Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

Research Article

A Study of the Operational Efficiency of SAIL Plants Using SAP-LAP Framework

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ARTICLE INFO

Received: 29 Sept 2024

Revised: 12 Oct 2024

Accepted: 27 Nov 2024

ABSTRACT

Steel is one of the most essential products of the modern world and is strategically important for any industrial nation. The steel industry is characterized by high capital intensity, high dependence on bulk raw materials, cyclical growth trends, perpetual over-capacity, and relatively low profitability. This is why the problems associated with the steel industry are generally complex, and the Indian steel industry faces several challenges, including competition from foreign players, rising costs, and increasing environmental regulations. Therefore, it becomes crucial for the Steel industry to adopt efficient management practices that can help it overcome these challenges and improve its performance. Steelmakers need a flexible system management paradigm and a Holistic Framework. One such framework is SAP-LAP, which aims to streamline business processes and enhance efficiency. The SAP-LAP model gives better insight into the status of the case problem, expectations from that case problem, and how to change these expectations into reality. The flexible model of the SAP-LAP, along with internal and external environments, also considers the impact of the dynamic environment on inter-organizational systems and intra-organizational systems. This case study analyzes the challenges faced by the Steel industry and how the SAP LAP framework can help overcome these challenges. The study is based on secondary data sources and Expert views based on open-ended questionnaires from SAIL steel plant senior and middle-level Executives with an experience of more than 15 years in the Indian steel industry. The experts' views were transformed into the SAP-LAP framework and the SAP-LAP analysis. The findings of the study present a report, which serves as a valuable resource for businesses operating in the Indian steel industry or any other sector looking to improve their efficiency and management practices.

Keywords: SAP-LAP Framework, Steel Industry, operational efficiency, Key performance Indicators, productivity, quality, Raw Material utilization.

1. INTRODUCTION:

1.1 OPERATIONAL EFFICIENCY

To sustain in the competitive market, it is required to cater to the products at the required quality standard, optimum utilization of resources, and within a minimum lead-time with on-time delivery by improving Operational efficiency.

2 OPERATIONAL EFFICIENCIES OF THE STEEL PLANT:

Based on Key Functional Areas of Operations Management, the operational efficiency of a steel plant refers to how effectively and productively the integrated steel plant operates to achieve its Goals and Objectives. Key performance indicators considered to measure process and operational efficiency in the steel plants are**:** Raw Material Utilization: productivity, Quality control**.**

3. SAP–LAP FRAMEWORK:

The present study uses an interpretive method, namely 'situation– actor - process–learning– action–performance' (SAP–LAP) analysis, to enhance the understanding and analysis of business excellence. The data is collected from

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Journal of Information Systems Engineering and Management
2024, 9(4s)
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the Annual reports, QMS reports, and Sustainability reports available on the organization's website. The collected data is analyzed for Situation, Actor, and Process, and based on this analysis, suggested Learnings and actions.

4. SAIL AND ITS INTEGRATED STEEL PLANTS:

SAIL is an Indian state-owned steel-making company with an annual turnover of Rs 103480 crores. SAIL operates 5 integrated steel plants at Bhilai, Bokaro, Rourkela, Durgapur, and Burnpur with an annual capacity of 20.63M T. Stiff competition from private players and exports has made the business more challenging and competitive. For in-depth analysis and finding solutions for sustainability SAP LAP framework is being considered for the case study.

4.1 SAP-LAP Framework for SAIL integrated steel plants. The SAP LAP framework has gained popularity due to its comprehensive approach and ability to integrate different business processes seamlessly. while the SAP LAP framework has been widely used to improve efficiency in business management, its effectiveness in the Indian steel industry remains unexplored. This study seeks to address and examine the operational efficiency of SAIL-integrated steel plants through the SAP LAP framework.

5. LITERATURE SURVEY:

Sumit Kumar and Pardeep Gupta (2020)" Case Study on Business Excellence Issues of an Indian Automobile Manufacturer Using SAP-LAP Framework." This study focused on improving Business Excellence by the application of an interpretive framework that helps in multi-criteria decision-making. The organization was facing issues in achieving business excellence. SAP-LAP framework methodology has been adopted for analysing managerial context and to aid management decision-making to enhance the understanding and analyse the business excellence issues in ABC Ltd.

Based on SAP analysis, learning issues are identified, and actions are suggested with a proposed set of performance parameters. The findings of the study revealed the need for the formulation of an energy liaison policy, a focused maintenance approach with the adoption of latest technology, and the use of IT for cost management.

It was observed that in a situation of high inflation, an organization can become cost-effective by going for an alternate source of power, and the quality rejection rate in the organization was high due to the poor quality of parts supplied by vendors. So, this paper suggests helping with the implementation of quality management at the supplier end.

Tapan Kumar Sahoo D K Banwet and Kiran Kumar S Momaya (2010). Strategic Management in Practice: Dynamic SAP LAP Analysis of an Auto Component Manufacturing Firm in INDIA. The paper examined the reality of Strategic Technology Management (STM) in the Indian context. This study examines the longitudinal technology development at an auto component manufacturer in India and analyses the linkage between STM and business performance using the SAP-LAP analysis.

The case has been analysed using a flexible system methodology based on the SAP-LAP (Situation-Actor-Process, Learning – Action Performance) framework to evolve the 'learning issues' regarding the actual practices and to bring out the 'suggested actions' for 'improvement in the performance'. The methodology is applied in two steps, comprising SAP analysis and LAP synthesis. The findings of the SAP-LAP Analysis are that the Organizations need to have a strategic intent and are required to put in efforts to build technological development capabilities. Both active technology development and technology transfer play a key role in developing the organization's technological capabilities. The benefits of technical collaborations can be drawn to the best extent only with the parallel upgradation of the local manpower and design and evaluation capabilities. Organizations need to absorb and further build upon the technical know-how to attain a long-term technological edge.

Dr. Ramandeep Kaur (2021) "Deconstructing De-globalization As a Challenge using the SAP-LAP Analytical Model: A Case Study of the Indian Economy". Before the global financial crisis (2008), emerging market economies saw vigorous global demand, substantial improvements in terms of trade, and abundant capital inflows. However, trade growth has been frail after the financial crisis. It has been found that the world is moving towards the de-globalization era, and the developed nations have marked their instigation. The United States, Britain, and India have adopted the policy of deconstructing De-globalization. In the current study, the SAP-LAP analytical

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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
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model has been used to understand the variables that have brought the shift in paradigm towards deglobalization in India. The objective of the study is to apply the SAP-LAP framework to analyse the determinants consisting of 'situation', 'actors' and 'processes and 'learning', 'action', and 'performance' leading to de-globalization in the Indian context.

To measure the extent of de-globalization, the Globalization Index was chosen, as it very efficiently measures the extent of a country's interdependence with the rest of the world. In addition to indicators on economic and social interconnectedness, and how politically integrated a country is with the rest of the world. The period under review is from 1990 to 2016. The index ranges between 0 and 100, and the higher the number of points on the index, the more interconnected that country is with the rest of the world.

The globalization index can be seen in the Indian economy, which indicates that there is huge growth potential, but the degree to which it is interconnected is still very low. Also, India's score from 2007-2016 is almost the same, around 30; therefore, it can be interpreted that its interconnectedness with the rest of the world, during the post-financial crisis, is also almost stable and is not growing further. It is also observed that the effect of a financial crisis can be seen in every trading economy.

6. DISCUSSION

6.1 AIM AND OBJECTIVES

- **Aim**
  - The main aim of this study is to implement the SAP-LAP framework to increase the efficiency of the Indian Steel industry.
- **Objective**
  - To identify the parameters for measuring operational efficiency in steel plants.
  - To carry out SAP-LAP analysis of SAIL units for the last 5 Financial years, 2018- 2019, 2019-20, and 2020-21, 2021-22, 2022-23.
  - Comparing the operational efficiency of SAIL units BSP, BSL, DSP, RSP, and ISP.
  - To suggest strategies for enhancing operational efficiency.

6.2Research Methodology:

The Research work aims to compare the overall operational efficiency of 5 Integrated Steel Plants under the umbrella of SAIL. Every integrated steel plant works in a value chain of different units working in coordination as one is the input material supplier to the other, till the final product reaches the customer. The focus is to do a critical analysis of each plant with a detailed study of the different units of each plant that are working in coordination with each other to improve the overall operational efficiency of the plant.

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https://www.jisem-journal.com/
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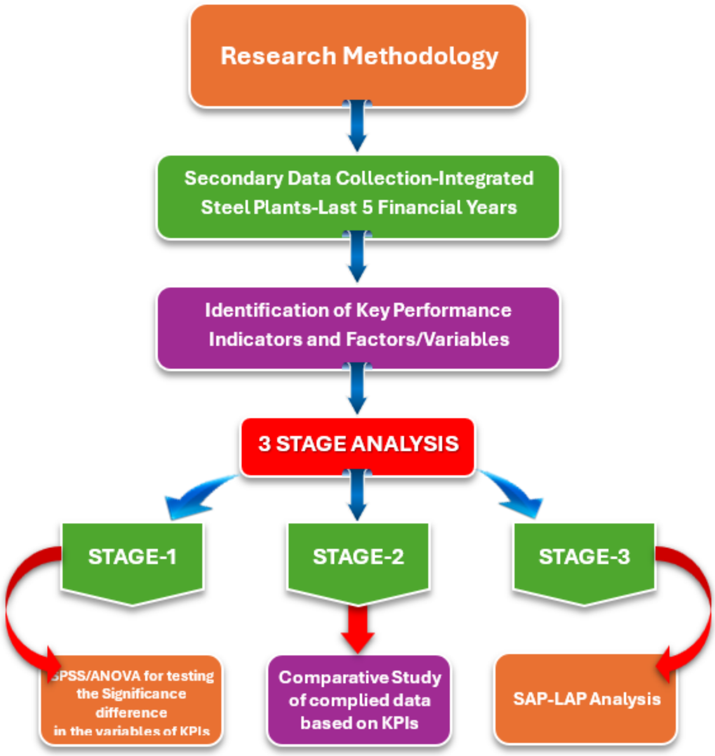

6.3Data Collection

- **Secondary Data:** Secondary Data is considered from the Annual reports, Individual plant statistical reports, RDCIS operational reports, Sustainability reports, websites, journals, and books. The study is focused on the SAP-LAP analysis of integrated steel plants of the last 5 years, so the secondary data collection will be for the last 5 Financial years, 2018-19, 2019-20, and 2020-21,2021-22,2022-23.
- **Sample size-** Experienced steel plant executives having a minimum experience of 15 years in a steel plant at the level of ED/GM/DGM level in different Integrated steel plants of SAIL.
- **Primary data:** The secondary data results are transformed into a questionnaire for experts' views, and the primary data is used to define the criteria for usage of the SAP-LAP Framework for further analysis and ranking of SAIL plants based on operational efficiency.

7. COMPARATIVE STUDY BASED ON SECONDARY DATA:

Examining the issues related to the operational efficiency of manufacturing units of integrated steel plants, key performance Indicators are considered that offer a comprehensive view of integrated steel plant operations with a focus on sustainability.

- **Productivity:** The study evaluates productivity through parameters such as BF coke yield from dry coal, sinter productivity, and yields from charge mix, blast furnace productivity, crude steel yield from a total metallic charge in BOF, continuous casting yield, and the yield of various operating mills across different plants.
- **Raw Material Utilization:** In the blast furnace route of steelmaking, raw material consumption accounts for more than 85% of manufacturing costs in the iron-making zone. Thus, meticulous utilization and a focused approach to cost, availability, and metallurgical properties are essential.
- **Quality Control:** The study assesses various quality control parameters, including coal blend proportions (indigenous and imported), coke properties (M40 and M10), coal-to-hot metal ratio, coke rate, fuel rate, coal dust injection, sinter burden, and slag rate in blast furnaces.

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7.1 DATA Analysis based on comparative study:

key performance indicators data is compiled from 5 Integrated steel plants under the umbrella of Steel Authority of India Limited. The secondary data is collected from SAIL annual reports of the last 5 financial years (2018-19,2019-20,2020-21,2021- 22,2022-23), Sustainability reports of SAIL, Annual operation statistical reports of 5 integrated steel plants (BSP, BSL, RSP, DSP, and ISP) journals, and magazines. Statistical and qualitative analyses have been done considering the focused parameters for each performance indicator of the operational efficiency of SAIL plants.

7.2 Analysis of the comparative study:

BSP's Contribution in Hot Metal, Crude Steel, and Saleable Steel Production Was 27%, 28%,26%, respectively. In contrast, BSL's contributions were 23%, 22%, and 22%, respectively. RSP Contributed 22%, and 22%, 21% Respectively, but the Profit Figures Show a Remarkable Performance by BSL With 32% Share and RSP Stood Second With 23.30%, and BSP Despite High Volume in All three Production Areas stood 3rd With 23.26% Contribution. Even With Less Volume Of HM, CS, and SS, Production Of 13%, 12%, and 10% of the total SAIL figures for both DSP and ISP made a Profit for The Last Consecutive 3 Years, which were Otherwise Loss-Making Units for years together.

Table -1 Productivity figures of SAIL Plants

Average Of 5 Years	BSP	BSL	RSP	DSP	ISP
Bf Coke from Dry Coal	76.1	69.28	69.2	68.77	69.16
Sinter Productivity (2&3)	1.106	1.109	1.297	1.028	1.26
SP (Yield from Charge Mix) %	73.32	72.16	69.12	68.77	77.54
Bf Productivity	1.72	1.679	1.873	1.656	1.92
Crude Steel from Metallic Charge	86.56	88.78	88.32	88.16	91
Mill Yield	93.99	91.64	87.17	92.8	95.31

Table 2: RMU of the Average of 5 years of SAIL plants.

Parameters	BSP	BSL	RSP	DSP	ISP
Iron Ore	572.4	569.2	445.6	520.2	372.45
Sinter	1105.6	1146.4	1261.8	1113.4	1287.97
Coke Dry	459.86	482	422.4	467.4	398.2
CDI	75.36	56.6	116.6	51	95.6
Nut Coke	26.32	227.4	30.8	20.4	60.6
TMI Kg/T	1137.28	1139.4	1140.7	1116.27	1111.8
Hm	1021.44	1022.16	1052.2	1051.8	1073.6
Steel Scrap	109.79	104.42	85.5	65.2	38.5
Lime+calcined Dolo	92.6	79.6	114.02	104.58	90.13

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Journal of Information Systems Engineering and Management
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Table 3-Quality Control Analysis of SAIL PLANTS (Average) - 1

Parameters	Units Of Measurement	BSP	BSL	RSP	DSP	ISP
CDI	Kg/T Of Hot Metal	75.46	56.6	116.6	50.938	95.6
Sinter In Burden	%	65.88	66.286	73.59	68.15	76.978
Slag Rate (Kg/T)	Kg/T Of Hot Metal	452.2	400	383	348	356.5

Table 4-Quality Control Analysis of SAIL PLANTS - 2

AVERAGE OF 5 FINANCIAL YEARS 2018-19 TO 2022-23						
PARAMETERS	UNITS OF MEASUREMENTS	BSP	BSL	RSP	DSP	ISP
COAL BLEND						
INDIGENOUS	%	9.22	15.95	10.732	16.31	6.34
IMPORTED	%	90.78	84.05	89.27	83.69	93.66
M40	%	85.82	78.136	79.34	82.14	86.36
M10	%	6.8	9.224	8.632	7.5	6.3
COAL TO HM	RATIO	0.9058	0.937	0.95	0.9462	0.939

Table 5- Financial Figures of SAIL Plants

(Rs. In Crores)	**2022-23**	**2021-22**	**2020-21**	**2019-20**	**2018-19**
SAIL-Profit After Tax	1,903.00	12,015.00	3,850.02	2,021.54	2,179.00
BSP	376.16	2,240.34	1,095.81	1,799.03	509.37
DSP	638.88	1,004.37	733.07	-442	278.62
RSP	521.07	5,610.26	2,106.40	-409.2	1,472.21
BSL	840.84	6,052.86	2,251.50	48.44	1,916.49
ISP	339.77	661.82	66.51	-1,091.69	-402.05
SAIL (Rs. In Crores)	**2022-23**	**2021-22**	**2020-21**	**2019-20**	**2018-19**
Sales Turnover (Gross Sales)	1,03,768	1,02,805	68,452	61,025	66,267
Net Sales	1,03,768	1,02,805	68,452	61,025	66,267
EBIDTA	9,379	22,364	13,740	11,199	10,283
Depreciation	4,963	4,274	4,102	3,755	3,385

Table 6-AVERAGE OF 5 YEARS OF SAIL Plants

Average of 5 Years (Rs. In Crores)	**BSP**	**BSL**	**RSP**	**DSP**	**ISP**
Sales Turnover	22048	4485.76	**17182**	9603	9562
Total Income	23006	5751	**19177**	10179	9956
EBITDA (Back Calculation)	3,269	1574.82	**3488**	875	1128
Depreciation	**1046**	112.316	974	253	774
Financial Cost (Interest)	**937**	331	550	202	421
PBT (Before Exceptional Items)	1286	1535.2	**1964**	421	-67
Exceptional Items	75	17.6	164	-35	23
PBT (After Exceptional Items)	1211	1546.85	1860	456	-90
Depreciation, Fin Cost	1983	443.32	1524	455	1195
PBT	1204	**1544.13**	**1860**	443	-85

8. SAP-LAP ANALYSIS:

Data collected from different SAIL plants for the last five years has been analysed in 3 stages. The secondary data collected has been tabulated into key performance indicators, and other factors were identified for each KPI. The first stage, SPSS and ANOVA are applied to test the significant differences in the variable (here Factors) of each KPI across the five different steel plants. In the second stage, analysis is done by the comparative study of SAIL plants of 5 years and an average of compiled data. In the third stage, the SAP-LAP framework technique is used to get the final findings of our analytical work on the improvement of the operational efficiency of SAIL plants. Based on the Expert's views SAP-LAP Framework was developed, and an analysis was done for each KPI. For each KPI, Contextual relationship to find the influence of the actor's role in the process and the influence of actions on various performances. This is done by forming a Binary matrix followed by an Interpretive matrix of binary influence. Then the interpretive logic and the knowledge base are formed considering each actor's comparative dominance in every process. Then the Dominating interaction matrix is used the rank actors, considering that each process tabulation is done. Finally, the clear picture in the form of a Dominance matrix ranking of actors' roles concerning processes will be figured out. A similar process is repeated for ACTION considered as Rank Variables and PERFORMANCE considered as Reference Variables. The whole exercise of SAP-LAP analysis indicates final learnings and a clear-cut picture of the ranking of the involved team members and actions, which are the central concern of the management process and decision-making.

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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
https://www.jisem-journal.com/

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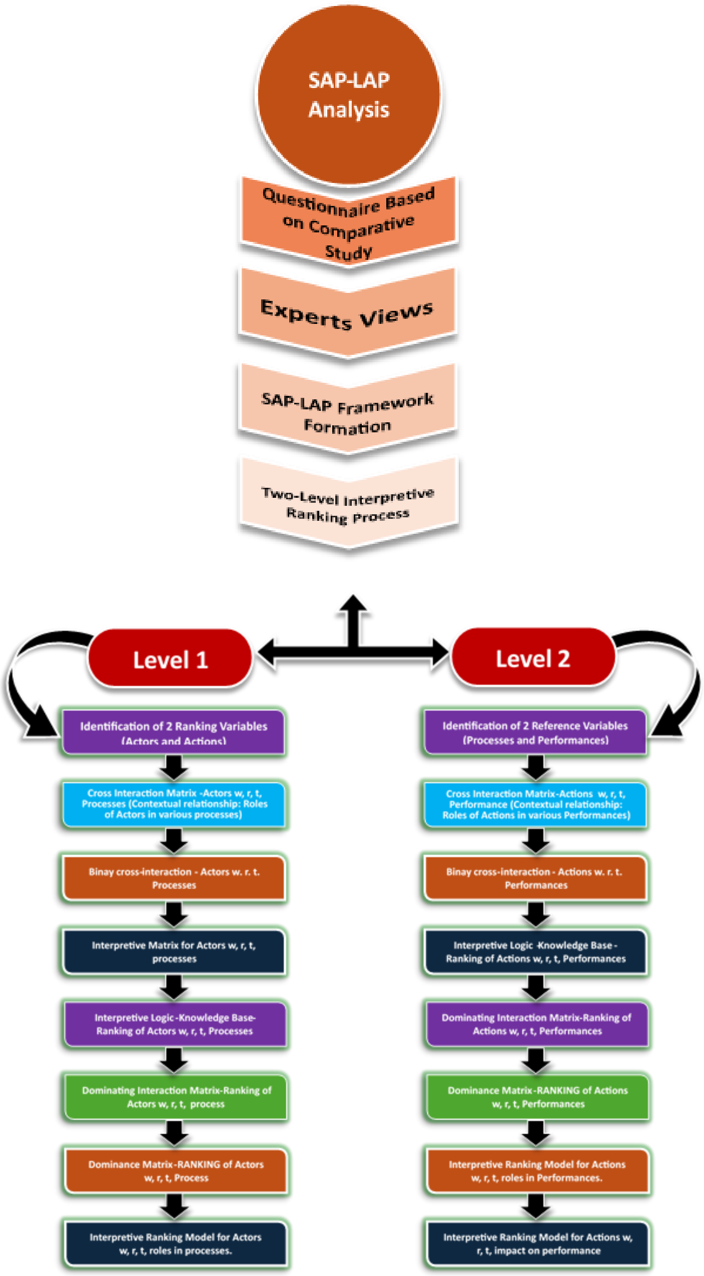
SAP-LAP FRAMEWORK



8.1 SAP-LAP PRODUCTIVITY

	SITUATION-PRODUCTIVITY
S1	Fe% % in sinter should be more than 54%
S2	Building new stamp charging batteries and dismantling old coke oven batteries.
S3	A Mean size of 20-40 mm is used in SAIL BFs.
S4	Challenges that hinder the operational efficiency of sintering plants are Raw material quality, sintering process, and equipment maintenance

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Journal of Information Systems Engineering and Management
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e-ISSN: 2468-4376
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S5	More consumption of prepared Burden.
S6	The average BSP coke rate was as high as 459 Kg/T, and that of ISP was the lowest at 398 Kg/T
S7	TMI figures are good for the ISP compared to other Steel plants.
S8	Higher BF productivity at ISP & RSP.
S9	Crude steel production from the metallic charge needs to be at a maximum.
S10	Slag rate is a critical parameter in BF operation, impacting productivity, fuel efficiency, and hot metal quality
S11	Sintering is the most appropriate choice for SAIL's integrated steel plants
	ACTORS-PRODUCTIVITY
A1	HOD of Sintering Plant.
A2	HOD of OHP
A3	Top Management of individual plants
A4	HOD Mines
A5	Raw Material Supply In charge
A6	COKE OVENs In charge
A7	HOD BFs
	PROCESSES-PRODUCTIVITY
P1	Proper mixing of input material to the Sinter machine bed for sinter formation.
P2	Better optimization of sinter, pellets, and good quality lumps at BFs.
P3	More focus on raw material quality, and their mixing proportions improves sintering efficiency.
P4	More sinter usage leads to good sinter porosity and better gas permeability, and good waste utilization
P5	Learnings from ISP (Best-Performing Plant): Ensure consistent, high-quality Coke, Raw Material Mix, and Injection Practices.
P6	Focused approach to use prepared burden, reduce Iron Ore consumption.
P7	Metallic charge optimization- Balance scrap. DRI and Hot Metal.
P8	Improving raw material quality and optimizing burden preparation
P9	Sintering is a thermal agglomeration process, suitable for Iron ore fines, Iron-bearing waste, Coke fines, and Fluxes (lime, dolomite)
	LEARNING-PRODUCTIVITY
L1	Technological discipline in the form of the proper size of input materials, homogenizing in the Nodulizer.
L2	Reduction in operational cost due to reduced oven compartments, and the ability to use lower-grade coal
L3	Minimizing Sinter returns will improve the efficiency of Sintering and BF operations.
L4	Development of cluster-centric culture.

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Journal of Information Systems Engineering and Management
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L5	Maximizing waste and fines utilization and optimizing iron ore utilization.
L6	The actions considered in the process will improve the operational efficiency of the sintering plant.
L7	Optimization of Sinter consumption improves porosity and quality
L8	Learnings from ISP (Best-Performing Plant)
L9	Regular review and implementation of best practices will drive continuous improvement.
L10	Emphasis should be on improving BF productivity.
L11	Higher crude steel production from a minimum metallic charge.
L12	Reduction in slag rate influences the operational efficiency of BFs.
L13	Sintering is the most appropriate choice for SAIL's integrated steel plants
	ACTION-PRODUCTIVITY
Ac-1	Care to be taken in crushing, mixing, and homogenizing feed to the sinter bed.
Ac-2	Strict technological discipline is to be adhered to at SPs to supply good quality and the specified size to BFs.
Ac-3	Strategy to increase prepared burden usage.
Ac-4	Implementing advanced process control systems.
Ac-5	As the data indicates, RSP and ISP's Sinter consumption is high, and subsequently, Iron ore consumption is less, and BF productivity has improved.
Ac-6	Identify best practices from the ISP and implement them across plants.
Ac-7	Material Balance Analysis, raw Material Quality Control, process Optimization, and Technological Upgradation.
Ac-8	Focused approach to using prepared burden, reduce Iron Ore consumption.
Ac-9	KPIs to be tracked are the crude steel production rate, Metallic charge utilization, and scrap-to-hot metal ratio.
Ac-10	The actions to be taken, considering factors directly influencing slag rate reduction in BFs, are Raw Material Quality and Burden preparation.
Ac-11	Sintering: High iron ore fines utilization, Efficient recycling of iron-bearing waste, Improved blast furnace productivity, Enhanced reducibility and strength, Cost-effective and widely adopted technology.
	PERFORMANCE-PRODUCTIVITY
Per-1	Maximizing Sinter Machine Productivity
Per-2	Stamp charging increases the bulk density by 30-35%, and the productivity of the oven will increase by 10-12 %.
Per-3	Improves permeability and reducibility at BFs, enhances smooth gas flow, smooth descent of burned, and finally increases productivity.
Per-4	Enhance collaboration, employee engagement teamwork to improve quality and productivity.
Per-5	Improved BF Efficiency, enhanced productivity, reduced raw material cost.

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Per-6	These improvements can lead to increased productivity and reduced cost of the sintering plant.
Per-7	Regular review and analysis of data will ensure continuous improvement and sustainability.
Per-8	By adopting the strategies of ISP, SAIL plants can reduce coke consumption and improve efficiency.
Per-9	Optimization of metallic input can reduce cost and enhance productivity.
Per-10	Raw material quality and burden preparation can significantly improve BF productivity, efficiency overall sustainability.
Per-11	By focusing on these issues, SAIL plants can improve crude steel production efficiency, reduce costs, and enhance overall plant performance.
Per-12	Reduced slag rate, improved hot metal quality, increased productivity, Enhanced fuel efficiency, better environmental performance
Per-13	Efficient recycling of iron-bearing waste, improved blast furnace productivity

Exhibit-1

BINARY CROSS INTERACTION MATRIX FOR ACTORS w, r, t, PROCESS-PRODUCTIVITY-1

	P1	P2	P3	P4	P5	P6	P7	P8	P9
A1	1	X	1	1	1	X	X	X	1
A2	1	X	1	X	1	X	X	1	X
A3	X	1	1	X	1	1	1	X	X
A4	X	X	1	X	1	X	X	1	X
A5	1	X	1	1	1	1	X	1	1
A6	X	1	X	X	1	1	X	X	X
A7	X	1	X	1	1	1	X	1	X

Exhibit-2

INTERPRATIVE MATRIX ACTORS w, r, t, PROCESS-PRODUCTIVITY-1

1	P2	P3	P4	P5	P6	P7	P8
per g of s of rgical es to ter nine for TER tion	**X**	**More focus on raw material quality and their mixing proportions**	**More Sinter usage improves porosity, better gas permeability.**	**Learning the best practices from ISP like more sinter usage**	**X**	**X**	**X**
ring input OHP s to	**X**	**Focusing more on raw material quality leads**	**X**	**ISP's focus at OHP for handling Raw**	**X**	**X**	**Improving Raw material quality has a**

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e-ISSN: 2468-4376
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oved ing ncy at RING nt.		to good mixing at Nodulizer at SPs		Material resulting in best productivity at SINTER plant.			direct effect on BF productivity.
	Emphasis by top management of plant for the Usage of more proportion of SINTER, have better effect on BF productivity.	More focus on raw material quality checks up and their mixing proportions leads to better BF Efficiency	X	Learning of best practices from ISP like more sinter usage leads to good BF efficiency.	Focused approach to use prepared burden, reduce Iron Ore consumption,	Metallic charge optimization at BOF reduces blow time	X
	X	More focus on raw material quality checks up and proper handling during transportation leads to better efficiency at mines.	X	ISP's best performance indicates that initial focus at OHP for handling Raw Material was taken due care.	X	X	Improving Raw material quality has direct effect on BF productivity
of r urgical to e r R ion	X	Quality raw material supply affects operational efficiency at SPs & BFs	Fines Quality supply leads to better quality of SINTER to BF leading to improved BF efficiency	Learning of best practices from ISP like more sinter usage leads to good BF efficiency.	Focused approach to use prepared burden, reduce Iron Ore consumption,	X	Improving Raw material quality have a direct effect on BF productivity
	Quality COKE supply improves BF productivity.	X	X	ISP's performance is the best due to better coke supply from COKE OVENS.		X	X
	Quality SINTER produced with	X	More Sinter usage improves porosity,	ISP's best performance indicates that initial	More prepared burden like SINTER,	X	Improving Raw material quality

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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
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	improved fines quality leads to improved BF productivity		**better gas permeability more waste utilization of fines**	**focus at OHP for handling Raw Material was taken due care.**	**PELLETS, and minimum IRON ORE improves BF efficiency.**		**improves BF productivity and Efficiency**
1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**

Exhibit-3

INTERPRETIVE LOGIC-KNOWLEDGE BASE RANKING OF ACTORS w, r, t, PROCESSESS - PRODUCTIVITY-1									
A1 OVER A2	P3, P5-D, P4, P9-ND	P1-D P8-ND	A3 OVER A1	P2, P6,P7-ND P5-D		A5 OVER A1	P3-D, P8-ND	A7 oVER A1	P4, P5, P9-D ,P2,P6,P8-ND
A1 OVER A3	P1, P4, P9-ND, P3-D	P2, P6, P7-ND P5-D	A3 OVER A2	P3, P5-D P6, P7-ND		A5 OVER A2	P1, P3, P6-D P4-ND	A7 oVER A2	P2, P4,P6,P9-ND P5, P8-D
A1 OVER A4	P1,P4,P9-ND P5-D	P8-ND P3-D	A3 OVER A3	X		A5 OVER A3	P4,P8,P9-ND P3,P6-D	A7 oVER A3	P4,P8,P9-ND P5,P6-D
A1 OVER A5	P1, P4, P5-D P9-ND	P3-D, P8-ND	A3 OVER A4	P2, P6, P7-ND P5-D	P3-D, P8-ND	A5 OVER A4	P1, P4, P6, P9-ND	A7 oVER A4	P2, P4, P6, P9-ND P5-D
A1 OVER A6	P1, P3, P4, P9-ND,	P2-ND P5-D	A3 OVER A5	P2, P7-ND P5-D	P4, P8, P9-ND P3, P6-D	A5 OVER A5	X	A7 oVER A5	P5, P6, P9-D
A1 OVER A7	P1, P3-ND	P4, P5, P9-D, P2, P6, P8-ND	A3 OVER A6	P3, P6, P7-ND	P2, P5-D	A5 OVER A6	P1, P3, P4, P6, P8, P9-ND	A7 oVER A6	P4, P6, P8,P9-ND
			A3 OVER A7	P3, P7-ND P2-D	P4, P8, P9-ND P5, P6-D	A5 OVER A7	P1, P3-ND P4, P8-D	A7 oVER A7	X
A2 OVER A1	P1-D P8-ND		A4 OVER A1	P8-ND P3-D		A6 OVER A1	P2-ND P5-D		
A2 OVER A2	X		A4 OVER A2	P8-D		A6 OVER A2	P6-D P2-ND		
A2 OVER A3	P1, P8-ND	P3, P5-D P6, P7-ND	A4 OVER A3	P3-D, P8-ND		A6 OVER A3	P2, P5-D		

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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
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A2 OVER A4	P1-ND P3, P5-D	P8-D	A4 OVER A4	X		A6 OVER A4	P2-ND P5-D		
A2 OVER A5	P5-D	P1, P3, P6-D P4-ND	A4 OVER A5	P3, P5, P8-D	P1, P4, P6, P9-ND	A6 OVER A5	P2-ND P5-D		
A2 OVER A6	P1, P3, P8-ND	P6-D P2-ND	A4 OVER A6	P3, P8-ND	P2-ND P5-D	A6 OVER A6	X		
A2 OVER A7	P1, P3-ND	P2, P4, P6, P9-ND P5,P8-D	A4 OVER A7	P3-ND, P8-D	P2, P4, P6,P9-ND P5-D	A6 OVER A7	P2, P5-D		

Exhibit-4

DOMINATING INTERACTIONS MATRIX-RANKING OF ACTORS w,r,t, PROCESSES-PRODUCTIVITY-1							
	A1	A2	A3	A4	A5	A6	A7
A1	X	P3,P5-D,P4,P9-ND	P1,P4,P9-ND ,P3-D	P1,P4,P9-ND P5-D	P1,P4,P5-D P9-ND	P1,P3,P4,P9-ND ,	P1,P3-ND
A2	P1-D P8-ND	X	P1,P8-ND	P1-ND P3,P5-D	P5-D	P1,P3,P8-ND	P1,P3-ND
A3	P2,P6,P7-ND P5-D	P3,P5-D P6,P7-ND	X	P2,P6,P7-ND P5-D	P2,P7-ND P5-D	P3,P6,P7-ND	P3,P7-ND P2-D
A4	P8-ND P3-D	P8-D	P3-D ,P8-ND	X	P3,P5,P8-D	P3,P8-ND	P3-ND ,P8-D
A5	P3-D ,P8-ND	P1,P3,P6-D P4-ND	P4,P8,P9-ND P3,P6-D	P1,P4,P6,P9-ND	X	P1,P3,P4,P6,P8, P9-ND	P1,P3-ND P4,P8-D
A6	P2-ND P5-D	P6-D P2-ND	P2,P5-D	P2-ND P5-D	P2-ND P5-D	X	P2,P5-D
A7	P4,P5,P9-D ,P2,P6,P8-ND	P2,P4,P6,P9-ND P5,P8-D	P4,P8,P9-ND P5,P6-D	P2,P4,P6,P9-ND P5-D	P5,P6,P9-D	P4,P6,P8,P9-ND	X

Exhibit-5

DOMINATING MATRIX, RANKING OF ACTORS w, r, t, PROCESSES-PRODUCTIVITY-1

	A1	A2	A3	A4	A5	A6	A7	NUMBERS DOMINATING (D)	NET DOMINANCE (D-B)	RANK DOMINANCE
A1	0	4	4	4	4	4	2	22	7	3

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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
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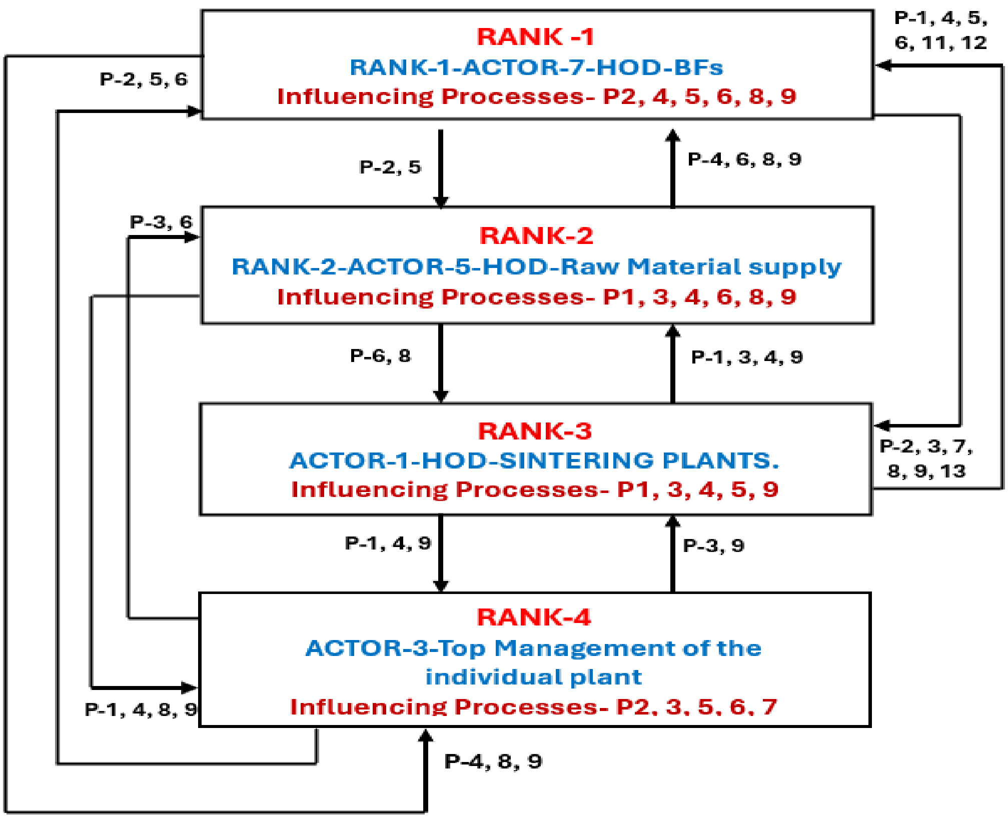
A2	2	0	2	3	1	3	2	13	-8	5
A3	4	4	0	4	3	3	3	21	1	4
A4	2	1	2	0	3	2	2	12	-8	5
A5	2	4	5	4	0	6	4	25	8	2
A6	2	2	2	2	2	0	2	12	-11	6
A7	3	6	5	3	4	5	0	26	11	1
NUMBERS BEING DOMINATED (B)	15	21	20	20	17	23	15	131		

Model-1

INTERPRATIVE RANKING MODEL FOR ACTORS w, r, t, ROLES IN THE PROCESSES-PRODUCTIVITY-1



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2024, 9(4s)
e-ISSN: 2468-4376
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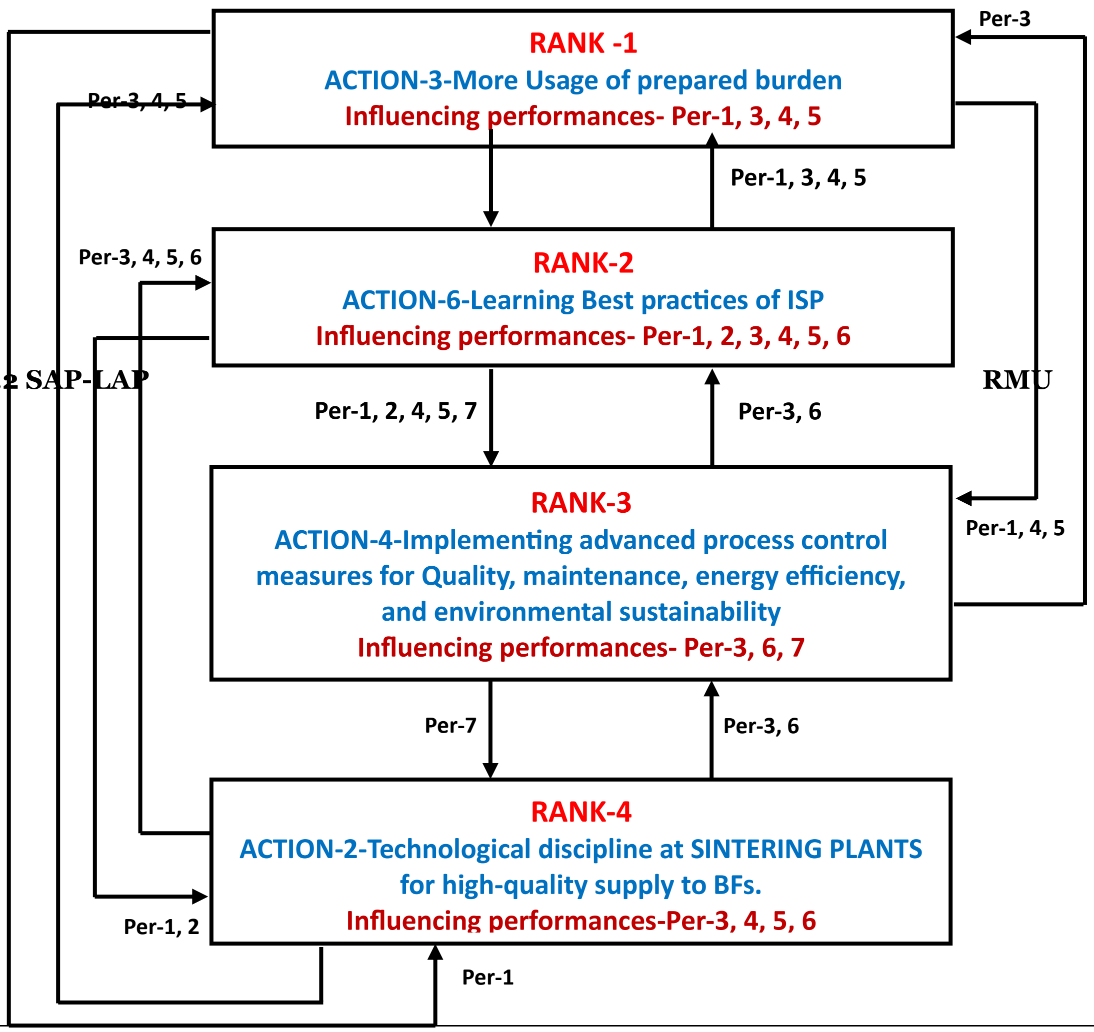
Model-2

INTERPRATIVE RANKING MODEL FOR ACTION w, r, t, IMPACT ON PERFORMANCE-PRODUCTIVITY-2



8.2 SAP-LAP

RMU

SITUATION-RMU	
S1	Unloading of Raw Material
S2	Screening and crushing
S3	Bedding and Blending
S4	PPC, Railways, T&D, RMD Coordination
S5	Improved Gross Yield of SINTER
S6	Blending followed by crushing.
S7	BD Range of crushed coal (840-860 Kg/m³)
S8	Reducing the cost of production of Mines
S9	Long-term contact with suppliers of coal

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S10	Price Volatility of Imported Coal
S11	More usage of prepared burden
S12	Optimizing coal usage (Imported: Indigenous)
ACTORS-RMU	
A1	Railway Coordinator
A2	HOD OHP
A3	Maintenance is in charge of the OHP
A4	HOD Coke ovens
A5	HOD Sintering Plant
A6	HOD Blast Furnaces
A7	HOD Services
A8	HOD RMD
A9	In charge of the Coal Handling Plant, COKE OVENS
A10	In Charge MINES
A11	RMD DIRECTORATE
A12	CORPORATE -COAL SUPPLY IN CHARGE
A13	TOP MANAGEMENT PLANT
PROCESSES-RMU	
P1	Wagons unloading coal in tipplers
P2	Blending of different grades of COAL
P3	Schedule for raw materials requirement
P4	Monitoring and optimizing raw material quality.
P5	Stacking of the coal in the open yard, blending, storage in coal towers, and then crushing
P6	Usage of coal with less moisture and ash content.
P7	Focus on Operational Efficiency of Mines
P8	Long-term contract with imported coal suppliers.
P9	Diversify supply sources.
P10	The consumption pattern of Iron ore in BSP was 572 kg/T, and the minimum was for ISP 384.48 Kg/THM
P11	High indigenous coal usage in BSL (15.95%) indicates potential cost savings. Low usage in ISP (6.34%) suggests prioritizing coke quality for Blast Furnace efficiency.
P12	Investment in the development of mines
P13	Explore alternative fuels like biomass, gas, or renewable energy.
P14	Unloading of iron ore, limestone, and other material in bunkers
ACTION-RMU	

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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
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Ac-1	Train operators on quality control and improvement
Ac-2	Implement advanced screening technologies -vibrating screens and roller screens,
Ac-3	Use automated bedding and blending systems.
Ac-4	Proper coordination with Railways, traffic, RMD, and Quality control departments by CGM (services)
Ac-5	Focus on raw material quality from different sources.
Ac-6	High BD coal usage for coke making
Ac-7	Optimizing Mines- implementing advanced drilling techniques.
Ac-8	Focus on enriching the ore fines to reduce the Silicon content.
Ac-9	Effective long-term contracts for Iron ore suppliers.
Ac-10	Diversification of supply sources, and Coal blending to optimize quality and cost.
Ac-11	Iron Ore Optimization, increase usage of prepared burdens like sinter and pellets,
Ac-12	High Indigenous coal usage in BSL (15.95%) indicates potential cost savings, and Low usage in ISP (6.34%). The quality vs. Cost trade-off needs to be focused.
PERFORMANCE-RMU	
Per-1	By focusing on screening, crushing, blending, and reclamation, SAIL can significantly improve raw material quality and improve production efficiency at sintering plants, coke ovens, and blast Furnaces
Per-2	Improved ore quality, enhanced production efficiency of coke ovens, SPs, and BF, cost saving, and environmental benefits
Per-3	Improved ore quality and enhanced the production efficiency of coke ovens, SPs, and BF. cost saving and environmental benefits.
Per-4	Enhance operational efficiency, improve product quality, and reduce costs
Per-5	Improves Blast Furnace productivity. Reduce energy consumption and better utilization of sintering capacity.
Per-6	Improved coke strength and reduced coke fines enhance BF operational efficiency/
Per-7	Technological developments at Mines have a direct effect on the Improvement in the overall efficiency of the Sintering Plant and Blast Furnaces.
Per-8	Waste utilization and improving the overall efficiency of the plant.
Per-9	Reduce price volatility and ensure a consistent supply
Per-10	Stable pricing, reduce dependency on a single source, streamline logistics, and reduce lead time.
Per-11	Consistent running of the bigger Blast Furnace in ISP and optimization of iron ore and sinter resulted in better operational efficiency of the Blast Furnace at ISP
Per-12	By striking a balance between cost and quality, SAIL can optimize coal usage, ensure consistent coke quality.
LEARNING-RMU	
L1	Reduce waste and impurities, cost savings, and environmental benefits.
L2	Removal of impurities, uniform particle size, and improvement in the quality of ore and coal

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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
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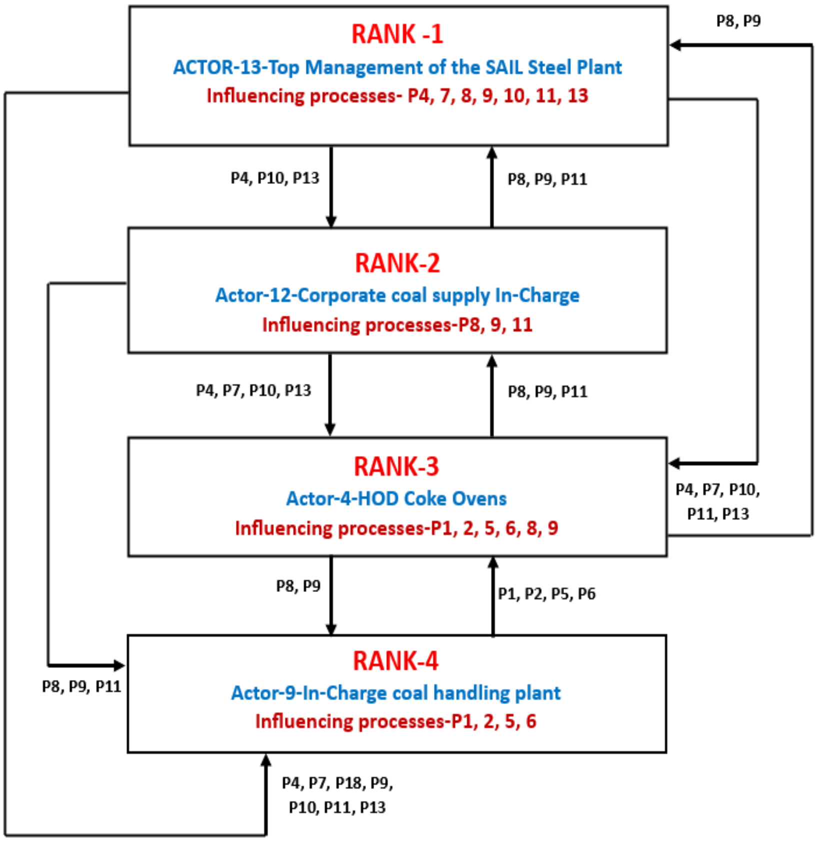
L3	Accurate bedding and blending ensure a homogenous mixture of different stacks of ore and coal.
L4	Advanced planning of raw materials helps smooth the operation of coke ovens, blast furnaces, sintering plants, and other units.
L5	High yield reduces waste, and improved sinter quality enhances blast furnace performance.
L6	A higher BD range will increase yield at coke ovens, and the operational efficiency of the BF will increase.
L7	Improvement in overall operational efficiency and reduction in the overall cost of production in the Mines area.
L8	Enriching the ore fines waste utilization would facilitate cost reduction and more prepared burden usage.
L9	Diverse suppliers will mitigate risk, and strategic partnerships will maintain long-term relationships with suppliers.
L10	Fostering strong relationships with suppliers and developing a flexible and adaptable business strategy.
L11	Increasing prepared burden usage will drive long-term sustainability and profitability
L12	Leveraging cost-benefit by using more indigenous coal, and the Quality of coke plays an important role in improving operational efficiency

INTERPRATIVE RANKING MODEL FOR ACTORS w, r, t, ROLES OF PROCESSES (RMU-1)



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Journal of Information Systems Engineering and Management
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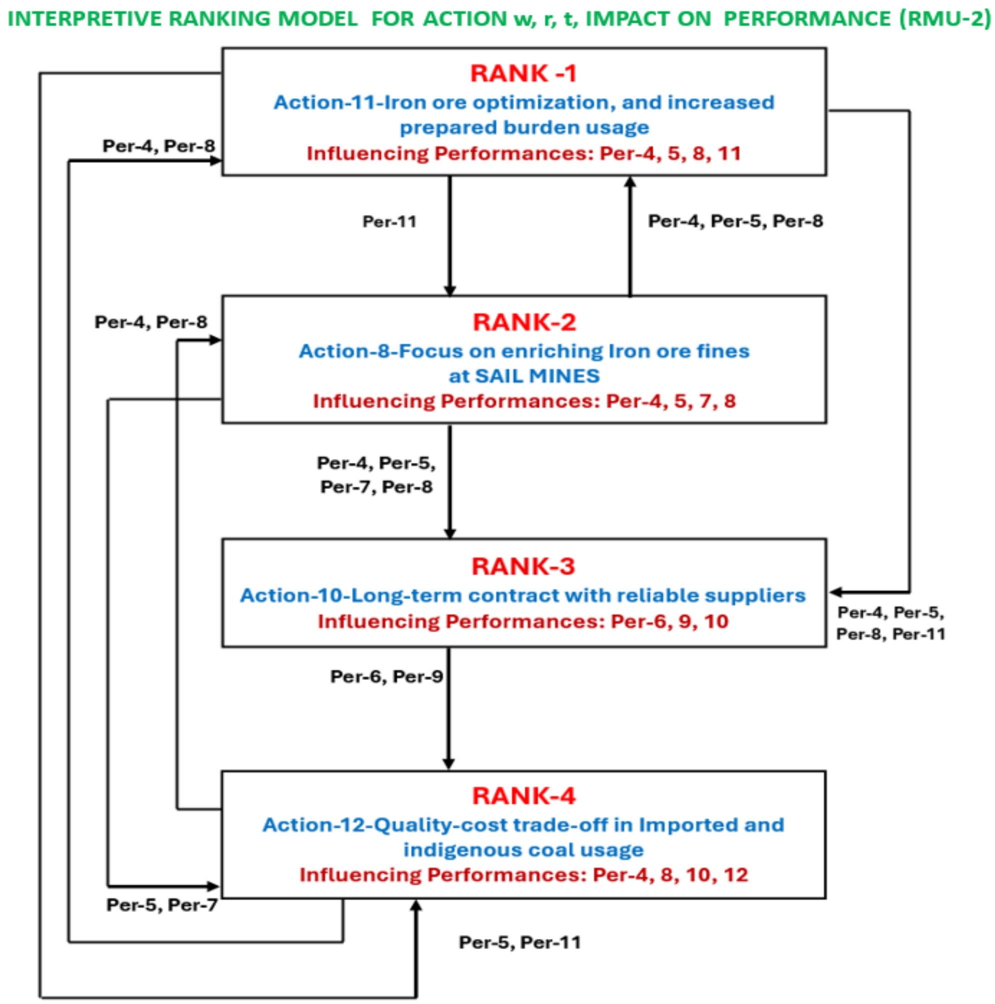

8.3 SAP-LAP QUALITY

SITUATION-QUALITY	
S1	Higher M40 value for BSP & ISP.85-86, comparatively less for BSL & DSP (for less imported coal)
S2	Sinter 75%, pellets 10%, and Iron ore 15% usage is most suitable for SAIL plants in BFs
S3	400 to 600 layers are considered. The best is around 500
S4	Depleting the quantity of Iron ore in operating SAIL mines and a lack of expertise of NMDC in running the operations of steel plants.
S5	More usage of Indigenous coal in the blend
S6	High ASH in coal leads to a reduction in process efficiency in coke ovens and less yield.
S7	Post-carbonization plays an important role in determining the efficiency of coke ovens.
S8	Coke consumption plays the most significant role in impacting the techno-economic factors of Sinter making.
S9	Maintaining an efficient slag drainage system for good Iron making.
S10	Strategic usage of more Hot Metal and minimum scrap usage in steel melting shops in BOFs.
S11	Higher CDI rate in BFs in SAIL plants.
S12	Better coal to HM Ratio in BSP in the last 5 financial years.
S13	Coke quality depends on blending accuracy, full charge of ovens, consistent pushing,

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Journal of Information Systems Engineering and Management
2024, 9(4s)
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S14	Nodulizer drum with atomized water spray makes a green mix for feeding on the sinter bed.
	ACTORS-QUALITY
A1	COKE OVEN IN CHARGE
A2	BF IN CHARGE
A3	SINTER PLANT IN CHARGE
A4	RAW MATERIAL IN CHARGE
A5	OHP IN CHARGE
A6	STOCK BLENDING AND BEDDING IN CHARGE
A7	STEEL MINISTRY OFFICIAL
A8	CMD SAIL
A9	CMD NMDC
A10	COAL HANDLING PLANT IN CHARGE
A11	QUALITY IN CHARGE
A12	INCHARGE IRON ZONE
A13	BF MAINTENANCE IN CHARGE
A14	SINTER PLANT MAINTENANCE IN CHARGE
A15	BF CDI INCHARGE
A16	IN CHARGE SERVICES PLANT
A17	SMS IN CHARGE
A18	TOP MANAGEMENT OF PLANT
A19	RAW MATERIAL DIRECTORATE
	PROCESSES-QUALITY
P1	Strong and cohesive coke with high M40 value usage in the BF.
P2	Systematic combination and feeding of Sinter, pellets, and iron ore to the BF through conveyors to the BLT Hopper
P3	layer-by-layer stacking and reclamation of the raw material, particularly coal and iron ore
P4	Supply of high Fe% % Iron ore to SAIL plants (other than BSP) from external sources like NMDC
P5	Sending experts from SAIL to run the NAGNAR steel plant
P6	Observing the coke properties regularly, the coal proportion of imported and indigenous coal is to be adjusted to increase the local coal.
P7	Coal washing -gravity separation, float-sink separation, coal beneficiation-magnetic separation, coal crushing, screening, and blending
P8	During post-carbonization, the focus should be on blending accuracy, full charge of coke ovens, and consistent pushing.
P9	Mixing of derived proportions in the nebulizer and then sending the green mix to the sinter bed.
P10	Maintaining good slag viscosity with high temperature and good slag basicity of 1.1 to 1.3.
P11	Maintaining good slag fluidity.
P12	Focus on scrap processing, segregation, and supply to the Steel Melting shop.
P13	Internal arising to be segregated and resupplied to the steel melting shops
P14	Judicious usage of scrap with a strategy for sustainability
P15	Increasing desulphurization efficiency and reducing Si content
P16	Use of alternative iron sources like DRI, HBI
P17	The data analysis indicates that the CDI and other techno-economic parameters are mostly in RSP, ISP,

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Journal of Information Systems Engineering and Management
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	and positivity in BSP because of consistently bigger BF operations.
P18	Well-designed and maintained injection system.
P19	Furnace parameters Optimization.
P20	Resource optimization- Effective utilization of resources.
P21	Awareness among the team members about the cost and operational benefits of CDI.
P22	Improvement in coal sizing, blending, charging, and coal moisture reduction techniques.
P23	Develop a coal blending strategy and optimize coal mixtures.
P24	Ensure consistent oven charging.
P25	Standardize pushing schedules and monitoring.
P26	Coke quenching technique: Adopt optimal quenching methods (e.g., water or inert gas), monitor quenching temperatures.
P27	Indigenous coal quality variation: Implement quality control measures, regularly test and analyze coal samples
ACTION-QUALITY	
Ac-1	Coke with a high M40 value and a low M10 value is preferred in BFs
Ac-2	Continuous supply of pellets, iron ore, and sinter of good quality.
Ac-3	With the use of pellets (10%) in larger furnaces, the Iron ore requirement will be reduced to 10%. The total requirement of SAIL plants is to be calculated, and based on that, the quality Iron ore demand from NMDC is to be determined. Subsequently, ore fines can be sent to NMDC for agglomeration. Blend high-quality NMDC ore with SAIL's depleting reserves.
Ac-4	The focus should be on improvement in the production capacity of SAIL COAL mines.
Ac-5	Coal from low ash mines, implementing efficient mine practices, and adding ash-reducing additives during transportation.
Ac-6	Optimizing post-carbonization conditions leads to coke strength, quality, and better ash management.
Ac-7	Optimizing coke consumption to reduce coke cost, energy consumption, and environmental impact.
Ac-8	Usage of desulphurized and low silica HM of more than 95% in all the SAIL units will reduce dependency on scrap.
Ac-9	Standardize Coal Quality
Ac-10	Regularly benchmark with international standards and share best practices among plants
Ac-11	Regularly review and analyze data and identify areas for improvement.
Ac-12	Optimized coal sizing and blending,
Ac-13	Better maintenance of coal handling equipment
Ac-14	Minimized coal degradation during handling and storage
Ac-15	Effective quality control measures
Ac-16	Potential for reduced coke rate and improved furnace productivity
Ac-17	Advanced mixing technologies- Intensive mixing (paddle, drum or pan mixing), Nebulizing drums and discs, continuous mixing system.
PERFORMANCE-QUALITY	
Per-1	Coke with high M40 value increases coke strength, coke reactivity, porosity, coke size distribution, and coke quality.
Per-2	In OHP/RMHP operations. The 500 mm bed layers have proven to be a sweet spot.
Per-3	SAIL will access high-quality iron ore, enhance plant efficiency, enhance expertise in agglomeration,

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	and reduce fine accumulation. NMDC-Utilization of SAIL's expertise for value-added processing, potential revenue generation through fines agglomeration
Per-4	Indigenous coal usage will increase, resulting in lower dependency on imported coal.
Per-5	Improved coal quality improves coke productivity, reduces energy consumption.
Per-6	Pre-carbonization influences coke yield and VM content, whereas post-carbonization refines and finalizes the coke properties, which directly impact BF operational efficiency.
Per-7	Reduction in sinter production cost, increase in fuel efficiency, and improvement in sinter quality.
Per-8	Efficient slag drainage reduces furnace downtime and improves productivity.
Per-9	Optimization of scrap quantity and Enhanced usage of HM for operational control of the process increases steelmaking Process efficiency.
Per-10	Increase in CDI rates, Reduction in coke rate, and enhancement in productivity.
Per-11	Efficient coal utilization and minimal wastage reduce production costs and improve hot metal quality.
Per-12	Improvement in Coke Quality, reduction in cost, increase in efficiency, and reduction in emissions. Improved coal charging practices
Per-13	Improved sinter quality (strength, reducibility, and thermal stability) Increased productivity (higher sinter output and machine utilization), Enhanced machine efficiency (reduced energy consumption and maintenance), Better process control and stability
LEARNING-QUALITY	
L1	High M40 indicates that coal is suitable for Coking, optimizing coal blend, improving coke quality, and improving BF productivity and process efficiency.
L2	Optimize burden composition, improve BF stability, reduce fuel consumption.
L3	Bed layers determine homogeneity and a lower standard deviation.
L4	Mutual benefits for SAIL and NMDC. A WIN-WIN situation for both organizations (collaborative approach).
L5	Dependency on imported coal will be reduced, and the overall cost of production will be reduced.
L6	consistent coal availability with predictive ASH content,
L7	Post carbonization determines coke structure, and porosity, influences the strength and reactivity of coke.
L8	Coke consumption is the most important factor affecting the techno-economics of a sinter plant in a steel plant.
L9	Efficient slag drainage reduces furnace downtime and improves productivity.
L10	More HM usage consistently in all SAIL units will improve overall operational efficiency, and scrap usage can be aligned with regeneration and arising.
L11	CDI and other techno-economic parameters are encouraging for RSP, ISP, and positivity in BSP because of consistently larger BF operations
L12	As indicated by BSP records, a lower COAL TO HM ratio indicates better Coke Quality and better handling ability.
L13	Coal blending accuracy plays a crucial role in the consistency of coke quality.
L14	Monitoring and adjusting mixing parameters at Nodulizer.

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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
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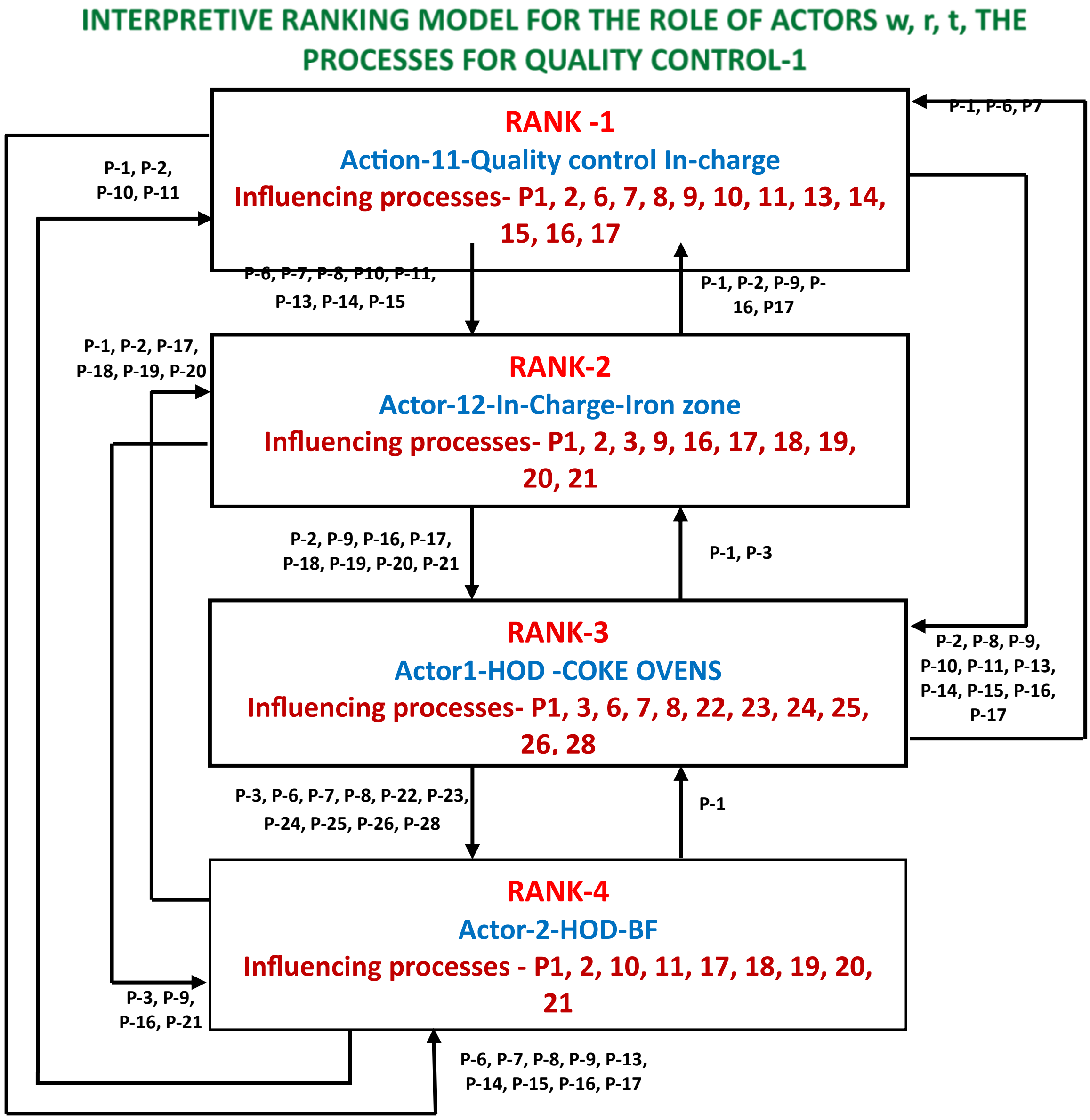
Model-5



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Journal of Information Systems Engineering and Management
2024, 9(4s)
e-ISSN: 2468-4376
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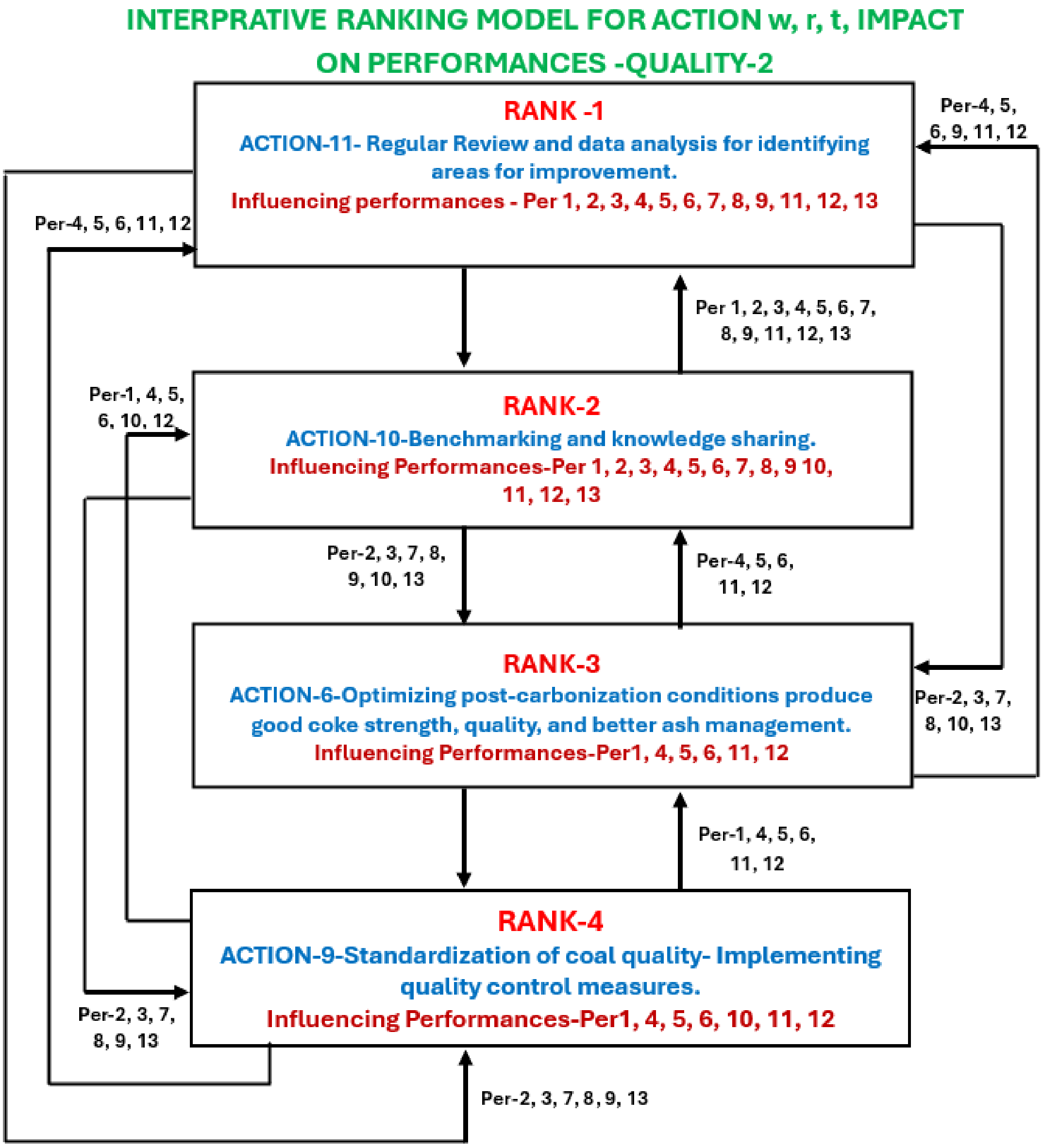
Model-6



9. FINDINGS OF THE WORK ON THE OPERATIONAL EFFICIENCY OF THE SAIL PLANT THROUGH SAP-LAP ANALYSIS:

Analysis indicates the ranking of actors concerning the processes and the ranking of actions impacting performances:

9.1 PRODUCTIVITY:

SAP-LAP analysis indicates that the involvement and coordination of HODs of all departments play a vital role in every incremental improvement in productivity, considering different processes. However, prioritizing and identifying the most important actors' involvement affects the processes is judiciously considered in the SAP-LAP analytical approach:

- HOD of Blast Furnaces, Sintering plant, and Raw Material In-Charge's involvement and focused approach in handling different processes of productivity make the real difference in productivity figures.

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- Strategy to use more prepared burden in BFs, learning from the best practices of ISP, like the consistent running of the bigger Blast Furnace, high-quality coal usage for good MICUM value coke production, and its usage for more efficiency of the BF of ISP.
- To implement advanced process control systems, investment in new Technologies, collaboration with Industry experts, Research Institutes, and continuous monitoring and evaluation of operations through Data analytical tools.

9.2 Raw Material Utilization:

The top management role is vital for the procurement of imported coal from different sources, ensuring quality and timely assurances for both imported and indigenous coal combinations.

The corporate coal supply team needs to be deeply involved in the coal supply since 60% of the raw material cost is borne by COAL.HOD COKE OVENS' role is very important in coordination with all agencies in the long-term and short-term planning of raw material security.

Iron ore optimization, increase usage of prepared burden like more than 85 % SINTER and about 10% Pellets, and the rest, Quality Iron ore.

Iron ore fines enrich mines to reduce Silica content, enrichment by palletization and briquetting at BSP Mines and other SAIL mines for waste utilization.

Long-term partnerships with reliable suppliers for stable pricing and negotiation of flexible contracts with price adjustment mechanisms.

9.3 QUALITY CONTROL:

- QUALITY IN-CHARGE's role is in overall coordination with all operational and service departments to improve the operational efficiency of different sections of an integrated steel plant.
- The iron zone IN-CHARGE plays a vital role in focusing on the operational efficiency of the sintering plant, coordination with COKE OVENS, and various attached sections of Blast Furnaces.
- Regular review and analysis of Data and identifying areas of improvement.
- Benchmarking and knowledge sharing among different Integrated Steel plants.
- Optimizing port carbonization conditions improves coke strength, quality, and ash.
- standardizes coal quality.

10. CONCLUSION:

ISP performed very well in all operational parameters considered for the study. In the areas of Raw material utilization, Quality control, productivity, and Equipment availability and utilization, ISP's performance is the best. This indicates the consistency and efficiency of operational units.

Strategically, a few steps are to be taken for the consistent growth prospects of SAIL:

Early completion of projects, modernization, and expansion plans are to be completed according to the schedule to avoid exceeding the financial budget.

Focusing on these major issues of inefficiencies in operations and implementing 4.0 technologies, conducting regular audits, developing strategic partnerships and collaboration, and investing in R&D, we can strategize for excellent work culture and systems development in different units of SAIL

A long-term strategy for operating coke ovens and gradually transforming the old coke oven batteries into stamp charging will improve overall efficiency and overcome the prevailing bottlenecks.

Collaboration with technology providers, AI experts and research institutes will keep SAIL updated with the latest advancements and best practices.

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A long-term strategy for operating coke ovens and gradually transforming the old coke oven batteries into stamp charging will improve overall efficiency and overcome the prevailing bottlenecks.

Spreading the culture of learning by interactive and knowledge sessions across SAIL will help in the improvement of the overall efficiency of SAIL plants.

Major threats of SAIL, like Competition in Volume, Quality, and Service, and imported coal price volatility and its impact on profit margin, can be mitigated by a strategic action plan and its judicious implementation.

Smooth inter-departmental relations, Healthy competition, a strong ICR Model, cost control workshops, and Frequent interactive sessions can enhance productivity and competitiveness.

Further scope of work: The operational efficiency of a steel plant is not confined to the key performance indicators considered in this study and mentioned in this article. However, for a holistic and sustainable more performance indicators are considered Like Equipment availability and utilization, Eco, Energy, and Financial Efficiency. This will be incorporated in our next article.

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e-ISSN: 2468-4376
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