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Flexible Trial Run Operation at Damodar Valley Corporation (DVC)

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1.0 Introduction

The Government of India has proposed a new set of rules "Electricity (promoting renewable energy through Green Energy Open Access) Rules, 2021" for the purchase and consumption of green energy, including the energy from waste-to-energy plants. The proposed rules aim to push for faster adoption of renewable power by addressing various concerns related to the green energy sector. "There shall be uniform Renewable Purchase Obligation (RPO), on all obligated entities that are – the distribution licensees, open access consumers, and captive power consumers," said the proposed rules. The RPO is a mechanism under the Electricity Act 2003 by which the big consumers have to purchase a certain percentage of their total consumption of electricity from renewable energy sources.

India is the world's 3rd largest consumer of electricity and the world's 3rd largest renewable energy producer with an installed capacity of 111 GW in the year 2022, consisting of solar (55 GW), wind (41 GW), small hydropower (5 GW), biomass (10 GW), large hydro (47 GW), and nuclear (7 GW).

Considering the above scenario, it is obvious for the thermal utilities to adapt to the situation and upgrade their conventional power generation operation procedure to flexible operation procedure. Flexible power plant operation comprises three dimensions: low minimum load operation, short and efficient start-ups and shut-down, and high Ramp rates. Most measures for flexibility enhancement aim at low minimum load operation. A more specific definition was put forward by IEA (2011): "Flexibility expresses the extent to which a power system can modify electricity production or consumption in response to variability, expected or otherwise." IEA (2014) introduced a distinction between a broader concept of flexibility and a narrower concept of Ramping flexibility: "In a narrower sense, the flexibility of a power system refers to the extent to which generation or demand can be increased or reduced over a timescale ranging from a few minutes to several hours."

As per CERC notification, under section 79(1) h of the Indian Electricity Act, 2003, the technical minimum thermal load (MTL) (without oil support) of the unit is 55%. It is being considered that the 1%/min. of the installed capacity as the Ramp rate.

Indian grid is comfortably placed in case individual units maintain a basic Ramping capability of 1%/min. Therefore, it may be concluded that Ramp rates are not a challenge for the integration of renewable generation into the Indian grid.

In 2006 the Indian Prime Minister and the German Chancellor established the Indo-German Energy Forum (IGEF) to promote an energy dialogue. As a part of this effort, the owners aim at reducing the minimum load and increasing the speed of load Ramps in several power plants. It has been suggested to the IGEF/Siemens/VGB team to collect the process data/parameters from start-up, shutdown, and low load operation of these units, and has analyzed this data to identify potential problems during operation at low load and faster load Ramps.

In the meeting on "Flexibilization of Power Plants" under the auspices of IGEF on 04.03.20 at MoP regarding a further possible plant for test runs at another TPS, JS, Thermal has requested CEA to share the plants identified for test runs with task force flexibility under the IGEF. DVC, Durgapur Steel TPS, Andal (Unit # 1) was identified for test runs with the support of VGB and Siemens.

The initial data of Durgapur Steel TPS units and preliminary assessment has been carried out by DVC/VGB/

Table 1

Date	Weekday	Test	Load
28.03.2022	Monday	Minimum Load Test	210 MW (or less)
29.03. 2022	Tuesday	Minimum Load Test	180 MW (or less)
30.03. 2022	Wednesday	Load Ramp Test	Between 290 and 500 MW
31.03. 2022	Thursday	Load Ramp Test	Between 290 and 500 MW

Siemens. Before commencement of the test the following main issues have been discussed:

(a) Earlier units has operated at 55% minimum load, but checking to achieve the lower loads have not been done.

(b) There is a concern about large variation in coal quality. The volatile matter content (VM) is sometimes as low as 13 to 14 % and the gross calorific value (GCV) is also very low, which can pose limitations in reducing minimum loads further down.

(c) Reducing coal mills below 4 numbers at low loads has not been done earlier.

For successful completion of the trial run, several rounds of the meeting were organized to discuss the initial assessment and the roadmap of the test runs. After detailed discussion, Durgapur Steel TPS Unit#2 had been finalized for the subject trial operation from 28/03/22 to 31/03/22.

The schedule was finalized as in Table 1.

The flexible operation test on Durgapur Steel TPS, Unit#2 of DVC was performed from 28.03.2022 to 31.03.2022 with IGEF, CEA MoP, GOI and Siemens India. During the test low load stable operation (without oil support) and RAMP rate testing on the machine with increase and decrease in load was conducted.

A stable minimum load of 160 MW was achieved without oil support on 30.03.22. Ramp up and Ramp down were also tested and a 2% Ramp rate was achieved in both cases, with some parameter variation observed at 3%. Operation of 500 MW Durgapur Steel TPS, Unit#2 at 32% load achieved.

The days wise detailed activities for performing the test are given below:

Starting point (28/03/2022)

1. Unit load 505 MW, Feeders B, C, D, F, G, H are in service
2. Unit load set point 505 MW, machine in CMC

Date: 28/03/2022 to 30/03/2022

Steps

1. Load set point reduced in steps of 10 MW from 505 MW at a rate of 5 MW/Min.
2. At 470 MW feeder H was taken out, at 440 MW feeder G was taken out, and at 370 MW feeder F was taken out of service.
3. Ensure consecutive mill operation for better flame stability.
4. Load reduced to 290 MW gradually keeping SP of lower mills at minimum coal flow of 45 TPH in CMC.
5. At 290 MW unit was kept for 2 hrs. for stability.
6. At 270 MW – as a precautionary measure, TDBFP ACV put into service from CRH, as IP extraction pressure to both TDBFP becomes low at lower load, due to which disturbance in drum level occurs.
7. After achieving stability in TDBFP, unload one TDBFP and keep it on 3500 RPM.
8. Now reduce load to 250 MW.
9. Oxygen set point slowly raised to 5.5%.
10. Wait for 15 minutes to attain stability.
11. After achieving stability start decreasing load in CMC. Keeping base mills minimum coal flow limit to 40 TPH.
12. At load 220 MW take any one FD fan out of service.
13. SCAPH was charged.
14. Turbine throttle pressure decreased manually.
15. Now take the machine into pressure control mode (as the limit of minimum load set point of CMC is 200 MW).
16. Burner tilt adjusted as per the requirement to raise RH temperature observing flame stability.
17. Manual damper i.e., AA was reduced to 25% at all four corners to keep wind box DP above 40 mmwcl (as per BHEL design curve).
18. Again, the oxygen set point was raised to 6.8 % to maintain furnace to wind box DP.
19. Now slowly load reduced to 155 MW.
20. At this load, coal flow was 92 TPH, coal ratio 0.593, MS pressure 90 Kgsc, oxygen setpoint 6.8 %, wind box DP 20 mmwcl, MS/HRH temp 531/498ºC.
21. After stability, a minimum load of 160 MW was achieved without oil support.

Date 30/03/2022 Time: 10:15 Hrs.

Starting point

CMC Load SP = 500MW, Actual Load = 501MW

Steps

- Ramp Down
  - Time 10:15 hrs.- CMC Load SP changed to 375 MW @ 2% Ramp.
  - Time 10:27 hrs. - Load achieved 375 at @ 10.75 MW / Min
  - Time 10:40 hrs.- Load SP was 375 MW, Actual Load = 387 MW.
  - Time 10:40 hrs.- Load SP changed to 275 MW @ 2% Ramp.
  - Time 10:48 hrs.- Actual Load achieved = 274 MW @ actual Ramp Rate of 14.16 MW /Min
- Ramp Up
  - Time 13:27hrs.- CMC load SP =205 MW, actual load = 207MW
  - Time 13:27hrs.- CMC load SP was changed to 300MW in one go @ 2% Ramp
  - Time 13:37hrs. - Actual Load achieved= 300MW @ actual rate of 9.5 MW/Min
- Ramp up
  - Time 14:57 hrs. - Actual Load =333 MW, load SP was changed to 430MW @2% Ramp
  - Time 15:08 hrs. – Actual Load achieved= 433 MW @ actual rate = 9 MW/Min
- Ramp up
  - Time 15:53 hrs.- Actual Load = 430MW, load SP changed to 490MW @2% Ramp
  - Time 16:04 hrs.- Actual Load achieved= 522 MW, @ actual rate = 8.36 MW/min
- Ramp down
  - Time 16:33 hrs.- Actual Load = 480 MW, load SP changed to 355 MW @ 3% Ramp.
  - Time 16:43 hrs.- Actual Load achieved= 355 MW @ actual rate 12.5 MW/min
- Ramp down
  - Time 17:07 hrs.- Actual load = 362 MW, Load SP changed to 250 MW @ 3% Ramp.
  - Time 17:14 hrs.- Actual load achieved= 250 MW @ actual rate 16 MW/min
- Ramp up
  - Time 18:29 hrs.- Actual Load = 275MW, load SP changed to 400MW @3% Ramp
  - Time 18:42 hrs.- Actual Load achieved= 396 MW, @ actual rate = 9.38 MW/min

Date 31/03/2022 Time: 10:22 Hrs.

Starting Point

CMC load SP= 497MW, Actual Load =485 MW

Steps

- Ramp down
  - Time 10:24 hrs.- CMC load SP changed to 350 MW @ 2% Ramp. Load achieved 356 MW at 10:36hrs @ 11.75 MW/min
- Ramp up
  - Time 11:12 hrs.- CMC load SP =350 MW, Actual Load = 351 MW
  - Time 11:14 hrs.- CMC load SP was changed to 470 MW in one go @ 2% Ramp
  - Time 11:26 hrs.- Actual Load achieved= 478MW @ actual rate of 10.58 MW/min

Issues/Observations related to technical minimum and RAMP rate:

AT 55%

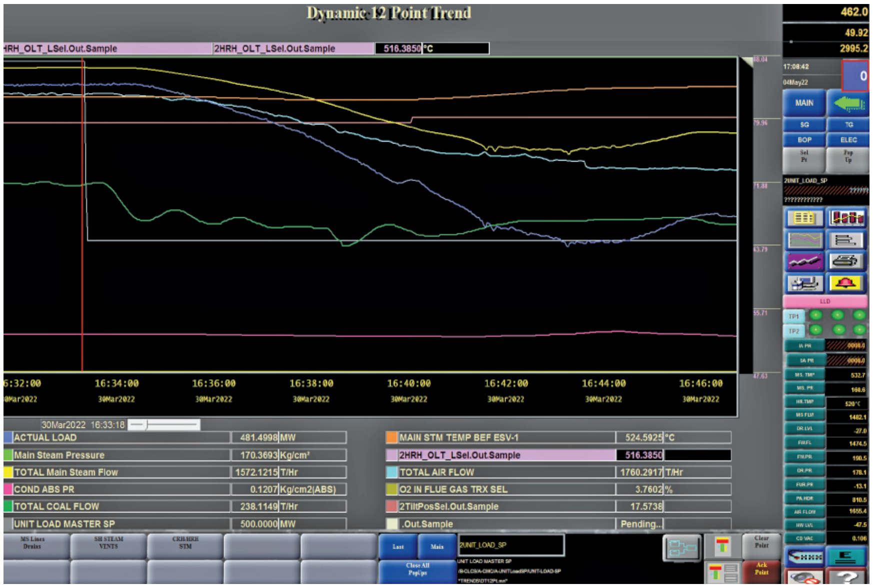
- Not much issue at 55%.
- Transient load condition drum level fluctuation due to opening of BFP recirculation valve.
- Higher APC due to marginal condition for 2 CEP running.
- Load increase will take a longer time if one CW pump is taken out from service.
- Similarly, due to the reduction in number of operating coal mills, it takes higher time at the requirement of higher ramp and quantum.
- Frequent load change increases fatigue loading of components and may be causing boiler tube leakage in attachment weld failure.
- Proper tuning of the control system is required.

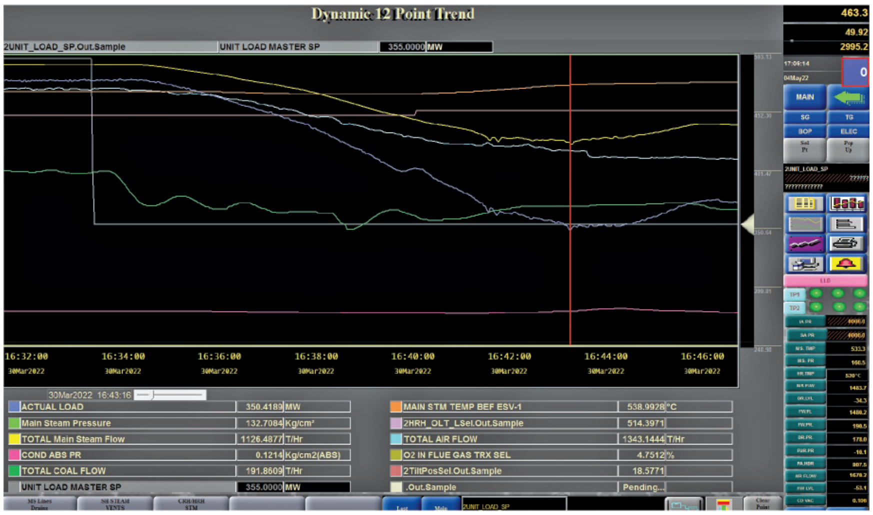
At 40%

- Flame instability at lower VM coal.
- Low wind box pressure hence chance of overheating in Water wall.
- Single FD Fan, BFP, and CEP hence the reliability of unit less as any tripping may cause Unit tripping.
- Same in case of coal mill also any tripping of coal mill will reduce load will be lower than 30% hence chance of malfunctioning of control including Drum Level Control.
- TDBFP steam source from CRH: at low load good but higher load with higher CRH pressure, control by TDBFP Aux control valve is difficult.
- Temp control is required fast tuning.

Ramp rate

- Up to 2% RAMP rate is not much problem at 55% but sudden change to higher load is difficult as the number of coal mills has to be increased in service.





- At 40%, due to less margin, 2% of the rated load is difficult but 2% of running load is not so difficult, but the higher quantum of load cannot be achieved as less number of Aux. running and starting all the equipment takes time.
- Higher ramp – higher temperature cycles less boiler tube life due to fatigue loading.
- Chemical parameter variation particularly in old/ dirty boiler.

Some solutions

- Less variation in coal quality.
- Better tuning of the control system.
- Coal mill variable orifice of flow balancing of coal mill pipe in respect to minimum air flow (dirty pitot test at minimum flow) such that at low loading flow is balanced.
- Starting third BCW pump at a load lower than 50%.

Suggestion/ Recommendation

- With the integration of RE in the power system where the fast rise and drop are expected from the thermal power plant, each machine should have a faster ramp rate otherwise if a smaller number of machines connected in the system is having high rate, the machine which is behaving properly will have very high fluctuation in generation.
- Priority of machines needs to be set for flexible operation and 6 monthly rotational schedules for flexible machines may be set.
- If there is no such system requirement test for flexibilization and RAMP rate may be conducted once in six months.
- With low load and high ramp chances of BTL will increase, hence for identified unit availability factor relaxation may please be thought of.
- Similarly, tariff incentives for such units should also be thought of.

Some of the trends of important parameters during the test:

C&I Role

- 'Velocity and acceleration based triggered controlled override logic' was introduced for better SH temperature control to reduce upside excursion of temperature in SH tubes.
- Other minor modifications in control loops were done to stabilize the system.
- 3 nos oxygen transmitters were installed at each APH I/L for better airflow control and combustion stability.
- Flame scanners were thoroughly cleaned and calibrated for flame stability.
- A small T3000 system has been installed and used as a data archive and data analysis. By this system, the collection of important plant data/parameters was done for further analysis purposes.

Other correlated points

- Apart from the flexibilisation operation of Durgapur Steel TPS Unit#2, DVC, in-house testing has been done in all 500MW and 600MW units and all are 55% compliant. For 250MW and 210MW units (Ball and Tube mill) in the process to achieve. For, CTPS (250MW), a minimum of 60% has been achieved. In-house technical minimum and Ramp rate test of units Durgapur Steel TPS#1, MTPS#7, BTPS-A, and KTPS#1 has been conducted at 55% load with 1% Ramp rate.
- In this regard, it is pertinent to be mentioned that, DVC has already placed one Work Order to M/s Solvina India Private Limited to conduct a Primary Frequency Response Test of seventeen (17) DVC units (except DTPS Unit#4, MTPS Unit#1&2, MHS Unit # 1-3). The said test has already been executed in Durgapur Steel TPS Unit#1&2.