IndianMachineToolManufacturers'Association (IMTMA)
Head Office: 10th Mile,Tumkur Road, Madavara Post,
Bangalore –562123, Karnataka, India.
T: 080-6624 6829 / 6624 6711 W: www.productivity.imtma.in

Annexure: A

IMTMA-ACEMICROMATICPRODUCTIVITYCHAMPIONSHIP AWARDS2023

FORMATFORSUBMISSIONOFCASESTUDY
FOR LARGE &MEDIUM COMPANIES ONLY
(Unit level / SBU level turnover> Rs.100 Crores)

Titleof the CaseStudy:

1. Name of company: DURGAPUR STEEL PLANT

Address of the Plant / Site location: DURGAPUR, WEST BENGAL

Tel No.: 9434791537 (J Mukhopadhyay, GM, BE, DSP)

Turnover (in Rs. Cr):**9,580** Crores (up to Q3, 2022-23)

No. of employees:**7,717** (as on 31.03.2023)

Industry sector (Pl. specify): STEEL

2. Name of the project leader: SAMIRON DE,

Designation : GM, WAP

Mobile No.: 9434791638

Email ID:samiron.de@sail.in

Alternate contact person: MAINAK CHAKRABORTY

Designation : SR. MANAGER

Mobile No.: 9434792186

Email ID:mainak.chakraborty@sail.in

3. Projectimplementation

Start date :01. 01. 2022

End date : 31.12. 2022

Is it in continuous operation now? (Yes/No) : yes

We certify that the project described here is factually correct and is in continuous operation.

We confirm that we have read the rules and guidelines governing this competition and agree to abide by the same.

We agree to nominate a member of our senior management to make thepresentation,in case this entry is short listed for final evaluation of the award.

We have no objections in IMTMA publicising our case study in their programs / website and other event promotional collaterals.

Name : DIPTENDU GHOSH

(Head of Company/Business Unit / Division)

Designation: ED (W) Electronic Signature: D. Ghosh 11.5.2023

Date: 11.5.2023

दीपतेन्दु घोष / Diptendu Ghosh
कार्यपालक निदेशक (संकार्य)
Executive Director (Works)
दुर्गापुर इस्पात संयंत्र
DURGAPUR STEEL PLANT

IMTMA-ACEMICROMATICPRODUCTIVITYCHAMPIONSHIP AWARDS2023

Annexure:B

Tick(✓) the appropriate box(es) that best describe your Case study

1. **Scope of the project:** (Please tick as appropriate)
   - [ ] **Multiple Value streams** (Improvements in Multiple Value streams/ product families resulting in breakthrough benefits).
   - [x] **Single Value stream** (Improvements in a Value stream / product family with significant benefits).
   - [ ] **Localized improvement within a Value stream** (Improvements in identified processes / pockets within a value stream, with incremental benefits).

2. **Project sponsor:** [x] Top management [ ] Senior management (CEO / CXO level)
   - [ ] Middle management (GM/ DGM/ AGM level)

3. **Project trigger:**
   - 3.1 [ ] External conditions [x] Internal competitiveness
   - 3.2 **Market conditions:**
     [ ] Uncertain demand [ ] Cyclical demand [ ] Low volume- High variety [x] Sudden increase in demand
   - 3.3 **Project approach selection**
     - [x] Primarily driven by the costs involved
     - [x] Based on financial benefits, gains
     - [ ] Based largely on adoption by peers/ Industry standard

4. **Project focus :**
   - [ ] Manufacturing System Redesign (MSR)
   - [ ] Productivity Through Quality improvement (PTQ)
   - [x] Digital Manufacturing &I 4.0
   - [ ] Total Quality Management(TQM)
   - [ ] Other innovation (Please specify) …………………
   - [ ] Better Asset Utilization (BAU)
   - [x] Optimizing Metal working Process (OMP)
   - [ ] Total Productive Maintenance (TPM)
   - [ ] Green & Clean

5. **Quality / Analytical tools:** Please tick If you have used any of the tools listed below for developing productivity improvement solutions.
   - [ ] Statistical Process Control (SPC)
   - [ ] Eight Disciplines of problem solving (8D)
   - [x] Standard problem solving tool
   - [ ] Six Sigma
   - Others (Please specify)…………………
   - [x] Design of Experiments (DOE)
   - [ ] Root Cause Analysis (RCA)
   - [ ] Theory of Constraints (TOC)
   - [ ] 7 QC Tools
   - [ ] Lean

6. **Project implementation includes**
   - [x] All activities within the organization
   - [ ] Upstream and Downstream partners/ suppliers

7. **Productivity improvement includes:** [x] Enhanced output [ ] Reduced inputs [x] Manpower Rationalization
   - [ ] Others.

IMTMA-ACE MICROMATIC
Productivity Championship Award 2023

Team: 1) NILAY GUPTA, CGM (WHEEL & AXLE PLANT)

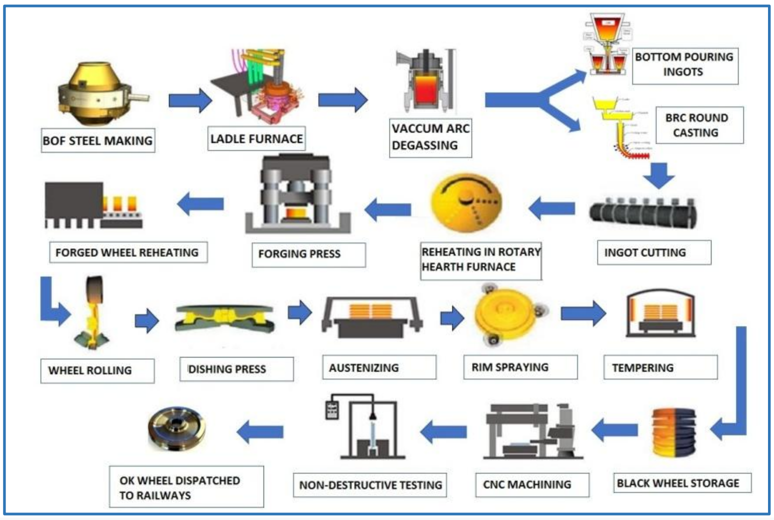
2) SAMIRON DE, GM (WHEEL & AXLE PLANT)

3) MAINAK CHAKRABORTY, SR. MANGER (WHEEL & AXLE PLANT)

1. Brief Description of the project

Steel Authority of India Limited (SAIL) is one of the largest steel-making companies in India and one of the Maharatnas of the country's Central Public Sector Enterprises. SAIL produces iron and steel at five integrated plants and three special steel plants. Durgapur Steel Plant (DSP) is a 2.2 MTPA integrated steel plant of SAIL situated at Durgapur in West Bengal. DSP has employee strength of about 8,000 people and is a major landmark in the industrial canvas of Eastern India. SAIL-DSP product basket caters to construction (TMT bars), transportation (Railway wheel), infrastructure (Light & Medium Structural) and power transmission sector (Bloom, Billets for re-rollers).

DSP has been supplying railway wheels to Indian Railways since 1960 from its Wheel & Axle Plant. The Wheel & axle Plant in Durgapur is one of the pioneer forged railway wheel manufacturing facilities in India. For decade's it has been successfully catered to the requirement of Indian Railways, its major customer. The plant is producing wheels manufactured as per the latest IRS specifications. The product is very quality sensitive. The daily safety of innumerable commuters depends on it. That is why we say "Nation moves on our wheels". The plant is Environment ISO 14001:2015, Energy ISO 50001:2018, Quality ISO 9001:2015, OHSAS 45001:2018 and SA 8000:2014 certified, and has been catering to the demand of railway wheel for Indian railways for decades.



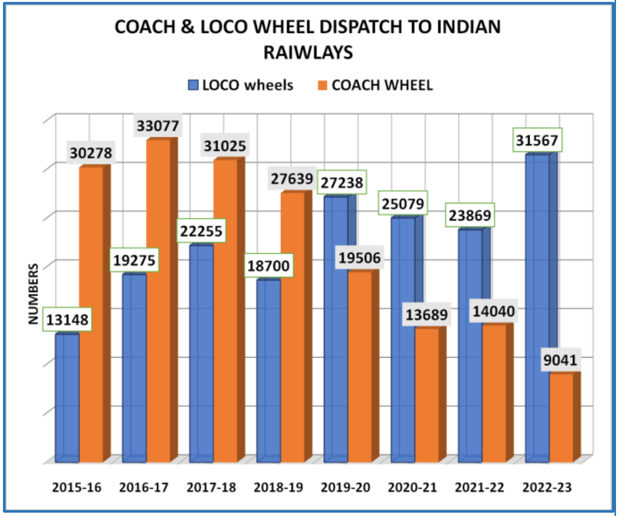
The process flow of the plant is as shown in the chart. The input material is Continuous cast bars or bottom poured ingots. The steel of Railway wheels is of special quality and is subjected to secondary refining (vacuum degassing) before it is cast into ingots. The ingots are cut into blocks of specified length in circular saw, and fed to a rotary hearth reheating furnace. After reheating at about 1260°C, the heated blocks are fed to the 63/12MN Press. DSP's wheel & axle plant uses a 63MN press to forge the heated block into preliminary shape. Forging is done in 3 steps: Upsetting, forming and punching. After that the forged wheel is reheated and rolled in a Computerised control vertical wheel rolling mill, where through precise path movement of rolls, the required rolled wheel dimension is achieved. After rolling, the wheel is pressed in 20MN dishing press where the web curvature is given. These wheels are subjected to heat treatment where required mechanical property is achieved. After heat treatment, each wheel is machined completely in CNC-VTB machines. After that, each wheel is passed through non-destructive testing of Ultrasonic testing, MPI and BHN Hardness testing, and finally dispatched to customers.

The Market for railway wheel has been ever increasing with the increased expenditure in railway infrastructure in the country. At present DSP is the major supplier of railway wheel in India. DSP has developed 11 different types of railway wheels with in-house expertise and is poised to be a major player in the railway wheel market. Now, railway wheels are mainly of two types: Coach Wheels and Locomotive wheels. Locomotive wheels are large diameter wheels ranging up to 1098 mm diameter. At present DSP caters to **the entire demand of locomotive wheels for Indian railways**. But these locomotive wheels were conventionally produced from bottom pouring ingots of 410 mm diameter in DSP. Bottom pouring routes are very cost intensive and also leads to high rejection. That is the reason why today's modern steel making process involves continuous casting route for casting of round bars, blooms and billets. DSP has installed a Bloom-cum-round caster (BRC) in the year 2014. But the maximum diameter of round bloom that can be produced by this caster was 340 mm. As a result, to accommodate the same material volume as a standard LOCO wheel block, the block length from BRC 340mm round bar would be very high compared to that from a 410mm diameter ingot. As a result, it would lead to buckling of the block during pressing in the forging press. Thus, use of 340mm BRC round bar for manufacturing of LOCO wheel was a bottleneck in DSP's wheel & axle plant.

With the shifting of demand pattern of wheels from coach to Locomotive wheels from Indian railways, it became imperative for DSP to enable use of continuous cast round bars for locomotive wheel production in order to increase productivity and reduces dependence on cost and energy intensive bottom pouring ingot route. The project aims to redesign the entire process chain so that Locomotive wheels can be manufactured from the energy efficient and modern Continuous cast BRC route in Wheel & Axle plant of Durgapur steel Plant.

2. *Trigger of the project*

The demand of Locomotive wheels from Indian railways started increasing over the last decade. Previously DSP used to have a product basket of 64% coach wheels and 36% Loco wheels in 2015-16. But in 2022-23, the supply of Loco wheels catered to 77.7% of the total product basket. But, this change in demand trend resulted in adversely affecting DSP's productivity. LOCO wheels were being produced by Bottom pouring ingot route. This was because the existing newly installed BRC could produce round blooms of maximum 340mm diameter, which were unsuitable for LOCO wheel production. The bottom pouring route of ingot casting is a primitive process in practise since 1960. The process is highly labour intensive and high dependence on supply of quality moulds; refractory from outside vendors makes it more rejection prone. On the other hand, Continuous casting process is equipped with automatic mould level controlled, latest electro-magnetic stirrer, closed casting resulting in no exogenous source of inclusion and a tundish head of 18T enabling inclusion floatation. This results in ultra clean steel, high productivity and lesser rejection at both block stage and during ultrasonic testing. Thus, it was envisaged by DSP that production of LOCO wheels through BRC continuous vesting route was imperative to improve productivity of wheel LOCO production. The comparison of both the process highlights the trigger of the project.



	Bottom pouring process	Continuous casting process
Ultrasonic Testing rejection	15-20 %	0.5 %
Material Discard	7 %	2%
Block Rejection	3 %	0%
Unit Cost of production of round bar	Rs 54,790/ton	Rs 48,459/ton

Thus, it was decided that changeover of process design to Continuous casting route was imperative for DSP in order to improve productivity of LOCO wheel production.

3. *Solution generation, Innovation and Complexity*

In discussion with OEM of Bloom-cum-round caster, it was decided to increase the diameter of round bar from *existing* 340 mm. But it was observed that with the existing 9m radius of the caster, the maximum diameter of round bar that can be continuously cast from the caster was 370mm. Now, the entire die design of our forging press was based on input material of 410 mm diameter. The length of input material for the press was 795 mm. But if the diameter was reduced, the required length will become 965 mm to accommodate the same material volume. Initially, 8 nos. experimental forgings with various process parameters were performed with these 965 mm x Ø 370mm blocks. The resultant forging product was found to be rejected due to improper material flow at the flange region of the die leading to under fill (Fig.1). It was analysed that, since the input block diameter has been reduced, the material flow at the extreme end of the closed die was insufficient. In fact, in all other railway wheel forging presses over the world, forging of such small diameter block to forged wheel is not done due to constraint in buckling characteristic and load requirement. Generally, the input block diameter for LOCO wheels all over the world is within the range of Ø 410-430 mm. Thus, this called for serious brain storming and innovation as the complete process design was to be re-engineered to enable stabilization of LOCO wheel production through Ø 370 mm round bars produced through CC route.

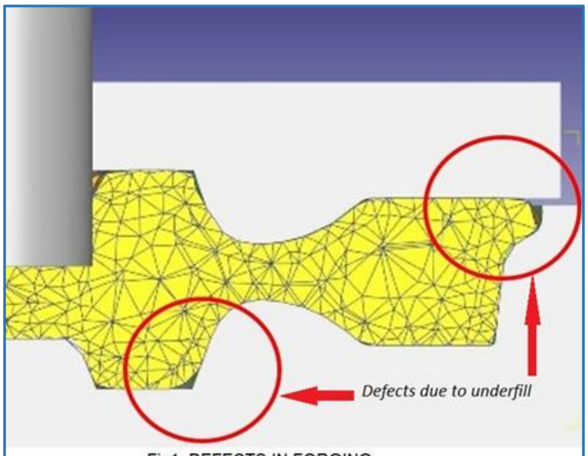


Fig1. DEFECTS IN FORGING

The team decided to go through a ***PDCA framework*** for accomplishing the objective of the project:

Objective:

The project aims for Optimization of process design for ensuring proper material flow during forging of LOCO wheel with input Block of 370mm diameter and 965 mm length. This will enable DSP to forge of LOCO wheels using round bars from cost-efficient Continuous casting route.

PDCA Framework:

PLAN

- Various factors which effect forging quality was enlisted
  - Die geometry
  - Process parameters of temperature, pressure, friction, speed etc
  - Input material composition and dimensions
  - Process perturbations like eccentricity, improper placement etc.
- Based on experience, brain-storming and analysis of results of initial 8nos. experimental forging, it was decided that ***optimization of Die geometry*** was key to achieve optimum material flow, thereby improve die filling
- It was decided to perform ***Design of Experiment (DOE)*** techniques with ***Taguchi analysis*** for achieving a optimized robust die design
- ***Identification of key parameters of die design***

Forging die assembly of the forging press at Wheel & axle Plant, DSP-SAIL consists of a set of two dies used in closed die forging (Fig.2). The design of die geometry plays a very vital role to ensure optimized material flow, thereby producing quality forging. The key parameters to be considered for ensuring optimized material flow was summarized, and based on experience, three levels of these parameters were identified for optimization using DOE.

	Variable	Nomenclature
1	A	Forming die inside boss angle
2	B	Forming die inside profile radius
3	C	Forming die outside profile radius
4	D	Draft angle
5	E	Preform dies groove depth
6	F	Preform dies groove radius

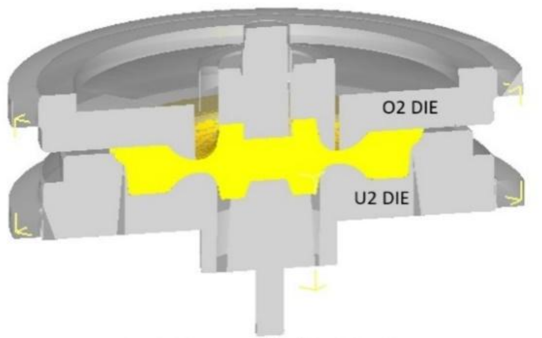


Fig.2: Die assembly of 63/12 MN press

Taguchi optimization technique was used to for 6 variables at 3 levels using L27 (3^6) orthogonal array

- ***Identification of Noise variables:*** Noise variable of Friction and temperature was considered and varied in a L4 (2^2) orthogonal array. This will ensure our design to be a ***robust*** design capable of taking care common process variation encountered in actual production.
- ***Identification of Response variable:*** The objective function was considered to be "Percentage of die filling cavity". The Signal/Noise ratio was set to be "*Larger the better*".

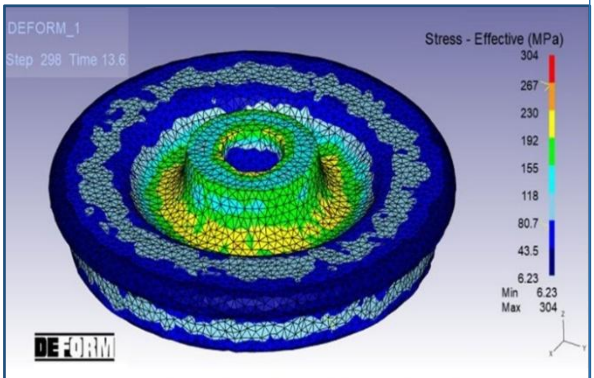


Fig. 3: Results of FE simulations in DEFORM 3D

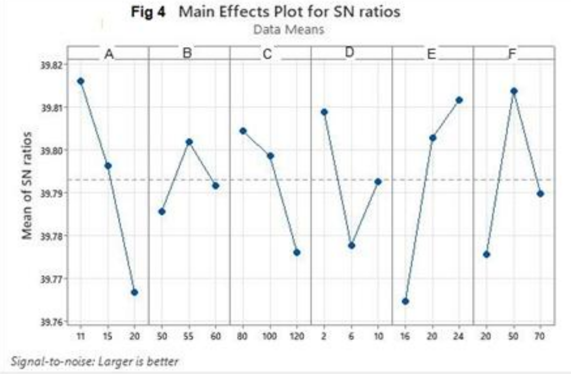
DO

- ***Development of FE simulation model in DEFORM-3D***

For performing the experimental runs required for DOE, the team decided to utilize a 3D Finite Element simulation model in DEFORM-3D software to virtually analyse the results of experiments and thereby optimize the parameters. The development of simulation model was achieved with the following steps:

- Development of Die model in Solidworks software
- Mesh convergence study
- Assumptions for initial and boundary conditions
- Defining die movement for forming operation

Fig 4 Main Effects Plot for SN ratios



- Validation of simulation output with experimental results of actual manufacturing

A typical result of simulation model is seen in Fig.3

- ***Taguchi method for optimization (DOE)***

For each experimental runs in DEFORM 3D, the maximum force in each operation was considered the stopping criteria, and "Percentage of die filling" was calculated for each run. For each run, the S.N ratio and Mean was calculated. The Fig 4 shows the Main effects Plot for S/N ratio, and the level of parameter which shows "highest Mean of S/N" ratio is the optimized levels for each parameter.

CHECK

- ***Validation of DOE results***

The optimized setting of die geometry as determined by Taguchi's method was validated first by 3D FE simulations. (Fig.5) it was found satisfactory. The CAD drawing was analysed and the die filling cavity was calculated. The mean and S/N ratio were found optimized and in close resemblance to that of results if Taguchi analysis.

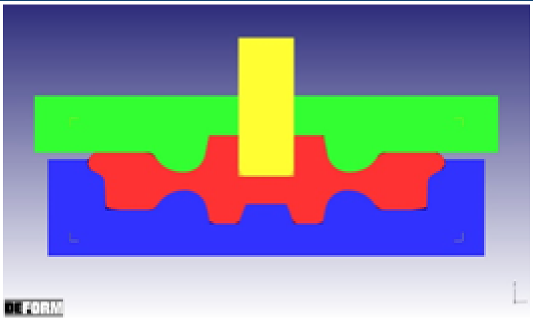


Fig.5: Checking of optimized geometry with 3D FE simualtion

ACT

- ***Trial implementation***

The optimized setting of die geometry as determined by Taguchi's method was used to manufacture dies of perceived designs. On completion of die manufacturing, Trial production of LOCO wheel production using optimized die geometry was undertaken. The results were analysed by physical measurement of the forged wheels. It was found satisfactory. All process parameters were noted down for further analysis and optimization. (Fig.6)

Fig.6: Results of Trial implemenation

It was found that the die filling has improved drastically, thereby enabling DSP to commence LOCO wheel production through BRC continuous casting route. In fact, the design was optimized considering various noise variables that we face in actual production, thereby developing a ***Robust die design.*** The use of Virtual 3D-FE simulation and Design of experiment techniques (DOE) enabled the trial phase to be highly expedited and also saved us huge amount of cost and time overrun.

4. Implementation

The complete stabilization of LOCO wheel production with continuous cast round bars (BRC) was achieved after successful trial implementation. With the successful finalization of die design, the team set up a roadmap for regular implementation. The key steps of Project implementation performed were:

- *Preparation of infrastructure:* Some of the logistic issues in our operational process for handling of these smaller diameter blocks and bars were identified by brainstorming. Accordingly, they were solved as enlisted in the table below:
    - ***Traceability:*** The issue of Traceability of Round Bars of Ø 370 mm was a major concern. It was decided that at SMS, proper colour-coding was to be introduced to ensure any mixing up of bars of different diameters
    - ***Storage of round bars:*** Ø370 mm bars are casted at BRC at 4.2m long length, which becomes very difficult to handle with EOT cranes. Proper stacking of these bars is a safety hazard. It was decided that a storage bin for these bars to be installed at wheel & axle plant for safe handling.
    - ***Issues with furnace height:*** The existing rotary hearth re-heating furnace, which is required to reheat the block before forging was not designed for block length of 965mm. Its hearth-to-roof distance was 950mm. Thus, a team of experts from refractory and mechanical was also consulted and the entire hearth was redesigned and modified to accommodate the higher length block
    - ***Issues with manipulator handling capacity:*** The manipulators grips used for handling hot blocks were also modified to enable gripping of blocks of smaller diameter.

- **Identify data points to be measured:** Key production parameters like pressure development and force requirement in forging press, Load generation wart. furnace soaking time, die filling index were established for the new route for enhance monitoring.
- **Set desired performance levels:** Target rate of production, optimum furnace temperature, soaking time, Pressure generation index in forging press, flash dimension and target dimension of forged wheel were established for this new route
- **Communicate the plan to stakeholders:** With metrics on the existing process in and knowing how we expect the new process to affect operations, it's crucial to relay that information to every stakeholder likely to be affected by the change. Structure training was implemented to all concerned persons mainly in Press and Furnace operations and maintenance,
- **Plan for review and evaluation:** Tracking of the wheels though the entire process line was ensured to review the performance of the product in different stages of inspection. This was critical in proper evaluation of the impact of the project.
- **Sustainability of the process:** The optimized die designs were documented and procurement drawings were developed for future sustenance. New gauges were developed for new die designs for proper monitoring of die dimensions.

With these initiatives, the stabilization and regular implementation of forging of LOCO wheels with Ø 370mm was successfully implemented.

- ***Green as a management concept:***

Being one of the largest producers of steel in the country, SAIL is committed to meet the demand for steel in a safe and sustainable way, without compromising the need of the future generation. The entire project is a testimony to SAIL's continuous endeavour for sustainable and green steel making. The following points portray how management aims to progress in its endeavour towards green steel making with this project:

- The project aims to enable SAIL-DSP to successfully convert 100%of its steel making through energy efficient continuous casting route of steel production. The main benefits of continuous casting over ingot casting are considerable energy savings, lesser scrap generation and reduced pollution. As per standard industry norms, Continuous casting process saves approximately 1 million BTUs per ton cast in comparison to BP route. At present DSP targets to annually supply 40,000 nos. LOCO wheel (0.583 ton/wheel) or 23,320 tons wheels to Indian Railways. With an average yield of 50% from ingot, which includes rejections, standard process loss, along with ingot discards, approx.46,640 tons of steel is required for this production. This steel required can be produced through Continuous caster (CC) route instead of bottom pouring. Thus, the project enables a saving of 46,640 million BTU of energy. This corresponds to a potential of **6,887 tons of CO2emission** saved annually due to implementation of this project.
- One of the major benefits of CC route of steel making is reduction in ultrasonic testing (UT) rejection. In fact, from an average UT rejection in bottom pouring route of 15%, caster route enables reduction of UT rejection to almost 1%. For the annual dispatch target of Wheel & Axle plant of 40,000 nos. of LOCO wheels, UT rejection accounts to approx. 7,000 numbers of wheels, or 4,081 tons of wheel production. As of FY22-23, for 21921 tons of wheel production, CO2 emission figure was 21,005 tons. Thus, the project also enables a potential saving of **3,910tonsof CO2 emission.**
- The implementation process for this project utilizes 3D FE simulation and Design of experiment techniques to stabilize the die design virtually. This has helped save an average 100 numbers (0.583 ton/wheel) of trial wheel production required for trial-and-error method of die design stabilization. Thus, the project implementation has ensured a saving of **55.86 tons of CO2 emission**.

Thus, management envisages a reduction of **10,852tons of CO2 emission** annually for a production target of 40,000 nos. (23,320 tons) of LOCO wheels, thus, helping in ***reduction in carbon footprints***.

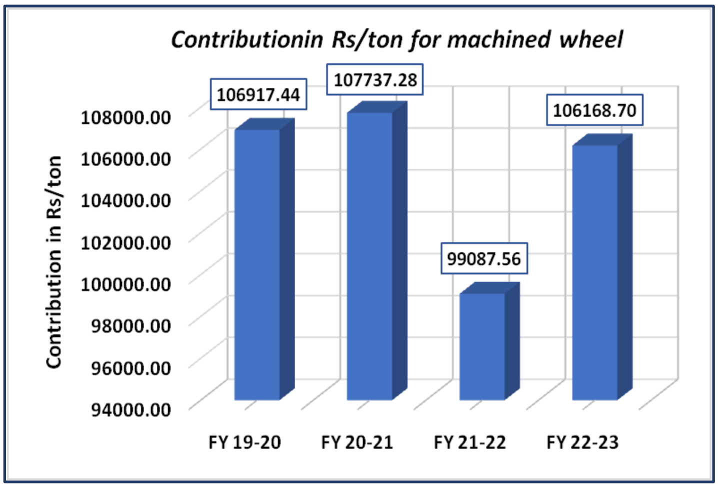
5. Results/Impact

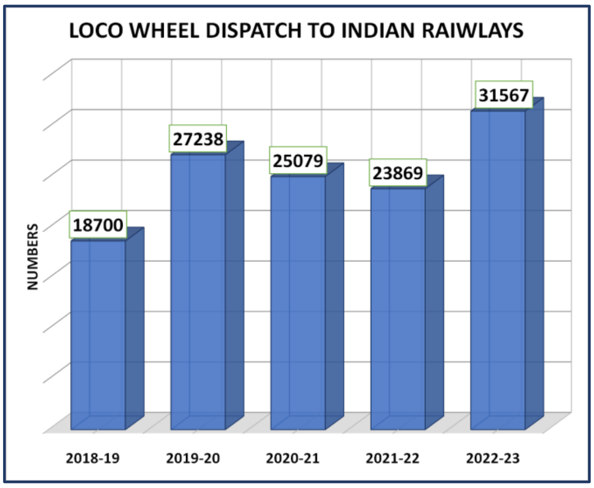
The continuous casting process saves energy directly through the elimination of energy intensive steps and results in increased yield. The unit cost of production for Bottom pouring route (B/P) is much higher than that of continuous caster route (CC) route of steel casting. Moreover, in ingots, there is top and bottom discards in ingots, which accounts to 7% of material loss as standard process loss. In BRC round bars, this discard is less than 2%. BRC route is characterized by improved surface quality resulting in negligible rejection at Block stage due to defects like pipe, cold-shut, metal beads, cracks etc. Another important aspect for CC route production is production of high-quality steel casting resulting in significant reduction in rejection due to UT testing. The average rejection figures for bottom pouring ingots are 15% while for CC round bars, UT rejection is < 1%. Railway wheels, being a safety product are subjected to stringent quality checks.

Each and every wheel after complete machining, are tested by Ultrasonic testing for internal flaws. The cost of wheel making as on Apr'23 is approx. Rs 1,48,409/- per tonnes. Thus, rejection at the final stage due to UT rejection causes huge loss to the company. Thus, implementation of this project enables DSP to completely shift to CC route of production for LOCO wheel making, thereby providing tangible benefits to the company.

Mandatory parameters:	Before (using BP ingots)	After (using CC bars)	Unit of Measurement
1.Productivity details: ➢ Yield of finished round from crude steel ➢ Reduction in process loss during wheel making for reduction in top and bottom discard losses	➢ 70-80% ➢ 7%	➢ 98% ➢ 3%	➢ % ➢ %
2. Reduction of rejects and rework • Block stage rejection (Pipe, cold-shut, metal beads etc.) • UT rejection	➢ 3% ➢ 15%	➢ Nil ➢ 0.5%	➢ % ➢ %
3. Quality ➢ Yield of wheel production ➢ Overall rejection in wheel(Incl. machining rejection, UT rejection, MPI, Hardness)	➢ 43.88% ➢ 28.47%	➢ 53.88% ➢ 15.13%	➢ % ➢ %
4. Direct Cost or Cost per piece/unit • Cost comparison between bottom pouring route & CC route of casting rounds	➢ Rs 54,790/ton	➢ Rs 48,459/ton	➢ Rs/ton
5. Manpower cost for B/P and CC route	➢ Rs 899.35/ton	➢ Rs 270.45/ton	➢ Rs/ton
6. Total Cost break-up for B/P and CC route • Material cost • Operating Cost	• Rs 48,150.15 • Rs 6,686.995	• Rs 46,789.56 • Rs 1,669.258	• Rs/ton • Rs/ton
7. Safety	>Old labour-intensive process. >More material handling due to increased scrap generation	Latest Automated process with less manual interventions.	

All these have resulted in improved contribution/ton in FY 22-23 for machined wheel by increased saving in variable cost. This has improved productivity and profitability of DSP and enabled increased dispatch of LOCO wheel to Indian Railways drastically in FY22-23. *It ensured DSP to cater to the entire LOCO wheel requirement of Indian railways, thereby ushering a new testimony for "AtmaNirbhar Bharat"*





6. Business Sustainability and Future Focus

The stabilization of CC round bars for production of LOCO wheels has been a game changer for DSP. Few of the important highlights that this project has achieved are as follows:

- Previously, due to stringent inspection norms, INDIAN RAILWAYS has imposed batch criteria in Ultrasonic testing of Wheels. It means that, if 5% wheels of a particular batch or Heat is rejected in UT testing, the entire batch would have to be rejected, irrespective of whether those wheels are conforming to the testing criteria or not. This was a major bottleneck for Wheel & Axle pant, and adversely affected the dispatch of wheels. But, with the stabilization of modern CC route, which ensures ultra clean steel and high quality of casting, Indian Railways, on observing a 0.5% UT rejection in the new route has waived the batch criteria for inspection of wheels. This portrays the trust that our customer has imposed on DSP and has helped DSP to increase the dispatch of LOCO wheels drastically in FY22-23. In-fact in the true spirit of building an "AtmaNirbhar Bharat", DSP catered to the major LOCO wheel requirement of Indian Railways.

- The pace of project implementation which utilized modern FE simulation and DOE techniques for die design stabilization has also enable DSP to develop new wheels for Indian railways. With expertise in latest techniques in metal forming, DSP has fulfilled orders for supply of latest LHB wheels to Indian Railways.
- The project has also earn customer's confidence, which can be realized from the fact that at present, DSP has got developmental order for developing wheels for "***Train-18 Vande Bharat*** *Express*", as an shining testimony of "AtmaNirbhar Bharat"

Thus the project enables DSP to capture market share for new railway wheels in a cost competitive approach.

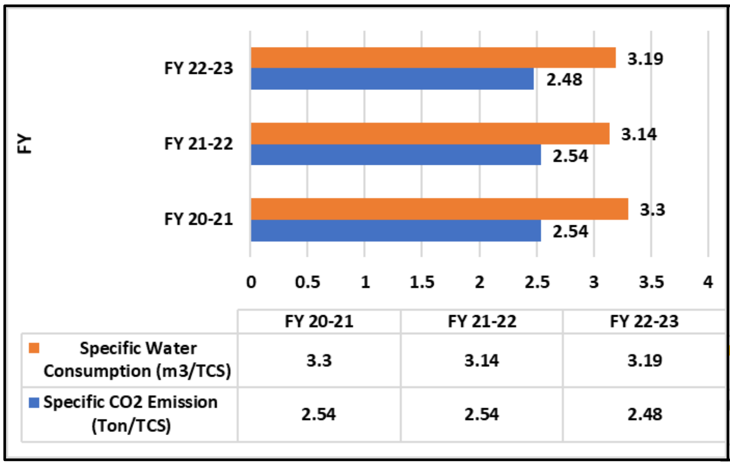
7. Resource Impact

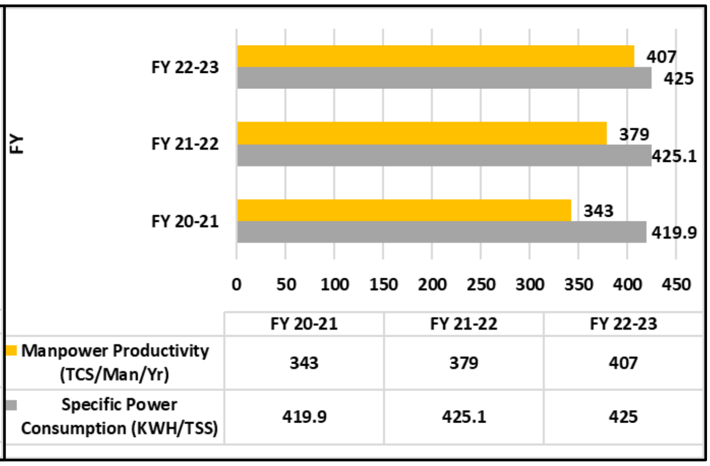
The project ensures energy efficient production of steel through CC route for production of LOCO wheel. Apart from ensuring profitability for the company, the project has tremendous impact on our resources. The caster route enables

- Considerable energy savings: approx. 1 million BTU / ton of steel production
- Less scrap produced: Mainly, the saving of bottom and top discards of the ingots (7 %)
- Improved yield: A reduction of rejection in UT of wheel from average 15% to less than1%. Also saving of process loss due to ingot end cuts improves yield by 7%.
- Improved labour productivity: Saving of costly manpower in labour intensive ingot stripping process
- Improved quality of steel: Application of latest Automation in CC steel making ensures production of ultra clean steel
- Reduced pollution: Hot steel is exposed to the atmosphere for a shorter time, producing fewer airborne particulate. The yield is increased which means that less primary steelmaking is required for a greater level of shipped steel. This means less coke manufacture in integrated plants using blast furnaces; coking is the largest source of pollution in steelmaking, particularly of toxic substances.
- Lesser scrap generation as a result of increase yield
- Lesser refractory waste generated.
- Savings in Consumption of Moulds, APC & FLUX.

Based on the analysis for Green targets for management, the project enables a potential of reducing 0.46 tons of CO2 emission/ Ton of Loco wheels produced. ***In FY22-23, 16,000 nos. of Wheels were produced through CC route. Thus, the project saved 4,290 tons of CO2 emission.*** All these had a positive impact on the techno-economic parameter of DSP as can be ascertained from the table below:

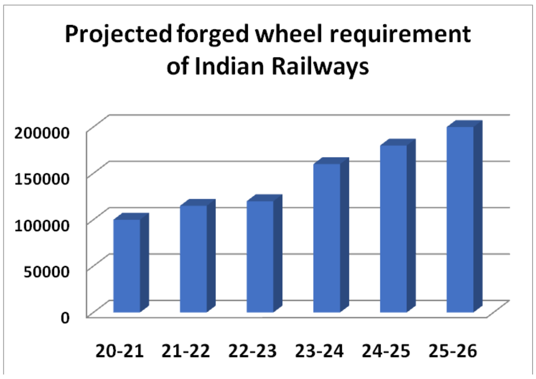
Parameters	FY 22-23	FY 21-22	Unit of Measurement
1. Specific CO_2 Emission	2.48	2.54	Ton/TCS
2. Specific Water Consumption	3.19	3.14	(m3/TCS)
3. Specific Power Consumption	425.0	425.1	KWH/TSS
4. Manpower Productivity	407	379	TCS/Man/Yr





8. Business metrics

- The project is seen as a key achievement in the field of railway wheel making. The entire die design is unique since forging of LOCO railway wheel of diameter Ø 1098 mm was achieved from round bars of Ø 370mm x 965 mm. In this context, it is noteworthy to mention that all over the world, forging of such narrow bars in a single upsetting and forming process is unique. This project ushers a new avenue in die design for railway wheel forging, and helped DSP in manufacturing LOCO wheels in a cost-efficient process.
- Now, forged Railway wheel is a niche product for any industry as it fetches one of the highest NSR. Infact, in FY22-23 average NSR of railway wheel was Rs 1,88,864.1/ton. Thus, even with only 3% of the total production volume of DSP, railway wheels contribute towards about 10% of the total profit. Wheel & axle plant of DSP was been a key driver in AtmaNirbhar Bharat endeavour. Over the years, we have developed 11 different types of Railway wheel.
- This project has helped DSP in ramping up of its LOCO wheel production. With the elimination of cast criteria and improvement in techno-economics, stabilization of LOCO wheel production through CC route has given DSP the edge in capturing of market share.
- Railway wheel is a product of national importance. Since 1960, DSP has been a major indigenous supplier of railway wheels. Infact, DSP has been the sole supplier of forged railway wheels to Indian railways till last year, until Forged wheel Plant, Raebareli was commissioned. The balance wheels are imported. With geo-political tension like Ukraine-Russia war, and government's focus on indigenous manufacturing, there lies a wide scope for DSP to capture the market share for railway wheels in India.



- Railway wheels are manufactured in two ways – forging route or casting route. However, for high speed trains and locomotives, forged wheel are preferred due to its high strength and durability. *According to Indian Railways estimation the requirement of wheels will go up to **2 Lakh per annum by 2026**with the induction of more semi-high speed trains.* With the government push for electrification in its aim to become a "Net Zero Carbon Emitter by 2030" and rapid investment for dedicated freight corridor, the demand for LOCO wheels, mainly WAG-09 loco wheels are bound to increase.
- With its cost efficient production route for LOCO wheels, and in-house expertise in die design and product development through 3D FE simulation and Design of experiments, DSP is posed to gather pace in increasing its dispatch and capturing market share for forger railway wheels.

9. Scope for horizontal deployment

- The technique of using Design of experiment (DOE) with 3D Finite element simulation is a cost effective process of analysing metal forming and optimization. This technique has been shared with other rolling mills of our company for optimizing metal flow in rolling mills. Various Shape rolling modules in FE code are being utilized in our rolling mills using these ideas.
- The study portrays an approach towards cost optimization and product development. This has been utilized in our plant for developing new railway wheels, latest being that of Train-18 Vande Bharat Express.
- Analytical study of process parameters, optimization of roll and die profiles, and optimization of metal working process are some of the future scope of horizontal deployment of this techniques.
- Planning is underway to enhance utilization of DOE and 3D FE simulation models in expediting product development in all finishing mills, with the aim to increase market share by tapping export potential.