alternative materials might be more expensive, affecting production costs and reducing profitability.

3. Inconsistent Product Quality: Raw materials contribute to the final product's properties and characteristics. The use of alternative or substitute materials may result in variations in product quality, affecting its performance, reliability, or meeting specified standards.

4. Operational Disruptions: Finding alternative raw materials often requires adjusting process parameters, retesting, or recalibrating equipment. These adjustments can disrupt the normal production flow, requiring additional time and effort to bring the process back to optimal conditions.

Purchase Procedure in RINL

FORMAT and REPORTS preparation is main parts of purchase procedure

FORMAT

1. INDENTING:
   - Annual Procurement List
   - Indent Check list Indent Proforma
   - Detailed Technical Specification
   - Proprietary Article Certificate
   - SPC Check list
   - Work Order
   - Status of work order received from SPC Status of indents, ITTs issued and A/Ts placed
   - Indent status, No. of indents sent to Purchase, A/T placed, pending deliveries Indent follow-up Card Indent Return Slip

2. TENDERING:
   - Proposal for enquiry
   - Control Register
   - Proforma for consideration of delayed/late tender
   - Stock Register Format for emergency items purchased
   - Invitation to Tender Formats
   - Tender opening form

3. TENDER EVALUATION:
   - Comparative Statement Purchase proposal
   - Guidelines for negotiations
   - Delegation of Powers
   - Related Powers
   - Purchase Committee Agenda Proforma Constitution of Purchase Committee,
   - Committee of Management, Committee of Directors and Powers thereof

4. PLACEMENT OF ACCEPTANCE OF TENDER AND ALLIED MATTERS:
   - Check-list for verifying Acceptance to Tender
   - Amendment to acceptance of tender

5. VENDOR REGISTRATION AND RATINGS:
    - Criteria for selection of vendors
    - Application form for Registration Proposal for Registration
    - Registration Certificate
    - Business Relations
    - Performance during use

REPORTS

Based on data available in Purchase Department as well as in the computer, various reports are generated for tracking all the indents from receipt of indent to placement of Purchase Order and subsequent follow-up of supplies. The details of reports and formats are as follows

*Reports on indents with the following data:

1) Indent No. and receipt date.

2) Purchase Case No.

3) Name of the dealing Officer.

4) ITT issued/not issued.

5) Tender opening date where ITT issued.

6) A/T issued/not issued.

*Reports of Acceptance of Tender with the following details.

1) Indent No. and date.

2) A/T No. and date.

3) Name of Supplier.

4) No. of items ordered.

5) Value of A/T.

6) No. of items supplied.

7) Value of items supplied.

*Reports for follow-up of supplies with the following details.

1. Supplier-wise A/T details as per 6.2.3

2. City-wise A/T details

3. Reminder letters/ telexes to suppliers 15 days before expiry of delivery.

*Other miscellaneous reports as follows:

1. Tender opening list to facilitate tender opening.

2. A/Ts placed on other than L1 basis for auditing purpose.

*Reports for MIS as follows:

1. Monthly summary report indicating the details of indents received, order placed and total value of order material group-wise for that particular month.
2. Report on scheduled receipt on particular month/ months for control of inventory/ payments.
3. Ordering status on weekly basis indicating the total commitments made vis-à-vis the budget allocation.

*Sample formats for some of the reports

ABC Analysis

ABC analysis is a widely recognized and effective technique used in inventory management to categorize items based on their value or significance. This powerful tool enables businesses to prioritize their inventory control measures and identify the items that have the most significant impact on costs or sales. By following a systematic approach, companies can conduct ABC analysis and make informed decisions regarding their inventory management strategies.

1. The first step in conducting ABC analysis is to gather comprehensive data about each item in the inventory. This includes collecting information on the price of the item and its annual demand. By obtaining accurate and up-to-date data, businesses can ensure the effectiveness of their analysis.
2. Once the data is gathered, the next step is to calculate the annual usage value for each item. This can be done by multiplying the price of the item by its annual demand. The resulting figure represents the overall importance of the item in terms of its value to the business. By calculating the annual usage value, companies can gain insights into which items have the highest impact on their operations.
3. After determining the annual usage value for each item, the items are ranked in descending order based on this value. This ranking allows businesses to identify the items that contribute the most to the overall usage value. The items with the highest annual usage value are placed at the top of the list, while those with lower values are positioned further down.
4. To further analyze the ranked list, it is crucial to compute the cumulative usage value for each item. This involves summing up the annual usage values as you progress down the list. The cumulative usage value helps in understanding the collective contribution of the items and aids in the subsequent categorization process.
5. Utilizing the Pareto principle, commonly known as the 80/20 rule, businesses can assign the items into three distinct categories: A, B, and C. Category A comprises the top 20% of items that contribute to roughly 80% of the total annual usage value. These items are of high value and require close monitoring and stringent inventory control measures. Category B includes the subsequent 30% of items that contribute to approximately 15% of the total annual usage value. These items possess a moderate level of value and require a proportional level of attention. Lastly, Category C encompasses the remaining 50% of items that contribute to the remaining 5% of the total annual usage value. These items have relatively lower value and can be managed with less effort, often carrying lower priority.

Regular review and adjustment of the ABC analysis is essential to ensure its continued relevance and effectiveness. Factors such as changes in prices, demands, or other variables can impact the categorization of items. Therefore, it is necessary to periodically reassess and update the ABC analysis to reflect the evolving dynamics of the business. By doing so, companies can maintain optimal inventory management practices and enhance overall operational efficiency.

It is important to highlight that ABC analysis serves as a valuable tool for prioritizing inventory management efforts. The categorization resulting from this analysis should guide decision-making related to inventory control, ordering policies, and investment allocation. By consistently applying ABC analysis, businesses can optimize their inventory management practices and achieve greater efficiency in their operations.

In conclusion, ABC analysis is a robust technique that enables businesses to categorize inventory items based on their value or significance. By following a structured approach and considering factors such as price and annual demand, companies can effectively prioritize their inventory management efforts. Regular review and adjustment of the analysis are crucial to ensure its continued accuracy and alignment with the changing dynamics of the business. By leveraging ABC analysis, organizations can enhance their inventory management practices and ultimately achieve greater operational efficiency.

Applying ABC analysis on the items used in the foundry at VSP, we find that the top 20% of items that contribute to roughly 80% of the total annual usage value are:

1. High Silica Sand Grade - A
2. High Silica Sand Grade - B
3. Sodium Silicate
4. Graphite Electrodes
5. CO2 Gas
6. Swing Frame Grinding Wheel
7. Magnesium Ferro Silico

Sl. No.:	***Item name***	***PRICE***	***Annual Demand***	***Annual Usage Value***	***Category***
1	High Silica Sand Grade - A	5478.22	1032.27	5655002.159	A
2	High Silica Sand Grade - B	4668.25	830.87	3878708.878	A
3	Sodium silicate	19.98	133414.73	2665626.305	A
4	Graphite electrodes	350030.00	6.66	2331199.8	A
5	CO2 Gas	21.23	37797.15	802433.4945	A
6	Swing Frame Grinding wheel	24678.62	25	616965.5	A
7	Magnesium ferro silicon	192585.00	3	577755	A
8	Linking binder,PART-B	249.58	1500	374370	B
9	Olivine sand	15000.00	20	300000	B
10	zinc	273000.00	1	273000	B
11	Refractory sleeves for stopper head	179.00	1000	179000	B
12	Thinner for Mould wash	54.00	3000	162000	B
13	Exothermic compound	30.00	4000	120000	B
14	Insulating sleeves dia 250	130.00	750	97500	B
15	Fe-Mn(HC) low phosphorous	94500.00	1	94500	B
16	Teak Wood,2000X200X30MM	243215.00	0.375	91205.625	B
17	Insulating sleeves dia 300	180.00	500	90000	B
18	Clay graphite stopper Heads	360.00	250	90000	B
19	Zircon Mould Wash water based	86.00	1000	86000	B
20	Insulating sleeves dia 200	105.00	800	84000	C
21	Teak Wood,2000X200X50MM	243215.00	0.25	60803.75	C
22	Teak Wood,2000X200X40MM	243215.00	0.248	60317.32	C
23	Deoxidising tubes	100.00	500	50000	C
24	Chain, Endless 16 mm	8050.00	6	48300	C

25	Chain, Endless 18 mm	11750.00	4	47000	C
26	Thermocole Sheets 100mm	135.05	300	40515	C
27	cloth disc al.	389.00	100	38900	C
28	Circular Saw blade	6995.00	5	34975	C
29	Insulating sleeves dia 150	60.00	500	30000	C
30	Mold Runner bricks Dia 50 x 50	83.90	300	25170	C
31	Thermocole Sheets 50mm	75.59	287.5	21732.125	C
32	Thermocole Sheets 85mm	130.09	100	13009	C
33	Mold Runner bricks L shape	126.27	100	12627	C
34	WWS Blades Band saw 1 1/2 ''	51.60	100	5160	C
35	Mold Runner bricks T shape	40.00	100	4000	C
36	Mold Runner bricks Dia 50 x 250	83.90	0	0	C
37	Teak Wood ,2000X200X20MM	243215.00	0	0	C
38	WWS Blades Band saw ¾”	25.80	0	0	C

Economic Order Quantity model in Inventory Management

The economic order quantity (EOQ) is a widely used inventory management model that helps businesses determine the optimal order quantity for their inventory. By calculating the EOQ, companies can minimize their inventory costs while ensuring that they have enough stock to meet customer demand.

The EOQ model takes into account several factors to determine the ideal order quantity. Two key parameters used in the calculation are ordering costs and holding costs.

- **Ordering costs** include expenses associated with the process of placing and receiving inventory orders. This includes administrative tasks like preparing purchase orders, communication costs, such as contacting suppliers, and transportation costs for shipping the goods. By minimizing the number of orders placed, a company can reduce the associated ordering costs.
- **Holding costs** refer to the expenses incurred for holding and storing inventory.

These costs include expenses related to warehousing, storage facilities, and inventory management systems. Holding costs are influenced by factors such as storage space requirements, insurance, security, and depreciation. By reducing the amount of inventory held, a company can minimize holding costs.

The EOQ model makes several assumptions to simplify the calculation process. These assumptions include:

1. Demand for the product is known and constant over time: The model assumes that the demand for the product remains consistent and does not fluctuate significantly during the time period considered.

2. Lead time is constant: Lead time refers to the time it takes from placing an order to receiving it. The model assumes that the lead time remains constant, allowing for accurate planning and ordering.

3. Cost per unit of the product is constant: The model assumes that the cost of each unit of the product remains the same, regardless of the order quantity.

4. Ordering cost is constant: The model assumes that the cost associated with placing an order, such as administrative and communication costs, remains constant for each order placed.

5. Holding cost is constant: The model assumes that the cost of holding and managing inventory, including storage and other related expenses, remains constant.

By incorporating these assumptions and considering the ordering costs and holding costs, the EOQ model calculates the optimal order quantity that minimizes the total inventory costs. The goal is to strike a balance between ordering too frequently (incurring high ordering costs) and ordering in large quantities (incurring high holding costs).

The formula to calculate Economic Order Quantity is:

$$\boxed{EOQ = \sqrt{(2 * D * S) / H}}$$

Where:

- D represents the annual demand
- S represents the ordering cost
- H represents the holding cost

Previously, by applying ABC analysis on the items used in the foundry at VSP, we find that the top 20% of items that contribute to roughly 80% of the total annual usage value are:

1. High Silica Sand Grade - A
2. High Silica Sand Grade - B
3. Sodium Silicate
4. Graphite Electrodes
5. CO2 Gas
6. Swing Frame Grinding Wheel
7. Magnesium Ferro Silicon

Applying the above formula, the EOQ for various raw materials used in the foundry at RINL is:

Sl. No.:	Material	Units Of Quantity	Ordering Cost (In ₹)	Holding Cost (In ₹)	Annual Demand	EOQ
1	CO2 Gas	KG	21.23	0.005	37797.15	17916
2	Sodium Silicate	KG	19.98	0.0004	133414.73	115448
3	Graphite Rods	TO	350030	10400	6.66	21
4	High Silica Sand (Grade A)	TO	5478.22	17	1032.27	816
5	High Silica Sand (Grade B)	TO	4668.25	5	830.87	1246
6	Swing Frame Grinding Wheels	EA	24,678.62	1244	18	27

The economic order quantity for the top 20% of items that contribute to roughly 80% of the total annual usage value comes out to be:

- CO2 Gas: 17916 Kg Or 18 Tons
- Sodium Silicate: 115448 Kg Or 115.5 Tons
- Graphite Rods: 21 Tons
- High Silica Sand (Grade A): 816 Tons
- High Silica Sand (Grade B): 1246 Tons
- Swing Frame Grinding Wheels: 27 Wheels

Hence by ordering the above calculated quantity, we can strike a balance between ordering too frequently (incurring high ordering costs) and ordering in large quantities (incurring high holding costs) for the most important items used in the foundry.

Reorder Point:

The reorder point is a concept used in inventory management to determine when to place a new order for a particular item or product. It represents the inventory level at which a replenishment order should be triggered to ensure that there is sufficient stock on hand before it runs out.

To calculate reorder point, we need the following parameters:

1. **Average Demand per day**: This refers to the average quantity of a product that is consumed or sold per day. It represents the average rate at which customers require or use the product. It is important to have an accurate estimation of the average demand to ensure that enough stock is available to meet customer needs.
2. **Lead Time in days:** Lead time is the duration between placing an order for a product and receiving it. It includes the time taken for processing the order, manufacturing or sourcing the product, and transportation or shipping. Lead time can vary depending on various factors such as supplier reliability, production capabilities, and shipping distance.
3. **Safety Stock:** Safety stock is an additional inventory buffer that is held to account for uncertainties in demand and lead time. Safety stock serves as a contingency to avoid stockouts and maintain customer satisfaction

The formula for calculating reorder point is:

Reorder Point = (Average Demand per day × Lead Time in days) + Safety Stock

In the context of the foundry operations at Visakhapatnam Steel Plant (VSP), it is important to note that no safety stock is maintained for the raw materials. This decision is based on the observed trend that stock levels frequently reach a depletion point of 0. Consequently, a safety stock level of 0 is considered for each individual item in the inventory. By not maintaining a safety stock, the plant aims to optimize its inventory control measures. This decision reflects a deliberate choice to operate on a just-in-time (JIT) inventory system, which seeks to minimize excess inventory and associated costs while ensuring a continuous flow of materials to support the production process.

Applying the reorder point formula, the reorder point for top 20% of items that contribute to roughly 80% of the total annual usage value in the foundry at RINL are:

Sl. No.:	Material	Units	Average daily consumption	Average lead time (in days)	Safety stock	Reorder point
1	CO2 Gas	KG	103.5538572	421.5	0	43648
2	Sodium Silicate	KG	365.519827	340.25	0	124369
3	Graphite Rods	TO	0.018259553	332	0	7
4	High Silica Sand (Grade A)	TO	2.828141312	335	0	948
5	High Silica Sand (Grade B)	TO	2.27637491	338	0	770
6	Swing Frame Grinding Wheels	EA	0.049315068	253	0	13

The reorder point from the calculations, for the top 20% of items that contribute to roughly 80% of the total annual usage value comes out to be:

- CO2 Gas: 43468 Kg or 43.4 Tons
- Sodium Silicate: 124369 Kg or 124.6 Tons
- Graphite Rods: 7 Tons
- High Silica Sand (Grade A): 948 Tons
- High Silica Sand (Grade B): 770 Tons
- Swing Frame Grinding Wheels: 13 Wheels

The above calculated quantity represents the inventory level at which a replenishment order should be triggered to ensure that there is sufficient stock on hand before it runs out.