ANNEXURE 11

Particulars of Energy Conservation, Technology Absorption and Foreign Exchange Earnings and Outgo
[Pursuant to Companies (Accounts) Rules, 2014]

(A) Conservation of Energy

(i)   Steps taken or impact on conservation of energy

Jamshedpur

- Green Power initiative – successfully commissioned Coke Dry Quenching Power Plant of 40MW Capacity

- New by-product gas fired Boiler of 136 tph capacity commissioned

- Coal firing has permanently stopped at the Works, maximising the by-product gas utilisation

- Best by-product gas utilisation of 98.18% achieved

- Highest ever by-product gas-based power generation achieved

- 1.3 Lakh LED lights installed in the Works

- Lowest ever blast furnace gas flaring - 1.9% against the previous best of 3.16%

- Four Variable Frequency Drives installed for high power consuming equipment

- Lowest ever specific water consumption of 3.28 m^3/tcs, 11% reduction over Financial Year 2017-18

- Coal blend optimisation to The Tata Power Company Limited Jojobera units from captive mines

- Energy & Electrode consumption optimised in Laddle Furnace arcing process at LD shops through digital initiative

- Energy Performance Improvement Team (**'EPIT'**) formed to drive Energy Efficiency Campaign across the Indian operations, exploiting cross learning and synergy

- Mandatory Energy Audit carried out through an accredited Audit team as per Energy Conservation Act

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Blast Furnace

- Increase in Pulverised Coal Injection (**'PCI'**) rate from 119kg/tHM to 150 kg/tHM, thereby reducing coke consumption

- Reduced specific water consumption from 0.56 m^3/tHM to 0.50 m^3/tHM by utilising waste water in slag granulation

- Reduced specific power consumption from 141 KWH/tHM to 115 KWH/tHM

- Substituted river sand by granulated slag for trough preparation

- Increase in share of dumped hot metal in granshot from 56% to 72% thereby reducing hot metal pooling

Hot Strip Mill

- Reduced mill specific power consumption from 122 KWH to 118 KWH through:

  − planned stoppages for longer duration in place of multiple shorter durations; and

  − higher pacing during rolling durations

- Reduced fuel consumption from 0.300 Gcal/t to 0.294 Gcal/t through air fuel ratio optimisation, Level 2 usage for combustion control and cutting fuel load during delays

Sinter Plant

- Reduced Water Consumption in Sinter Making in FY 2018-19 to 0.053 m^3/ton of Net Sinter (FY 2017-18: 0.08 m^3/ton)

- Reduced Solid Fuel requirement in Sinter Making in FY 2018-19 to 78 kg/ton of Net Sinter (FY 2017-18: 83 kg/ton)

Utilities

- Electrical power demand met from by-product gases utilisation - 56.46%

- By-product gas Utilisation - 93.98%

- Gas recovery - 45.11% of heats recovered

- TRT - Top Pressure Recovery Turbine average power generation 15MW

- Utilisation of LD gas in Coke Oven under firing to improve energy and combustion efficiency

- Centralised utility management established for efficient management of all utilities across plant

- Predictive controller model being used for ASU-Air Separation Unit to optimise power and subsequently reduction in oxygen venting

(ii) Steps taken by the Company for utilising alternate sources of energy

Jamshedpur

- Initiated projects on power generation from solar and non-conventional energy source. Pilot project on low grade energy recovery on progress.

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- Increased solid waste consumption in sinter making

(iii) Capital investment on energy conservation equipments

Particulars	₹ crore
Jamshedpur	
Recovery of sensible heat of Coke by installation of Coke Dry Quenching System in Battery # 10 & 11 at Coke Plant	62
Replacement of Boiler # 3 at Power House # 4	4
Installation of Variable Frequency Drive in HT motors with variable load	1
Provision for Light Diesel Oil firing facility in boilers of Power House # 4 (PH-4)	4
New LD Gas Holder	69
Capacity enhancement from 25 MW to 30 MW in PH-4	2
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CDQ- Coke Dry Quenching	65
TRT- Top Pressure Recovery Turbine	4

(B) Technology Absorption

1. Efforts made towards technology absorption

(i) Projects under Research and Development

Project title	Benefits
Jamshedpur	
Calcium Ferrite addition trials in Basic Oxygen Furnace (**'BOF'**) to improve dephosphorisation to level < 0.01%.	Plant trials with calcium ferrite in BOF helped to tap steel below 0.01% phosphorous with more than 60% confidence from hot metal containing higher phosphorus of 0.18% than the world average of 0.10%.
Utilisation of Ferro chrome furnace off gas	The project was targeted to demonstrate production of bio-ethanol from ferro chrome furnace off gas using Lanzatech Technology.
Development of flotation reagent for reverse flotation of sub grade iron ore	Chemical regents have been developed for selective separation of alumina/silica from iron ore slime by froth flotation process. The reagents have been conceptualised using first principle molecular modeling studies followed by lab scale synthesis and experimentation. These novel reagents show up to 10% yield improvement over commercial reagents.
Extraction of spinel and metal from Ferro chrome slag	Ferro chrome slag can be used for extraction of spinel and silico-chrome containing metal. Based on the laboratory results, plant trials were carried out.
Reduction roasting and magnetic separation of low grade Manganese ores	Low grade ferruginous manganese ores can be upgraded to high grade ores by reduction roasting and magnetic separation process. Based on the laboratory results, plant trials were carried out.
Nitrogen purging at Sinter plant	Plant trial helped to improve the strength of sinter and to reduce that cost of fuel. There was also a reduction in fuel consumption @2.5 kg/tonne of sinter, resulting in cost savings along with reduction of CO_2 emission.
Metallic Glass coatings on bearings	Nickel & Phosoporous containing hard metallic glass coating was deposited uniformly on bearing surface with at least double life warranty against high fatigue and electrochemical corrosion which also led to reduction in noise level.
Development of Advanced High Strength Steel 1000 steel for Automotive application	The steel is targeted to reduce weight of vehicle and fuel consumption
Development of steel for Lifting & Excavation application (>700 MPa YS)	The developed steel will help in weight reduction of equipment and cost saving.
Development of ferritic-bainitic780 MPa steel	The steel is targeted to reduce weight in Automotive wheel application.
VAVE and Early Vendor Involvement with Major Auto Customers	Value Analysis Value Engineering (**'VAVE'**) workshops were carried out for several models in FY 2018-19. These workshops are carried out to create value through cost and weight reduction ideas on the vehicle by means of use of newer steel grades, blank optimisation and engineering design changes. These activities result in improved Customer Service Index and opportunity to present Tata Steel new grades' material supply in newer models.
Micro-pillar forming	An innovative sheet metal forming technology has been developed and validated at lab scale mainly for automotive industry. This technology enables to increase the fatigue life of components significantly.
Third generation technology for full length profiling of copper staves	This technology gives reliable thickness profile along the length of the copper stave for the safe operation of blast furnaces.
To establish solid state joining of Aluminium to Steel for a motorbike handle application	Solid state fitting of Aluminium to Steel using magnetic pulse technique helped to achieve minimum load requirement without any post or pre-weld conditioning

Project title	Benefits
Improving blast furnace tuyere life	Tuyere is a copper casted component equipped with inherent cooling circuit to sustain in severe thermal environment while supplying hot blast, Pulverised coal inside the blast furnace. Based on detailed numerical analysis, modification of inherent cooling passageway of copper tuyere has been done. Modified design has yielded better cooling efficiency, lower copper temperature, lower thermal stress and reduction of incipient water boiling which will extent the tuyere life.
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Development of FB780 for WheelDisc Application	The development of FB780 for WheelDisc Application will help to reduce weight reduction and improve the fatigue life in vehicles. Tata Steel is the first manufacturer to produce FB780 Grade in India.
HS1000	Commercial Vehicle manufacturers currently use HS800 grade produced by Tata Steel (only domestic supplier). Development of HS1000 will help to reduce vehicle weight and increase the load bearing capacity of the vehicles. Tata Steel is the first manufacturer to produce such high tensile material for commercial vehicles.
Development of Dual Phase Grade DP600 through CT Control in ROT	Development of Dual Phase Grade DP600 through CT Control in ROT will help to cater to growing requirements of Dual Phase Grade for various automotive applications such as WheelDiscs and other structural components for improving fatigue life and crash resistance.

(ii) Process Improvement:

Jamshedpur

Mining:

- Establishing application of GPS based advanced portable tool to measure haul road parameters (gradient, curve radius, super elevation & rolling resistance) at Quarry - AB, West Bokaro. This will help to identify haul road problems, determine severity and allocate maintenance resources accordingly to improve haul road conditions thereby reducing haul truck fuel consumption and increasing the tyre life.

- Augmenting coal extraction ratio by increasing the backfilling rate at Bhelatand Colliery. Backfilling rate increased by ~24% by installing fish tale arrangement for homogenous mixing of water and sand.

- Site selection & prefeasibility study for underground coal gasification at Jamadoba for unlocking value from remaining coal resource (~200MT) which is unviable through current method of mining. All related baseline information/data is collated, Test bore hole drilling has been completed, hydro-geological & rock mechanics study is in progress.

Ore Beneficiation Technology

Recovery of Iron value from Slime using High Gradient Magnetic Separation ('**HGMS**') Technique: In absence of adequate beneficiation facility at Noamundi, ~16% of wet Run of Mine is discarded as slime having ~8% Al2O3 and ~55% Fe. HGMS trials on pilot scale indicated a potential to recover ~50% iron value from slime having ~3.3% Al2O3 and ~63% Fe.

Coal Beneficiation Technology

- Enhancing visibility of critical unit operations (Flotation, Vacuum Belt Filter, Reflux Classifier & Thickeners) at West Bokaro washery#3 by installation of flow meter (6 nos), density meter(6 nos) & turbidity meter (2 nos) to improve process efficiency. 5 flow meters & 3 density meters installed till March 2019. Remaining measurement systems to be installed & commissioned by May 2019.

- Reducing misplacement of clean coal in Dense Media Cyclones ('**DMCs**') by installation of real time monitoring system: An order has been placed on Commonwealth Scientific and Industrial Research Organisation (Australia) through minor capital scheme for procurement & installation of Electrical Impedance Spectrometer in 1 stream of DMCs (out of 4). Installation to be completed by August 2019. Based on the results, a decision for replication in the remaining streams would be taken.

- Integration of Intermediate size beneficiation circuit at Washery#3: Through detailed lab & pilot scale studies, it has been established that introduction of an intermediate circuit – Reflux Classifier for beneficiation of 0.5-0.15mm would result in clean coal yield gain by ~3-4%. A detailed project report consisting of preliminary engineering for the modified circuit, piping and instrumentation, equipment selection, specifications and general arrangement, project execution cost & duration prepared for approval & implementation.

- New generation mixing mechanism in Washery#3 Flotation cells: ~0.4% improvement in clean coal yield by replacement of conventional rotor-stator in the flotation cells with a new generation mixing mechanism.

- Hydrophobic Hydrophilic Separation – A non-conventional fine coal beneficiation technology to achieve higher clean coal yields at lower ash & moisture simultaneously: Lab scale results indicate a potential to enhance fine clean coal yield by ~4% at lower ash (<9%) and moisture (<2%). Based on the encouraging results, pilot scale studies to be carried out for establishing parameters such as specific reagent consumption, losses and power consumption, etc.

Coal coke:

- Plastic trial at CP1 has established that 0.1% plastic in the blend can be used without affecting coke quality

- Establishing a new low-cost Indonesian coal ('**SMM**') for TSJ blend

- Resolving the coke dumping issue at I Blast Furnace

- Evaluation of four different Bharat Coking Coal Limited coals to support domestic coal buying team

Agglomeration:

- Usage of coke dust (generated during screening of dry quenched coke) at the rate of 10 kg/tonne started in pellet plant. This helped in the replacement of costlier conventional fuels such as coke breeze and anthracite in pelletising

- Successful trial of carbon composite briquettes produced from plant reverts was carried out at C Blast Furnace resulting in reduction in coke rate by 25 kg/tHM

Blast Furnaces:

- Using extruded carbon-composite briquettes in the BF burden to reduce coke rate

- Curbing of raw flux additions in blast furnaces by using a predictive model

Ferro Alloys:

- Successfully established new way of Silicon reduction in ferrochrome at Bamnipal by addition of Chrome ore mines through a series of plant trials. The concept is going to be operationalised in Financial Year 2019-20.

- Metallurgical know-how for making Carbon composite chrome ore briquette at Ferro Alloy Plant, Gopalpur to lower production cost & utilisation of plant waste is established and plant trial is on

Process Visualisation & Diagnostics:

- Online Pile Visibility Model developed to facilitate reduction in sinter chemistry variation at TSJ - RMBB2

- Development of anomaly detection-based tool to facilitate quick process diagnosis

- Coke Oven Wall Health Monitoring System Development and Deployment at TSJ and TSK using Push Force Profile

Process Energy & Emission:

- Intermittent disposal of last of Electrostatic Precipitator dust in sinter plants implemented in all sinter plants which resulted in reduction of 10-15 mg/nm³ Suspended Particulate Matter level

- Predictive control for Total Dissolved Solid and Chemical Oxygen Demand of By-Product Plant waste water which helped in better control of Biological Oxygen Treatment process.

Characterisation & Specialty support:

- Identification and development of Coal tar distillation Product: In a collaborative project with National Physical Laboratory ('**NPL**'), Delhi all the coal tar samples generated in Tata steel coke ovens have been characterised and its feasibility for manufacturing high end distillation carbon product such as needle coke and carbon fibre has been assessed. The suitable collaboration agencies for carrying out the test work for producing high end carbon product like needle coke/carbon fibre is identified.

- Establishing LD slag for one of the component in Portland slag cement: We have significantly progressed in the endeavour of establishing LD slag as raw mix component in Portland slag cement. In a collaborative project with National Council of cement and building material Faridabad ('**NCCBM**'), LD slag samples have been characterised and subsequent study is in progress. We are in constant interaction with BIS and have managed to incorporate LD slag samples from other major steel plants in India like Sail and JSW in the existing study with NCCBM. Successful completion of this project will help to get acceptance from Bureau of Indian Standards which will lead to complete evacuation of 0-6mm fraction of LD slag.

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Raw Material Holding System

- Reduction in rail idle freight in Outbound logistics from 20.6% in Financial Year 2017-18 to 16.6% in Financial Year 2018-19

- Improvement in Pulverised Coal Injection rate at Blast Furnace from 150kg/tHM to 175 kg/tHM in Financial Year 2018-19 by debottlenecking PCI circuit.

- Reduction of water consumption in coke plant from 1.32 M³/TGC in Financial Year 2017-18 to 1.05 M³/TGC in Financial Year 2018-19

Blast Furnace

- Improvement in fuel rate at Blast furnace from 555 kg/tHM to 540 kg/tHM using advance analytics

- Improvement in Blast Furnace coke yield from 65% in Financial Year 2017-18 to 71% in Financial Year 2018-19.

Steel Melting Shop ('SMS')

- Improvement in casting speed of SMS Caster from 1.20 Mtr/Min in Financial Year 2017-18 to 1.24 Mtr/Min in Financial Year 2018-19

- Reduction of Hot Metal and Scrap in SMS from 1,118 kg/tcs in Financial Year 2017-18 to 1,111.8 kg/tcs in Financial Year 2018-19

- Reduction of lime consumption in SMS from 75.36 kg/tcs in Financial Year 2017-18 to 70.7 kg/tcs in Financial Year 2018-19

Hot Strip Mill

- Roughing Mill speed optimised through benchmarking with Jamshedpur and Tata Steel BSL Limited (**'TSBSL'**)

- Achieved better product properties through usage of lesser number of Finishing Mill stands (Use of 5 stands instead of 7 stands) for thicker sections

- Installed Laminar water header before Finishing Mill to avoid rescaling and hence Rolled in Scale defect

- Extra-to-order tonnage reduced by 80% because of width deviation by set up optimisation using advance analytics.

- Slab and Coil image identification mechanism for avoiding Rank-A defect

- Improve product yield by avoiding discarding prime material through usage of High resolution movable camera for detecting defects at offline inspection station

(iii) Product Development

Jamshedpur

- Tata Shakti, Tata Kosh and Tata Steelium launched and now, it will be commercialised through TSBSL

- Ford Global Approval for Galvanised automotive application.

- Bake hardening steel development through Jamshedpur

- Continuous Annealing & Processing Company Private Limited for automotive Commercial Vehicle segment

- Development of Eco-friendly passivation for Galvano to eliminate pre-treatment process at Customer end

- HC 80A with improved torsion properties to meet Customer demand

- Gr 3[Staple] for high speed wire drawing were to supply to niche Customer

- WR3M for high speed wire drawing increased productivity by 30%

- HC82BCr[LR] for single Low Relaxation Prestressed Concrete wire – Entry into new segment

- Fe 550D rebars with higher ductility

- Fe 600 rebars with higher strength and ductility

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- Volume Ramp up of all Automotive grades including critical grades such as HS800 @4kt/month, TPI Grades @ 8kt

- Development of Automotive Grades such as IF, FB780, JSH590BN, DP780, DP980, SPFH590 & HS1000 to improve Tata Steel's share of business in growing Automotive markets

2. Benefits derived from key projects:

Project title	Benefits derived
Jamshedpur	
Roughing mill window expansion for Skin panel rolling in HSM	8000 tonnes extra skin panel volume. Saving potential ~ 41 crore/annum
Improvement of productivity of New Bar Mill (**'NBM'**) by optimising water-box cooling using first principle-based model	Increase in rolling speed of 10, 12 and 16 mm rebar. One of the enabler to pave a way to cross the ABP target of NBM and reach the milestone of 1.037 MT in Financial Year 2018-19.
Improve the consistency in microstructure in high end High Carbon wire rods	Reduction in customer complaints and increase in productivity at customer end.
Successful Trial of HPPI grate bars	>1 crore/annum (potential)
Aluminum control prediction model (**'ACPM'**) for bath chemistry based on mill signal	Improvement in quality of galvanised automotive products from Continuous Galvanizing Line #2
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Reduction in rail idle freight in Outbound logistics	Development of customised wagon builder led to 24% reduction in rail idle weight through optimised loading of coils in wagons
Reduction of HM+Scrap in SMS	Implementation of slag detection system in convertor and caster led to reduction in HM+Scrap by 6 kg/tcs
Improvement in casting speed of SMS Caster	Increase in maximum casting speed of peritectic grades with development of high speed casting powder led to increase in throughput of SMS
Improvement in PCI rate at BF TSK from 150kg/tHM to 175 kg/tHM inFinancial Year 2018-19 by debottlenecking PCI circuit.	PCI mill availability increased to 92% in Financial Year 2018-19 as compared to baseline of 85%. Due to this, PCI injection level increased
Reduction of fuel rate at Blast furnace from 555kg/tHM to 540 kg/tHM using advance analytics	Fuel rate improved from the baseline level of 555 kg/tHM in H1 Financial Year 2018-19 to 540 kg/tHM

3. **Information regarding imported technology (last three years)**

Sl. No.	Technology imported	Year	Status
Jamshedpur			
1.	Slab Deburring & Slab Marking Machine in Caster# 1 & 3		
2.	Installation of Torch Cutting Machine in Caster# 1 & 3		
3.	Installation of Tension Leveller at CGL#1		
4.	Coil Box revamp at HSM		
5.	Installation & Commissioning of Twin RH Facility		
6.	Installation of 4th Grinder	2017	
7.	Installation of Surface Inspection System for TSCR		
8.	Installation of new Slab Scarfing machine		
9.	Power augmentation at BFRS		
10.	Fire fighting system at LD gas holder		
11.	Hot Rolled Skin Pass & Oiled ('**HRSPO**') coils at CRM Bara (Ph-II)		
12.	Barrel reclaimer		
13.	Conveyors for pre-screening plant at Noamundi		
14.	E BF Re-lining		Commissioned
15.	H BF - Augmentation of electrics		
16.	SP#2 Dedusting system	2018	
17.	Coke Oven Flare Stack		
18.	Upgradation of RCL1 at CRM		
19.	Dust extraction system at H BF Stockhouse		
20.	LD Slag processing plant		
21.	LD#2 Secondary emission Project-ESP-3 system		
22.	HSM Furnace skid revamping		
23.	Torch cutting at IBMD		
24.	Replacement of Boiler # 3 at PH#4	2019	
25.	Modification of Induration Burner at Pellet Plant		
26.	CDQ#10 and Power Plant		
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27.	Dynamic Soft Reduction facility in Slab Caster	2017	
28.	Installation of Slab tilter facility at Steel Melt Shop	2018	Commissioned
29.	Installation of RH Degasser facility at Steel Melt Shop		

4. **Expenditure on Research & Development (R&D)**

		(₹ crore)
(a)	Capital	2.82
(b)	Recurring	212.97
(c)	**Total**	**215.79**
(d)	Total R&D expenditure as a % of Total Turnover	0.31

(C) Foreign Exchange Earnings and Outgo

		(₹ crore)
	FY 2018-19	**FY 2017-18**
Foreign exchange earnings	6,497.94	5,898.19
Value of direct imports (C.I.F. Value)	14,519.26	13,355.43
Expenditure in foreign currency	450.04	334.94

On behalf of the Board of Directors

sd/-
N. CHANDRASEKARAN

Mumbai
April 25, 2019

Chairman
DIN: 00121863