International Research Journal of Power and Energy Engineering
Vol. 3(2), pp. 067-073, November, 2017. © www.premierpublishers.org, **ISSN**: 3254-1213

IRJPEE

Conference Paper

Enhancing Capacity Utilization of Coal Fired Thermal Power Plant through Better Operation and Maintenance Practices

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This paper describes the capacity enhancement of coal fired power plants through operational optimization, control techniques and better maintenance practices. The philosophy of "Prevention is Better than Cure" is dealt in detail to improve the Plant load factor (PLF) of plant. The energy conservation measures are also implemented in improving the plant performance and are enumerated in this paper. By adopting better maintenance practices for thermal power plants, enhance the capacity utilization of plants, thereby the present average PLF of 73.3 % of 210 and 250 MW units can be enhanced to about 95 % that will release an additional energy of about 1.2 lakh MU/year.

Keywords: Preventive maintenance; Capacity enhancement; Operation and maintenance; Plant load factor;

INTRODUCTION

The Indian power sector is highly dependent on thermal power generation i.e., 67% of total generation. The power generation by coal forms about 59.1% of total energy generation as on 30.06.2017 (Ministry of Power, 2017, Installed capacity of power generation in India, website: http://powermin.nic.in/en/content/power-sector-glance-all-india). The coal is fossil fuel which is a finite source of energy and is going to be exhausted. The Indian power sector has alarmed to reduce the energy loss and conserve the energy to reduce the huge gap between supply and demand. Therefore, it is essential to generate the power with energy efficiently (Performance Review of Thermal Power Stations 1999-00, 2006-07, 2007-2008, 2008-09, 2009-10, 2010-11 and 2011-12, website: http//:www.cea.nic.in). Many of the power plants have taken up lot of initiatives in conserving the energy while generating the power (Rajashekar P. Mandi and Udaykumar R Yaragatti, 2014). The performance improvement of individual thermal power generating units will help in achieving

- Increased power generation and there-by reducing the demand supply gap
- Reduction in power generation cost and thereby improving the competitiveness of Indian industry
- Reduction in Greenhouse gas emissions and Global warming

Preventive maintenance plays a major role in maintaining the reliability and availability of system or front. But in practice in most of the power plants and industries follow the break down maintenance rather than preventive maintenance. While considering the life cycle costing of equipment and cost for maintenance, the preventive maintenance will be much cheaper than break down maintenance. The preventive maintenance also helps in enhancing the productivity considerably.

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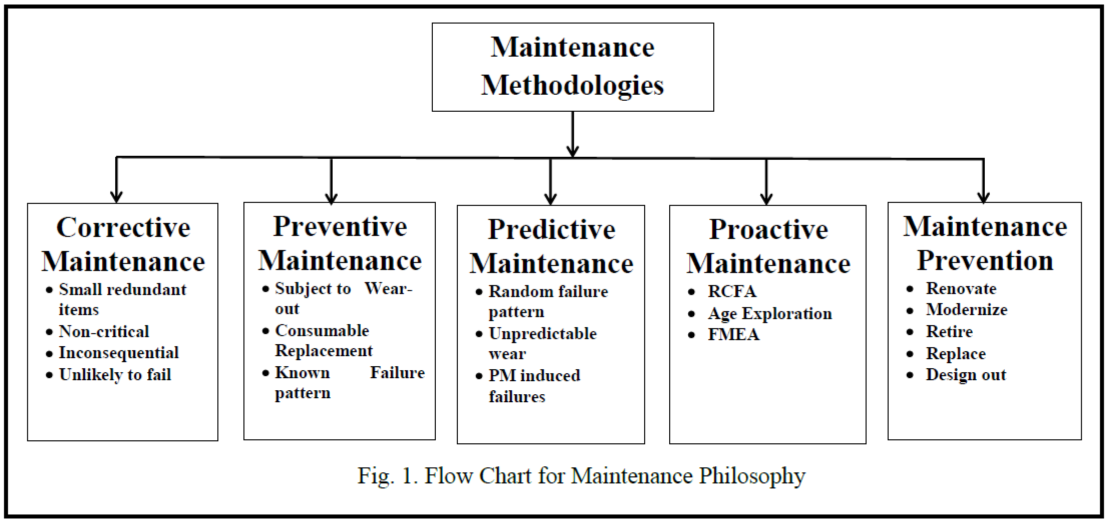


Figure 1: The flow chart of different maintenance practices.

Long-term benefits of preventive maintenance include:

- Improved system reliability. Decreased cost of replacement.
- Decreased system downtime.
- Better spares inventory management.

MAINTENANCE PHILOSOPHY

Maintenance is largely viewed as a cost-center, an evil, insurance, a disaster repairing function. But Maintenance must be perceived as an opportunity to improve reliability and availability of the equipment and of the unit as a whole. Maintenance must be used as a tool to maximize generation level and minimize cost, instead of just attending the equipment defects.

METHODOLOGY

The maintenance methodologies include Preventive Maintenance, Corrective or Reactive Maintenance, Predictive Maintenance, Proactive Maintenance and Maintenance Prevention techniques in an integrated manner to increase the probability that equipment will function with desired operating parameters over its life cycle with minimum maintenance. These different maintenance strategies must be proactively deployed to avoid breakdowns, premature equipment malfunctions and to increase response times to recover from failure, in order to effect improvements in overall plant availability. Appropriate selection of right maintenance strategy to deal with each situation, is based on maintenance requirements supported by sound technical and economic justification. Figure 1 gives the flow chart of different maintenance practices.

i) Corrective maintenance

Normally corrective maintenance for minor defects, inconsequential, for redundant equipment are requested through work requests. However any defect leading to failure of equipment to function in normal way is highly undesirable. This type of maintenance becomes Breakdown. Percentage of breakdown to total work orders is an indicator of maintenance performance in general. Minor defects do appear and helps in minimizing equipment failure and improving performance.

ii) Preventive Maintenance

The preventive maintenance program is the key to any attempt to improve the maintenance performance. It reduces the amount of reactive maintenance to a level that allows other practices to be effective. This is achieved by having plans/schedules for equipment to carry out standard maintenance activities such as lubrication tasks, replacement of worn out parts, checking of blockages, oil levels, etc. The preventive maintenance schedules are designed to strike a measured balance between achieving high equipment reliability through considerable lowering of failures and optimizing equipment down time that inevitably results from planned preventive maintenance. Systematic or scheduled maintenance, such as lubrication or replacement is done at regular intervals.

iii) Predictive Maintenance

The predictive maintenance uses an array of condition monitoring techniques to initiate the preventive action (like replacement of part or even small corrections like re-alignment of coupling), exactly when it is needed. Predictive maintenance helps in identifying the minute changes in equipment behavior, on account of any component degradation or any abnormal operating condition, which might lead to equipment failure. Various techniques are used to monitor the condition of almost all the equipment. Condition Monitoring describes a range of key technique used in Predictive Maintenance Engineering.

- Vibration Monitoring
- Lubricant analysis
- Motor current signature analysis
- Dissolved gas analysis for transformers

- Wear debris analysis
- Noise
- Magnetic particle inspection (MPI)
- ELCID Test
- Thermography
- Non-Destructive Test (NDT)

The application of Condition Monitoring program has specific advantages:

- Reduction in unplanned outages.
- Extension of plant life.
- Better deployment of maintenance crew.
- Advance planning in procurement of spares.
- Reduction in secondary damages.
- Increase in productivity.

A combination of traditional and latest techniques for monitoring equipment health delivers highest figures for availability and equipment performance. The monitoring schedules are followed by a dedicated Condition Monitoring Team and weekly / monthly reports hence generated are reviewed.

iv) Proactive Maintenance

Proactive maintenance uses analytical tools and techniques such as RCA, FMEA, Risk Assessment, etc., to eliminate or minimize or avoid stress condition on equipment. It works by carefully considering following questions:

- What does the system or equipment do?
- What is its function?
- What functional failures are likely to occur?
- What are the likely consequences of these functional failures?
- What can be done to reduce the probability of the failure, identify the onset of failure, or reduce the consequences of the failure?

B. Maintenance Prevention

Maintenance prevention is the most crucial, most costly and a long term maintenance strategy, as It involves techno-economic considerations. It is used for equipment with very high failure rates involving costly maintenance and high downtimes.

C. Preventing Failure

Every equipment item has a resistance to or margin to failure. Using equipment subjects it to stress that can result in failure when the stress exceeds the resistance to failure. Stress is dependent on use and may be highly variable. It may increase or decrease or remain constant with use or time.

MONITORING AND CONTROL

The operation and maintenance performance are monitored through various reviews and reports

A. Daily Planning Meeting

Daily maintenance review is pivotal in monitoring O and M performance, ensuring the implementation of the policies in day-to-day functioning of the plant. Reviews and monitoring in DPM (Daily Planning Meeting) ensure the healthy operation of the plant.

a) ***Daily Generation Report:*** Daily generation report includes all operational parameters of the plant. Plant Load Factor (PLF), Availability, Units Generated, Auxiliary Power Consumption, Specific Coal Consumption, Specific Oil Consumption, Fuel Stock Positions, etc., are given on daily, monthly and cumulative yearly basis. Any abnormal deviations in the performance are discussed, including the reasons and immediate corrective action and remedial measures for future.

b) ***Daily Maintenance Report:*** This report shows the maintenance performance at a glance on daily, monthly and yearly basis.

- Maintenance work status figures out the quantum of maintenance carried out during the day in terms of Work orders raised and attended, Clearance permits issued and cancelled and monthly work completion. It also shows the percentage of planned maintenance to unplanned maintenance.
- Maintenance Targets Status shows the status of all the maintenance performance indicators, namely Non-availability of Unit, Loss of Generation and Tripping of Unit on account of equipment under performance, Oil Consumption due to maintenance problems, Auxiliary Power Consumption and Maintenance Cost. All the maintenance departments namely Mechanical, Electrical, Control and Instrumentation, Civil and Coal Handling Plant are given target figures against each parameter. This daily review keeps maintenance aware of the current performance and further improving them.
- Equipment Status shows all major equipment under maintenance for the day. Critical equipment which are down or under maintenance for more than 7 days and 15 days are also listed to keep the plant management informed. Critical work orders, Equipment with abnormal parameters (detected through condition monitoring) or any other information affecting the plant performance are presented.

c) ***Daily Defect Report:*** All new and pending defects pertaining to all maintenance departments appear in Defect Review Report. These are reviewed, planned, scheduled and rescheduled. Inter departmental coordination and issues resolution is also catered. These defects are tagged as Corrective, Predictive, Modification, ES (Equipment Shutdown), US (Unit Shutdown), CS (Station Shutdown) and Miscellaneous.

PLANT PERFORMANCE

Performance evaluation of major HT auxiliary equipment were carried out at Unit 1 of 250 MW coal fired thermal power plant of Dahanu Thermal Power Station (CPRI, 2010, Investigation into performance of Thermal Power generating units at Dahanu TPS of Reliance Infrastructure Ltd. Dahanu, Maharastra, Report No: CPRI/ECDD/EA/68/10). DTPS is able to operate continuously the plant to generate power in the range of 262 (PLF: 104.8 %) to 270 MW (PLF: 108.0 %) by using the margins provided for each individual equipment, adopting and practicing better maintenance practices, better quality of coal and operating the generator at near unity power factor (Figure 2). The main parameters that affect the life of auxiliary equipment are current, winding temperature and bearing temperature (Bhowmick, M.S, 2008). All these parameters are collected from the hourly past data from HMI report of DTPS for all twelve months to consider all seasons. Figure 3 gives the operating margin of in-house HT equipment during the performance test conducted at 252 MW and 264 MW. It can be seen from the Figure that sufficient operating margin is left for individual equipment for the unit loading upto 108 %.

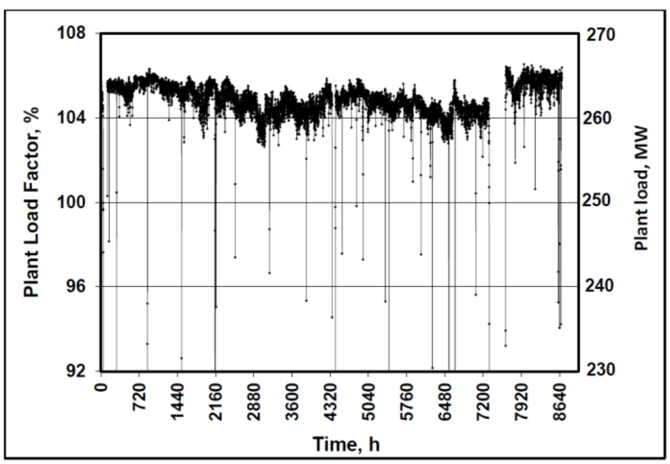
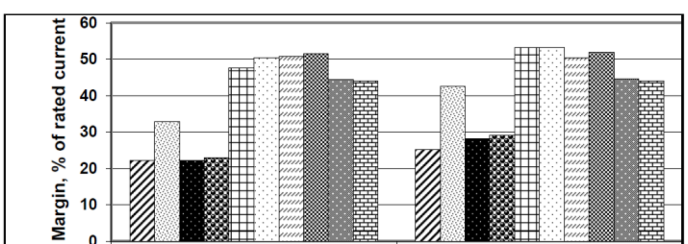


Fig. 2. Plant load during one year.



	Test 1: 265.5 MW (PLF: 106.2 %)	Test 2: 252 MW (PLF: 100.8 %)
BFP 1A	22.1	25.2
CEP 1A	32.9	42.6
ID fan 1A	22.2	28.2
ID fan 1B	22.9	29.2
FD fan 1A	47.6	53.3
FD fan 1B	50.5	53.1
PA fan 1A	50.8	50.5
PA fan 1B	51.5	51.9
Mill 1CD	44.4	44.7
Mill 1EF	44.1	44.1

Fig. 3. Margin available for HT equipment.

A. Boiler Feed pumps

There are two Boiler Feed Pumps (BFP) of 9000 kW. One BFP motor is powered from UAT bus and other is powered from station bus. One pump will be continuously working and other will be stand-by. The Booster pumps are mounted on the same shaft of main pump. The feed water flow is controlled by scoop coupling. The current rating of BFP is 920 A and the maximum current recorded at a plant load of 271 MW was 774.83 A (Figure 4). The currents are not exceeded the design current rating of BFP motors. The performance of these BFPs are quite good and the better performance of individual equipment had enhanced the overall capacity of plant. The BFP motor winding temperatures are varying in the range of 92.77 – 95.71 ^{o}C and are well within the permissible limit of 105 ^{o}C or 75 ^{o}C above the ambient temperature. The performance of cooling system of BFP is good and heat removal capacity is also quite good. The bearing temperatures of BFP are also analyzed for a period of one year. The BFP pump and motor bearing temperatures are in the range of 55.43 – 62.34 ^{o}C and are well within the permissible limit.

B. Condensate Extraction Pumps (CEP)

There are two Condensate Extraction Pumps (CEP) of 700 kW. One pump will be continuously working and second will be stand-by. CEP 1A is provided with Variable frequency drives (VFD). CEP 1A motor is provided with variable frequency drives. The current rating of CEP is 71.2 A and the maximum current recorded at a plant load of 271 MW was 62.21 A (Figure 5). The currents are not exceeded the design current rating of CEP motors. Performance of these CEPs are quite good and the better performance of individual equipment will enhance the overall capacity of plant. The CEP winding temperatures are varying in the range of 87.65 – 92.29 ^{o}C and are well within the permissible limit of 105 ^{o}C or 75 ^{o}C above the ambient temperature. The performance of cooling system of CEP is good and heat removal capacity is also quite good. The bearing temperatures of CEP are also analyzed for a period of one year. The CEP pump and motor bearing temperatures are in the range of 39.54 –53.21 ^{o}C and are well within the permissible limit.

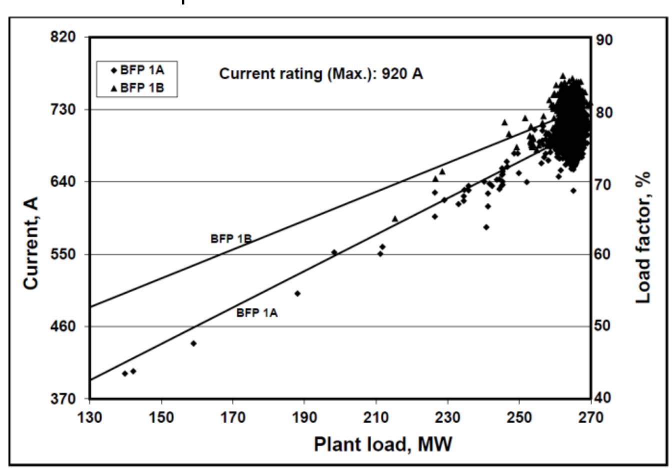


Fig. 4. Currents of BFPs.

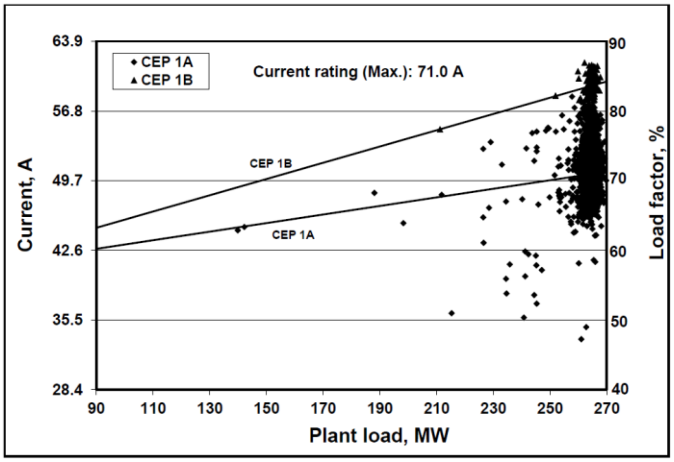


Fig. 5. Currents of CEPs.

C. Induced Draft Fans (IDF)

There are two Induced Draft Fans (IDF) of 1850 kW and both fans will be working continuously. The performance Test is conducted on ID fans during the energy audit study. The current rating of IDF motors is 205.5 A and the maximum current recorded at a plant load of 271 MW was 190.31 A (Figure 6). The currents are not exceeded the design current rating of IDF motors. Performance of these IDFs are quite good and the better performance of individual equipment enhanced the overall capacity of plant. The IDF winding temperatures are varying in the range of 85.21 – 96.89 ºC and are well within the permissible limit of 105 ºC or 75 ºC above the ambient temperature. The performance of cooling system of IDF is good and heat removal capacity is also quite good (Rajashekar P. Mandi and Udaykumar R. Yaragatti, 2008). The bearing temperatures of IDF are also analyzed for a period of one year. The IDF fan and motor bearing temperatures are in the range of 46.55 – 68.56 ºC and are well within the permissible limit.

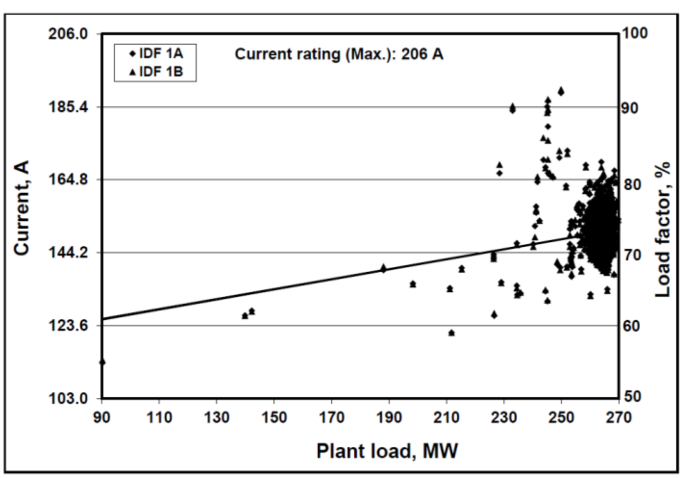


Fig. 6. Currents of IDFs.

D. Forced Draft Fans (FDF)

There are two numbers of 725 kW FD fans and both fans will be working continuously. The current rating of FDF motors is 80 A and the maximum current recorded at a plant load of 271 MW was 51.36 A (Figure 7). The currents are not exceeded the design current rating of FDF motors. Performance of these fans are quite good and the better performance of these individual equipment enhanced the overall capacity of plant. The FDF winding temperatures are varying in the range of 72.02 – 76.03 ºC and are well within the permissible limit of 105 ºC or 75 ºC above the ambient temperature. The performance of cooling system of FDF is good and heat removal capacity is also quite good. The bearing temperatures of FDF are also analyzed for a period of one year. The FDF fan and motor bearing temperatures are in the range of 49.25 – 91.80 ºC and are well within the permissible limit.

E. Primary Air Fans (PAF)

There are two Primary Air fans of 1350 kW to provide the primary air to mills. The current rating of PAF motors is 140 A and the maximum current recorded at a plant load of 271 MW was 114.25 A (Figure 8). The currents are not exceeded the design current rating of PAF motors. Performance of these fans are quite good and the better performance of these individual equipment will enhance the overall capacity of plant. The PAF winding temperatures are varying in the range of 63.72 – 84.86 ºC and are well within the permissible limit of 105 ºC or 75 ºC above the ambient temperature. The performance of cooling system of PAF is good and heat removal capacity is also quite good. The bearing temperatures of PAF are also analyzed for a period of one year. The PAF fan and motor bearing temperatures are in the range of 44.92 – 80.89 ºC and are well within the permissible limit.

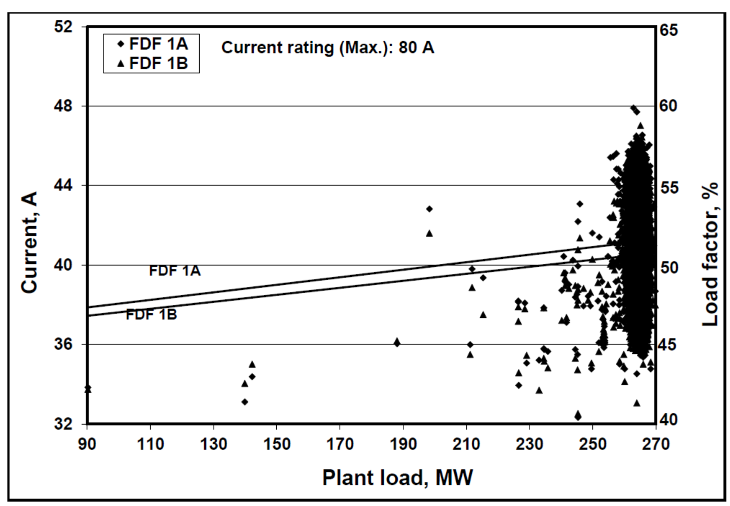


Fig. 7. Currents of FDFs.

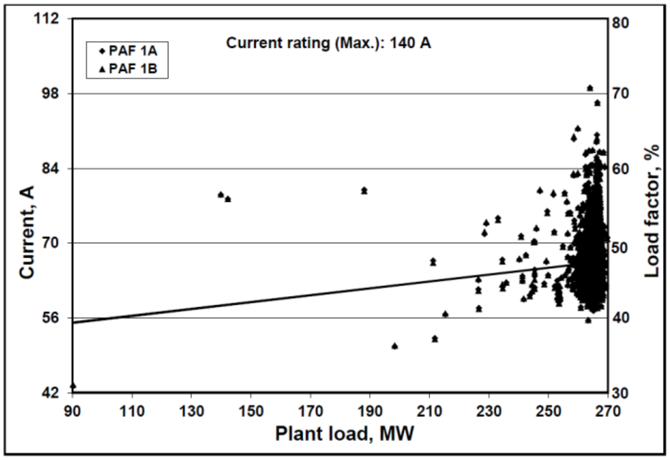


Fig. 8. Currents of PAFs.

F. Mills

There are three Mills of 2300 kW, Ball Tube mill BBD 4772, two mills will be working continuously and third mill will be stand-by to meet 100 % MCR load. Each mill is provided with two output coal pipes to provide coal to each elevation. The coal-air mixture temperature is maintained by varying the hot air and cold air flow to mills. The current rating of Mill motors is 260.6 A and the maximum current recorded at a plant load of 271 MW was 194.68 A 9 (Figure 9). The currents are not exceeded the design current rating of Mill motors. Performance of these mills are quite good and the better performance of these individual equipment will enhance the overall capacity of plant (Chris Harley et al., 2003). The Mill motor winding temperatures are varying in the range of 62.74 – 72.27 ºC and are well within the permissible limit of 105 ºC or 75 ºC above the ambient temperature. The performance of cooling system of mills is good and heat removal capacity is also quite good. The bearing temperatures of Mills are also analyzed for a period of one year. The Mills and motor bearing temperatures are in the range of 44.92 – 63.97 ºC and are well within the permissible limit.

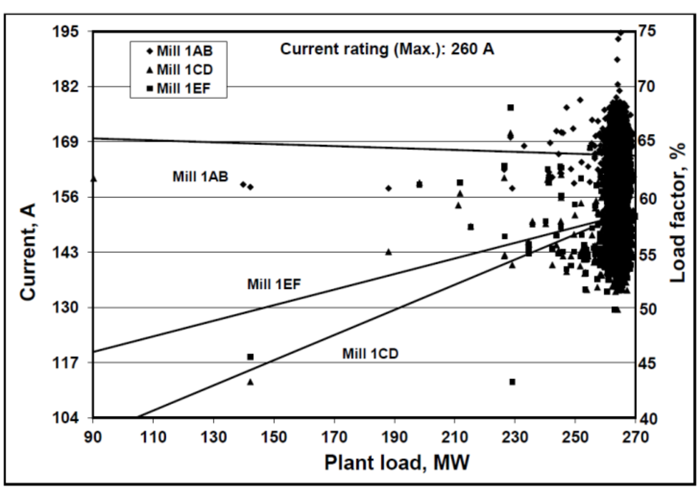


Fig. 9. Currents of Mills.

CONCULSIONS

The main conclusions are:

- As Power Station had shown a path to Indian Thermal Power Sector that the plants can run operate more than 100 % PLF with optimum operation and better maintenance practices.
- By operating units at maximum capacity without violating the design parameters of individual equipment, it will help to reduce the gap between demand and supply of electricity and conserve energy.
- Considering the national present average Plant Load Factor (PLF) of 73.3 % and around 350 sets of 210 and 250 MW units, by enhancing Plant Load Factor from 73.3 % to 95 % and considering 97 % plant availability that can enhance the additional energy generation of 1.2 lakh MU/ year, which will help for nation building.

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Accepted 23 October, 2017

Citation: Mandi RP and Jalkote PS (2017). Enhancing Capacity Utilization of Coal Fired Thermal Power Plant through Better Operation and Maintenance Practices. International Research Journal of Power and Energy Engineering, 3(2): 067-073.