MPL’s journey towards Flexibilization-”Minimum Power Limit REDEFINED”

Date: 22nd November-2022

Presentation By:

Team MPL

Lighting up Lives!

MAITHON POWER

Maithon Power Limited – A Brief Introduction

MPL MAITHON POWER LIMITED

Vision: Empower a billion lives through sustainable, affordable and innovative energy solutions**.**

FACTS AND FIGURES

First successful venture of **Public Private Partnership (PPP) model**, a joint venture of Tata Power and DVC.

Capacity:
1050 MW (525 MW X 2) Greenfield Project.

Beneficiaries:
DVC, WBSEDCL, TPDDL, KSEBL

COD Unit-1 : 01.09.2011

COD Unit-2 : 24.07.2012

Location:
Maithon, Jharkhand

A Throwback to FY22

SOC: 0.115 ml/kwh
Lowest ever SOC figure since inception

PLF: 81.42%
Highest ever PLF figure since inception

Forced Outage: 1.75%
Lowest ever FO figure since inception

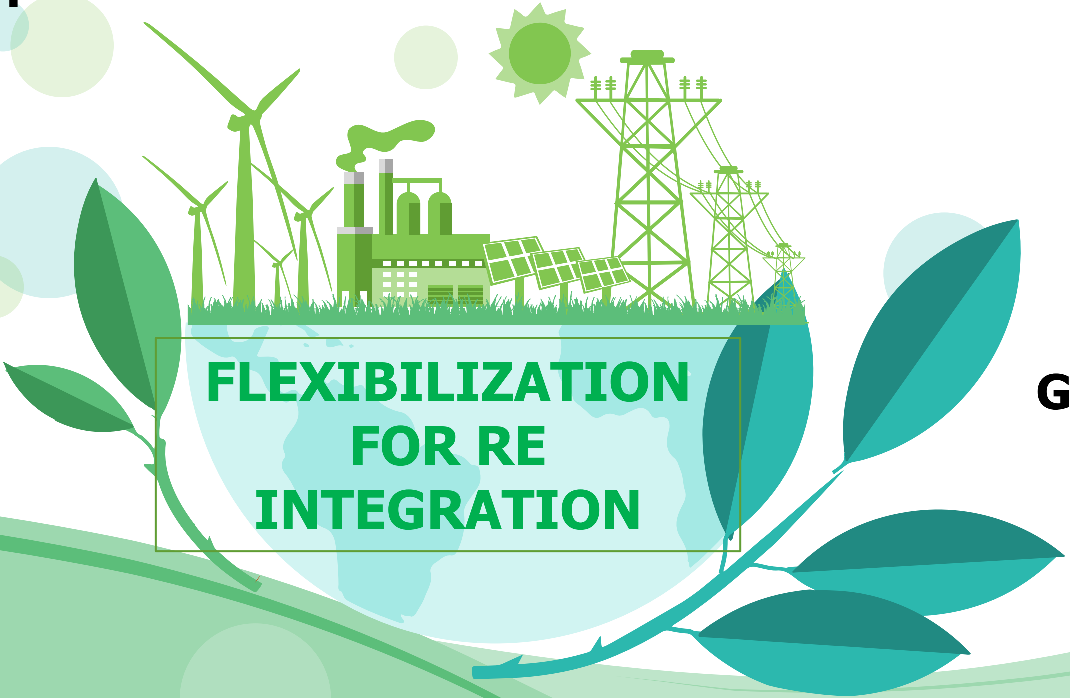
PAF: 93.12%
Highest ever PAF figure since inception

APC: 5.74%

Gross Heat Rate: 2373 kcal/kwh

Flexible Operation

Revised MTL



Higher Ramp Rate

Grid Security & Integrity

BUT WHY?

Indian Power Scenario-A Brief Introduction

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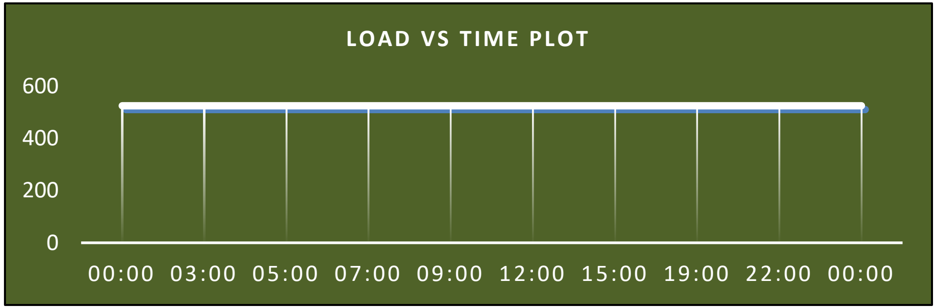
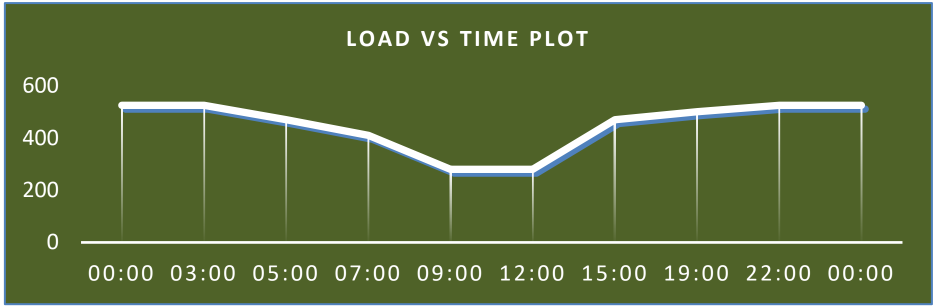
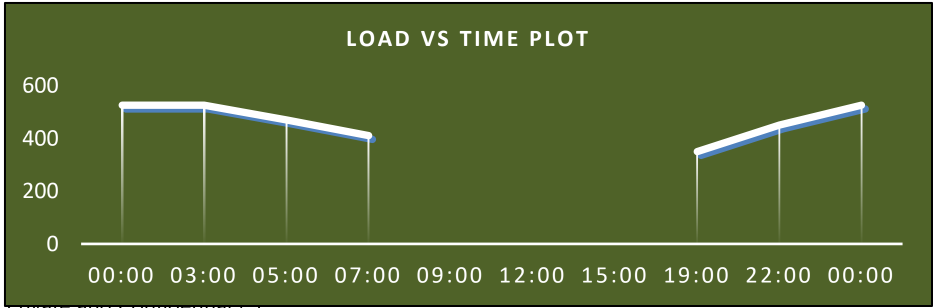
Indian thermal power sector is undergoing a radical transition with the advent of highly intermittent and low-cost renewable power generation, affecting a fundamental change in the business model of fossil fuel generation. As of now around 78% of India's power generation is met by thermal generators inspite of the target as set by the Government of India to increase the renewable generation by three folds (172 GW by 2022). This would require coal-based stations to bring down the load even below their Technical Minimum Limit, reduce the start-up time and progressively advance towards high ramp rates. The low merit order stations would also be required to operate in a two-shift basis mode or move to reserve shutdown.



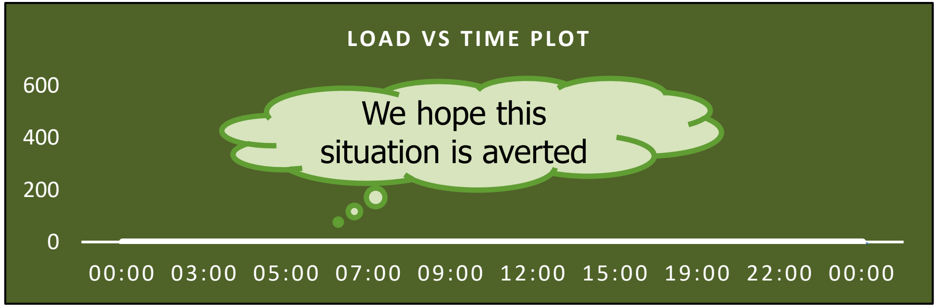
2015



2019



2025



2030

Flexible Operation – Present Scenario for MPL in FY22

MPL is already operating in the flexibilization regime

Flexible Operation-Thought Process

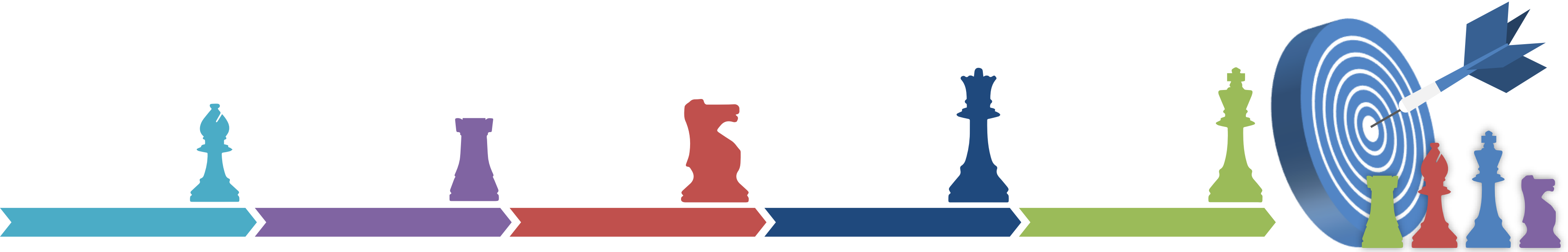
CEA ventured

- Under the Indo German Energy Forum (IGEF) flexibility roadmap, a task force was set up in India.
- The task force is undertaking studies to identify flexibilization measures and carry out a cost-benefit analysis to determine their scale-up potential.
- Based on the concept & importance of its strata, Unit-2 of MPL was selected by CEA-Ministry of Power, to conduct the flexibility test in Eastern Region.
- It is the second plant after NTPC Dadri to demonstrate the test in collaboration with IGEF.

Why MPL invested?

- Averting reserve shutdown.
- Benchmark in operational excellence
- Positive impact on performance parameters
- Increase in revenue owing to higher power sales in near future.
- Low count of reserve shutdowns will lower Cost on Customer - 25 lakhs/start up.

Being Ready For Flexi Operation



FY18

- *Station Minimum Technical Limit (Ex-bus): 680 MW*
- *69% Machine Loading*

FY19

- *Station Minimum Technical Limit (Ex-bus): 600 MW*
- *61% Machine Loading*

FY20

- *Station Minimum Technical Limit (Ex-bus): 541 MW*
- *55% Machine Loading*
- *Participation in RRAS & SCED*

FY21

- *50% loading trial done*
- *1% Ramp compliance*

FY22

- *U2 achieved 36% during IGEF trial.*
- *Participation in AGC*
- *AGC quantum 60 MW/unit*

FY23

- *AGC quatum 147 MW/block*
- *Discussion with vendors for stable & efficient operation at minimum load & during load ramp*
- *Feasibility study for 40% MTL & 3% ramp rate.*

Pre-Work and Preparedness for MTL Operation

Collaboration

Emergencies

Chances of failure

Readiness for 40% MTL operation

Predefined actions to tackle emergencies and unavoidable circumstances

Unit Response

Presence of mind!!

MTL Operation (40%)

All Protections active?

Step-wise approach

Manual Control

Quick Decision Making

Unknown scenarios

Clarity

Confusion

Harmful after effect

Performance Parameters

Effect of higher ramps

With all such probable thoughts, numerous brainstorming sessions were conducted to make the process more robust and fool-proof. Test procedure was shared by Siemens and same was prepared as an SOP where all apprehensions were taken into consideration.

Flexibility Tests identified for MPL

Date: 19th July to 21st July-2021

Coal Damper Tests

Adjustment of variable orifice in Mill-2D with two set of conditions, one at 525 MW and the other at 290 MW.

Date: 22nd July to 23rd July-2021

40% Minimum Technical Limit

40% MTL (210 MW) in pressure control , 40% MTL (210 MW) in CMC and further load reduction to 188.6 MW (35.92%).

Date: 26th July to 27th July-2021

Load Ramp Tests

0.5%, 1% and 1.5% load ramp tests were carried out from 290 MW to 525 MW. Load ramp to 210 MW was done at 0.285%.

Unfavourable Pre-Test Conditions and Mitigation Plan

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Minimum Load Test was conducted in a relatively controlled conditions as has been mentioned.

Following were the apprehensions that were possible in all the tests that were conducted:

1. SCC could not be predicted. It varied from 0.58 to 0.65 kg/kwh. Coal flow variations were obvious.
2. Availability of adjacent mills can be an issue (breakdown).
3. Low ambient temp would increase the duty of SCAPH, if FGET could not be maintained above dew point temp, it would lead to cold end corrosion of APH baskets.
4. LTSH, Divisional, Reheater metal temp excursions.

1 Good quality coal has been fired (SCC was maintained at 0.60-0.62 kg/kWh) during the Minimum load test as well as Ramp test.

2 3 adjacent mills were in operation (B-C-D). Prior to the test, maintenance job of all 3 mills were completed and was ensured to run without any issue.

3 AGC and RGMO was kept intentionally OFF to prevent any load variations. RRAS and SCED were also stopped during the test periods

4 Steam coil air preheater (SCAPH) was charged at low load. Additional auxiliary steam supplied from adjacent unit

5 Coal flow distribution and velocity profile for all the 4 coal pipes of Mill-2D were tried to equalize for better combustion and flame stability.

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Test Schedules

The tests commenced from 19th of July and was completed on 27th of July-2021. Experts from IGEF, Siemens, VGB, BMW Steel were all connected via MS Teams for proper co-ordination and execution.

19.07.2021
Adjustment of Measurement Equipment

20.07.2021
Coal Damper test at 525 MW

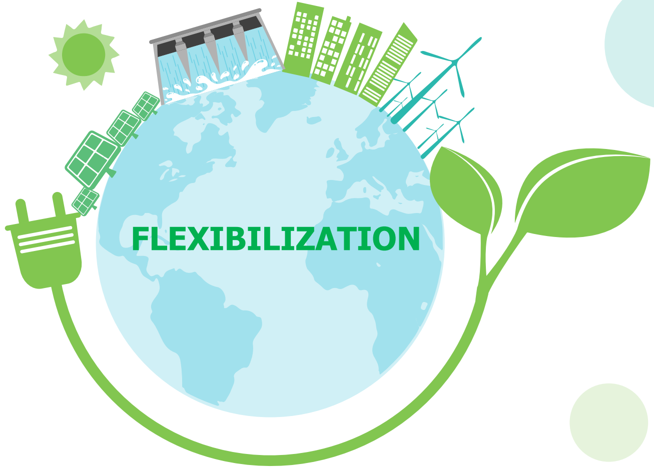
21.07.2021
Coal Damper test at 290 MW

22.07.2021
40% MTL in Turbine Follow Mode

23.07.2021
40% MTL in CMC and further load reduction to 188.6 MW

26.07.2021
Load ramp test from 525 MW to 290 MW

27.07.2021
Load ramp test from 290 MW to 210 MW



START OF IGEF TRIALS

Coal Damper Test-525 MW and 290 MW

On 20th July, Coal Damper Test was carried out in Mill-2D at 525 MW with a specific coal consumption (SCC) of 0.696 kg/kWh. Feeder loading of Mill-2D was kept in manual at a demand of 84% and its average coal flow was 58 TPH.

On 21st July, Coal Damper Test was carried out in Mill-2D at 290 MW with a specific coal consumption (SCC) of 0.631 kg/kWh. Feeder loading of Mill-2D was kept in manual and its average coal flow was 45 TPH.

- Variable orifice adjustment to equalize fuel in each corner.
- Low coal flow through D-3 (shortest pipe).
- Coal pipe temp were uniform in nature.
- Isokinetic sampling was done to rule out pipe choking.
- Longest pipe D-1 was kept at 100%.
- Coal flow of Mill-2D was reduced to 25 TPH, flame conditions at corner-1 and 3 deteriorated (at 290 MW).

Coal Pipe Corner	Damper Position (%)	Coal Flow (TPH)	Coal Pipe Velocity (m/sec)	Coal Flow Distribution (%)
D-1	100	18.8	28.3	30.8
D-2	60	20.6	17	35.7
D-3	**100**	**5.5**	**27**	**11.6**
D-4	73	8.5	29.6	21.4

Observations:

- Coal pipe-1,2 and 4 were OK as per Siemens and IGEF. Pipe-3 is suspected of being choked.
- Changes in PA Flow by 5 TPH did not influence Corner-3. Changes with respect to NO_x, O_2 were not appreciable.
- Low mill outlet temp (70^0C) due to wet coal.
- Issue may persist with the coal flow sensors.
- GCV of coal improved and mill outlet temp improved to 90^0C.
- Damper position of D-3 was kept at 65% and preparations for 40% MTL started.

Final Condition of Mill-2D:

Coal Pipe Corner	Damper Position (%)
D-1	100
D-2	60
D-3	**65**
D-4	73

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Minimum Load Test- 40% in Turbine Follow Mode (TFM)

On 22nd July, Minimum Load Test (40%) to 210 MW was carried out in Turbine Follow Mode with a specific coal consumption (SCC) of 0.63 kg/kWh.

Pre-test conditions:

- Load : 290 MW (55% load)
- Coal Flow : 182 TPH (SCC=0.63)
- MS Pressure : Manual at 140 kg/cm2
- Mill Combination preferred : B, C, D, E (44 TPH,46 TPH,44 TPH and 42 TPH of coal feeding)
- Burner Tilt : Manual control
- SADC : Auto control at 75-90 mmWC.
- MS/HRH temp : Auto control
- O_2 SP : Auto control SP 4.9%.

0.5% O_2 reduction by providing a bias of -0.5% at 10:40 hrs.

- There was no change in APH outlet flue gas temp after O_2 was reduced from 4.91% to 4.41%. Same was reverted to 4.91%.

10 kg/sq.cm MS Press reduction (140 kg/sq.cm to 130 kg/sq.cm)

- There was no noticeable change in APH outlet flue gas temp.

SH Spray in Auto and BT increased to 68% from 55% at 11:29 hrs.

- There was no change in APH outlet flue gas temp. BT was again reduced to 55%.

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Minimum Load Test- 40% (TFM)

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1. SCAPH was taken in service at 12:20 hrs
2. RCV of TDBFP-2A was opened at 290 MW and further load drop to 275 MW.

- Increase in SA temp from 35^{0}C/35^{0}C to 66^{0}C/86^{0}C.
- FGET at APH outlet increased to 129.6^{0}C/127.7^{0}C
- Fluctuation in drum level was in the range of +120 to -218 mmWC which was manually controlled.

1. BT was reduced to 50% from 55%.
2. Load was reduced to 275 MW in CMC at 12:50 hrs and further reduction to 255 MW. MS press was 123 kg/sq.cm.

- LTSH metal temp crossed the alarm limits (460^{0}C).
- At 255 MW, TDBFP-2A was taken out of service. MCV and ACV of TDBFP-2B opened to 100% to cater the feedwater flow due to low extraction steam press.

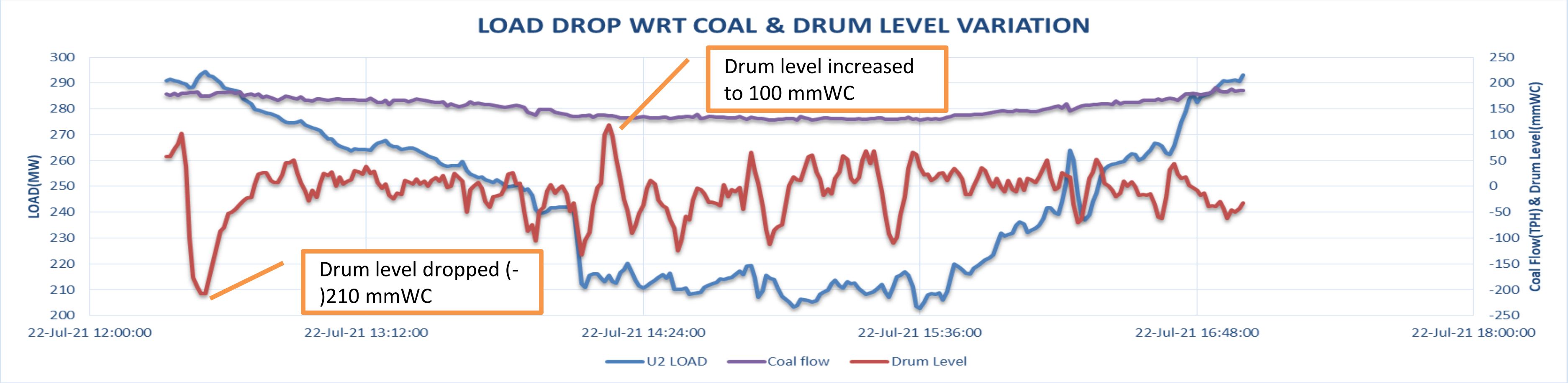
1. Feeder-2E speed was reduced to minimum.
2. Switch over to Turbine Follow mode at 240 MW. MS press SP was 110 kg/sq.cm where actual press was 109 kg/sq.cm.

- At 13:55 hrs, Mill-2E was taken out of service.
- Load drop from 240 MW to 210 MW at 14:08 hrs. Feeder speed of B, C and D were reduced by 5% manually to reach 210 MW.

1. Load=210 MW, MS press=107 kg/sq.cm was kept for 1 hour for stabilization

- Post stabilization load was increased to 230 MW in press control.Mill-2E was taken in service at 250 MW and TDBFP-2A at 270 MW. Unit load was further increased to 290 MW. CMC was taken in service and SCAPH was isolated.

Minimum Load Test- 40% (TFM)



Constraints/Observations:

Drum Level

- ACV of TDBFP-2B was controlled manually and MCV was controlled by varying the level setpoint.
- MDBFP was kept in Manual.
- Dependency on another Unit for PRDS.

Flame Stability

- AB-2, AB-3 and CD-2 flame intensity were in the range of 20-30 lumens.
- AB and BC fireball was flickering intermittently.
- Furnace to Windbox DP dropped to 33 mmWC from 55 mmWC.

APH outlet flue gas temp/Single Fan Mode

- FGET APH-A: 115.8^{0}C
- FGET APH-B: 115.1^{0}C
- FGET was maintaining on the lower side..

SH-RH steam/metal temp

- LTSH metal temp reached 467^{0}C during load ramp to 257 MW (Tag no-141).
- HRH steam temp dropped down to 529^{0}C.

Miscellaneous

- HP front bearing vibration-X increased to 116 microns.
- Hotwell level was maintaining>2000 mm.
- Cationic conductivity at CEP discharge was maintaining high>0.303 uS/cm.

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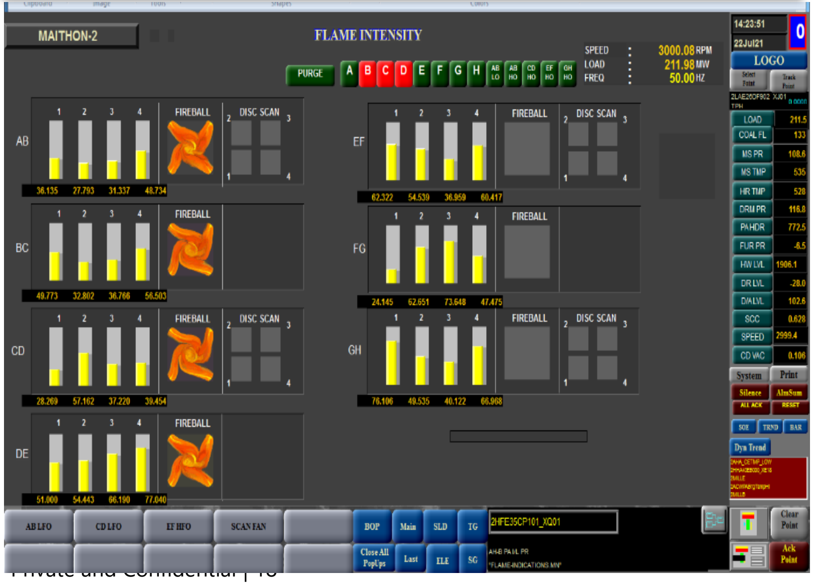
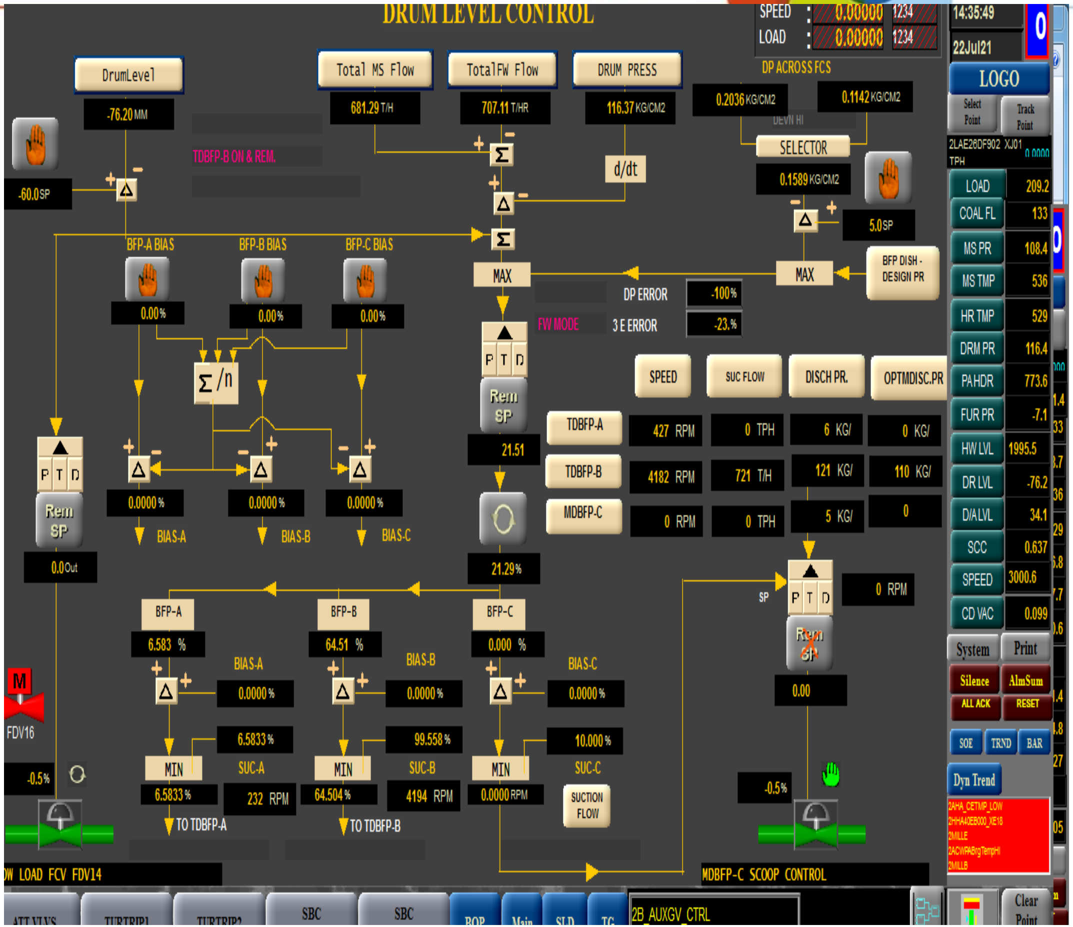
Minimum Load Test- Snapshots





Minimum Load Test- 40% in CMC

On 23rd July
kg/kWh. It
rried out in CMC
f 180 MW loa
consumption (SCC) of 0.61

Pre-test co
- Load : 290 W (55% load)
- Co
- N
- N

Pre-test co
- Burner Tilt
- SADC
- M
- C

control
WC.

10:30 - 11:00
- **Load SP: 290 MW**
- **MS Pr SP: 130 ksc**
- **TDBFP A R/C valve opened**
- **SCAPH Charged**

Drum level fluctuation 225 mm

11:00 - 11:30
- **FDF 2A was stopped**
- **Load SP: 275 MW**
- **MS Pr SP: 120 ksc**
- **Unit ramp rate : 3 MW/min**

FD Fan-2B ampere :79 A

11:30 - 12:00
- **IDF 2A was stopped**
- **CM 2E feed rate : 20 tph**
- **Load SP: 260 MW**
- **MS Pr: 115 ksc**

ID Fan-2B ampere variation from 930 to 1040 A

12:00 - 12:30
- **Load raised to 290 MW**
- **IDF 2A & FDF 2A re-started**

- Poor Flame condition
- Fireball of AB & BC unstable
- ~210 TPH SA Flow deviation in LHS and RHS WB

12:30 – 13:00
- **Load reduced to 250 MW**
- **MS Pr SP : 108 ksc**
- **Unit Load Rate : 2 MW/min**

13:00 - 13:30
- Load SP: 235 MW
- TDBFP 2B taken o/s
- Furnace to WB DP: 35 MMWC

TDBFP2A ACV : 100% open
TDBFP2A MCV: 68% open
Flame intensity improves

13:30 – 14:00
- Load reduced sequentially : 225 MW-210 MW-200 MW

14:00 - 14:30
- **Load reduced :** 195 MW – 190 MW
- **Min Load SP: 179 MW**
- **Min Load achieved: 188.6 MW**

AB/BC Fireball flickering
Load raised to 200 MW

14:30 - 15:00
- Load raised : 230 MW – 250 MW
- Unit ramp rate : 5 mw/min
- TDBFP 2B taken i/s

LTSH metal temp reached limit value of 460C

15:00 - 15:30

Load raised : 290 MW
MS Pr SP: 120 ksc

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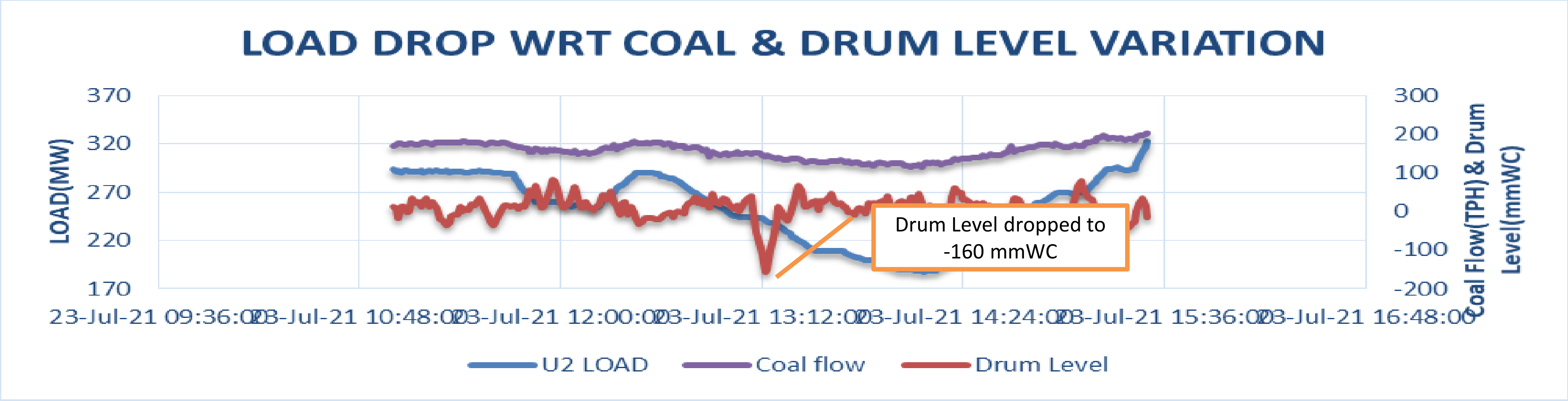
Minimum Load Test- 40% in CMC



Constraints/Observations:

TG Cycle Heat Rate was 2300 kcal/kWh

Drum Level

- ACV of TDBFP-2A was controlled manually and MCV was controlled by varying the level setpoint.
- MDBFP was kept in Manual.
- Dependency on another Unit for PRDS.

Flame Stability

- AB-2, AB-3 and CD-2 flame intensity were in the range of 20-30 lumens.
- AB and BC fireball was flickering intermittently.

APH outlet flue gas temp/Single Fan Mode

- FGET APH-A: 109.4^{0}C
- FGET APH-B: 112.2^{0}C
- FGET was maintaining on the lower side.
- Single fan operation could not be done due to flame instability and running ID fan high power consumption.

SH-RH steam/metal temp

- LTSH metal temp reached 467^{0}C during load ramp to 257 MW.
- HRH steam temp dropped down to 523^{0}C.

Miscellaneous

- HP front bearing vibration-X increased to 116 microns.
- Hotwell level was maintaining>2000 mm.
- Cationic conductivity was maintaining high>0.24 uS/cm.

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Minimum Load Test- Snapshots

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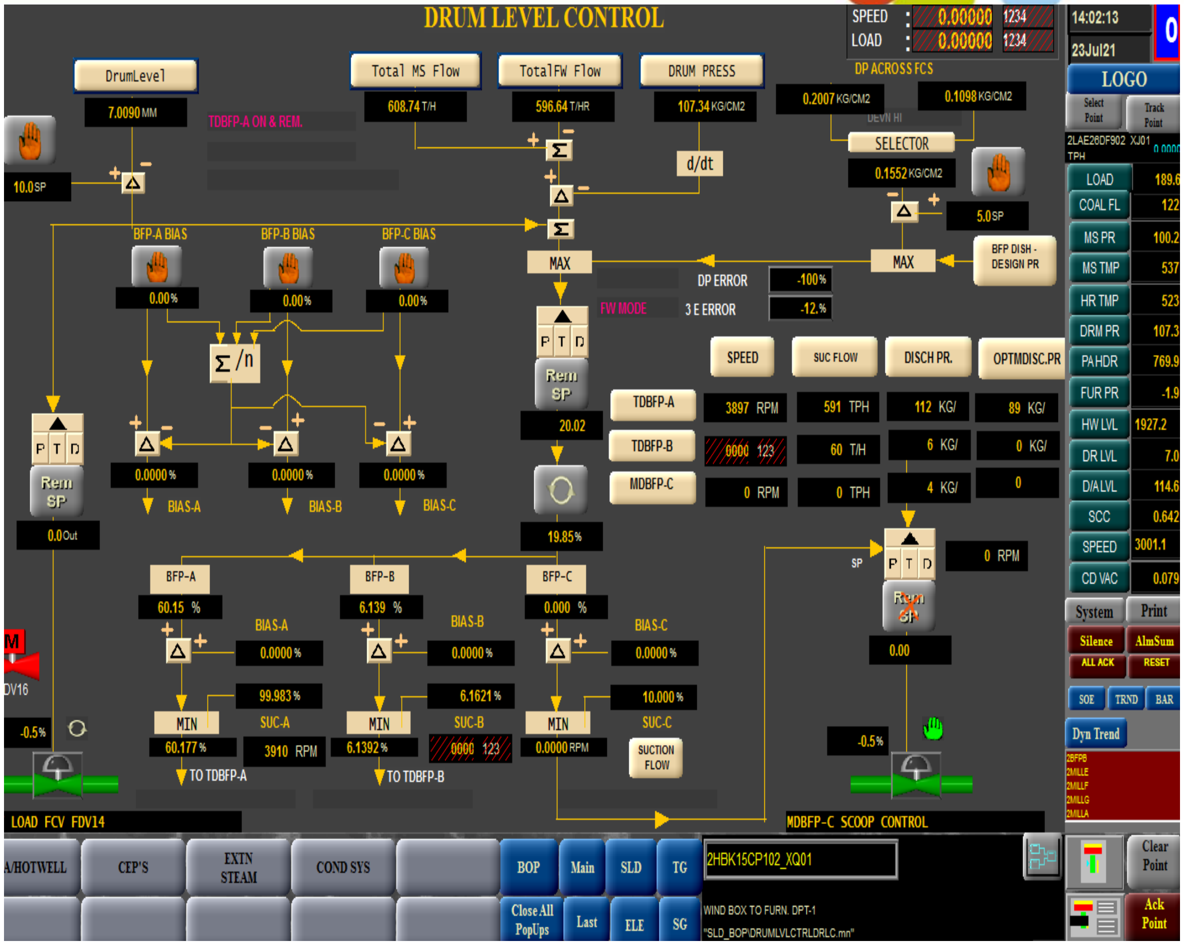

Load Ramp Tests

On 26th and 27th July, Load Ramp test (0.5%, 1% and 1.5%) was carried out in CMC with a specific coal consumption (SCC) of 0.61 kg/kWh. It was also in the schedule to check for the feasibility of 180 MW load.

Pre-test conditions:

- Load : 525 MW
- Coal Flow : 296 TPH (considering SCC=0.56)
- MS Pressure : Auto control at 172.9 kg/cm^2
- Mill Combination preferred : B, C, D, E, F, G All feeders in Auto.
- Burner Tilt : Auto control
- SADC : Auto control at 75-90 mmWC.
- MS/HRH temp : Auto control
- O_2 SP : Auto control SP 3.56%.
- RGMO & AGC was kept OFF at 11:23 hrs after communicating to the concerned authority.
- Superheater spray : 30 TPH (LHS/RHS=0/30 TPH)
- Reheater spray : 11 TPH (LHS/RHS=5/6 TPH)
- Superheater temp : 539^0C at 11:33 hrs
- Reheater temp : 535^0C at 11:33 hrs
- Reheater MTM temp : 592^0C max at 11:38 hrs (tag no- 260,258)
- UOFA and LOFA : Auto control

Load Ramp Tests (525 MW to 290 MW) : Challenges

Reheater MTM Excursion

- ❑ Max. RH Metal Temperature during trial: 606°C
- ❑ RH MTM excursion beyond alarm limit of 590°C
- ❑ No improvement even after lowering steam temperature < 537°C (rated)
- ❑ Manual intervention to control RH MTM excursion

Ramp Rate

- ❑ **1.5% ramp up** rate not attempted due to limiting factors of RH MTM excursion
- ❑ **1.5% ramp down** rate successful for 525 MW to 450 MW load range

Control Loop Response

- ❑ Sluggish response by CMC
- ❑ Further control tuning is required to achieve aggressive rame rate

IGEF Team response

- ❑ Drum level, RH metal temp excursions have been the major factor during load ramps

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Load Ramp Tests (290 MW to 210 MW)

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- ❑ Trial 1: No equipment status change
- ❑ Trial 2: Mill 2E stopped

290 MW -260 MW
Ramp : 0.5% (2.5 MW/min)

- ❑ Trial 1: Mill 2E stopped
- ❑ Trial 2: TDBFP-2B stopped

260 MW -240 MW
Ramp : 0.5% (2.5 MW/min)

- ❑ Trial 1: TDBFP 2A stopped
- ❑ Trial 2: No change

240 MW -225 MW
Ramp : 0.5% (2.5 MW/min)

- ❑ ***Trial 1: Turbine Follow Mode***
- ❑ ***Trial 2: CMC***

225 MW -210 MW
Ramp : 0.25% (1.25 MW/min)

210 MW -250 MW
Ramp : 1% (5.25 MW/min)

- ❑ Trial 1: No equipment status change
- ❑ Trial 2: Mill 2E started

250 MW -265 MW
Ramp : 1% (5.25 MW/min)

- ❑ Trial 1: Mill 2E started
- ❑ Trial 2: TDBFP 2B taken in service

265 MW -290 MW
Ramp : 1% (5.25 MW/min)

- ❑ Trial 1: TDBFP 2A taken in service
- ❑ Trial 2:

Key observations of IGEF/Siemens:

- Flame Stability have been the major influencing factor for Minimum Load operation
- Drum level, metal temp excursions have been the major factor during load ramps

Key Challenges faced during Load Ramp Tests :

- Drum level fluctuation while taking TDBFP out of service at 250 MW. Drum level controlled manually through ACV, MCV following level setpoint.
- HRH steam temperature maintaining < 520^{0}C.
- LTSH and Divisional metal temp were going above alarm values during ramp up from lower loads.
- Dependency on Unit-1 for PRDS (Steam for SCAPH and TDBFP ACV).

ACCOLADES

Becomes India's First Thermal Station to achieve stable 36% loading of Machine

IGEF @IGEFSO · Jul 23

Kudos to the excellent operator team from @TataPower for successful flexibility tests with 36% minimum load achieved. 🇮🇳🇩🇪 Indian and German experts from Tata Power MPL, @VGBPowerTech and @Siemens_Energy perform these tests supported by @MinOfPower @BMWi_Bund @IGEFSO.

IGEF @IGEFSO · Jul 23

36% minimum load achieved at @TataPower @damodarvalleyco JV Maithon Thermal Power Station in #Jharkhand. New milestone for #power sector in #India! 🙏 @MinOfPower @CEA_India @PosocoIndia witnessing 188 MW low load operation from control room at site!

IGEF Twitter handle

To reinforce TATA POWER commitment to all the stakeholders, Unit 2 of MPL division successfully demonstrated minimum load test at 40 % & 36%. It was witnessed & appreciated by CEA,POSOCO,ERPC & IGEF . MPL is the second plant in India after NTPC Dadri to achieve 40% & first in eastern region

Recommendations by Siemens

Replace feedwater recirculation valves with modulating type valves, as opening of the valves causes big disturbances.

Upgrade or implement new controls for turbine-driven boiler feedwater pumps when fed by auxiliary steam from another unit, as the controls are not working properly. Currently increased trip risk and a lot of operator attention required.

Upgrade of drum level control for operation at minimum load.
Implementation of automatic sequences for start-up and shut down of Mill, BFP, SCAPH etc.

Conduct a study of **thermal and mechanical feasibility** of part load operation with **different coal qualities**.
Chemistry Assessment

Optionally an **online performance calculation**, which calculates key performance indicators and will help operators in maintaining the efficiency high.

Thermal/mechanical upgrade of exhaust flue gas part / air part for increase of flue gas temperature level for Part load operation as well as for better controllability of flue gas temperature

Combustion investigation, consisting of slagging/fouling potential, milling system, burner system and impact of fuel compositions if required. **Boiler tuning at site** (optional-Simulations for combustion optimization (optional), consisting of Firing optimization, Slagging and fouling, Part load efficiency improvement and Emission calculation).

Bottlenecks for Flexibilization

40% MTL & 3% Ramp Rate

01 Equipment Reliability

- Cyclic Loading Stress
- High Forced Outage
- High Maintenance Expenses

02 Operational Excellence

- Part Load Operation
- Impact on Heat Rate & APC
- Cycle Water Chemistry
- APH & ESP Corrosion
- FD Fan & PA Fan Stalling

03 Multi-fuel Firing

- Biomass Co-firing
- Imported Coal

04 Ancillary Service

- New DSM Regulation
- SRAS Performance based Incentive
- Reduced RGMO compliance

05 Diagnostic Support

- OEM guidance for 40% load
- Capex for New Technology adoption such as Variable Orifice, Furnace Flame temperature, Boiler Temperature Modelling

06 Unit Reliability

- Mill/feeder tripping during 3 mill operation
- Furnace disturbance during FD/ID Fan tripping

Conclusion:

- Any unit can be flexed; however, all units need not. The flexing needs is to be decided based on the grid support required from the unit.
- Moderate amount of flexibilization can be achieved with modification in operational practices.
- Higher level of flexibilization can be achieved with retrofits and the decision should be taken on case-to-case basis as in some cases the retrofit cost may be prohibitive.
- The providers of flexibility must be motivated by incentivization.

Questions, If Any ?

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Thank You!

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