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RESEARCH ARTICLE

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CONDENSER PERFORMANCE ANALYSIS AND TROUBLESHOOTING

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ABSTRACT

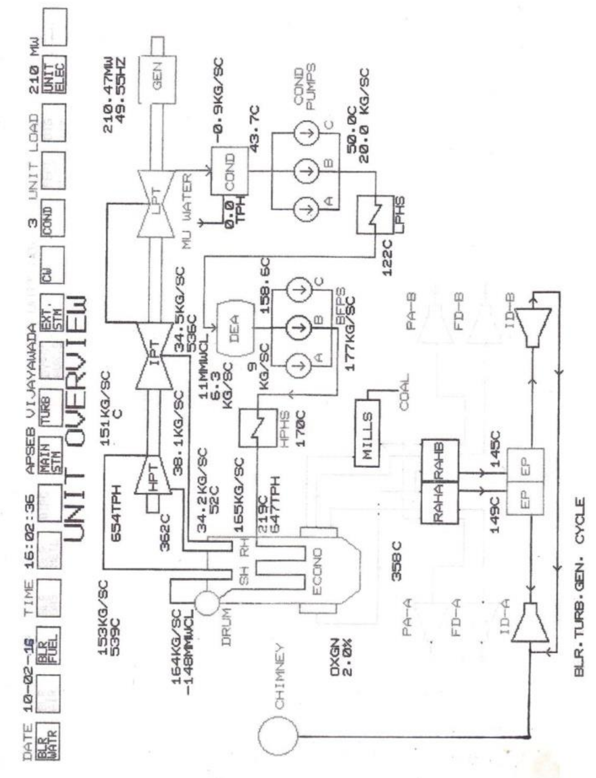
In the operation and maintenance of a power plant, the main steam surface condenser is virtually neglected compared with other components particularly rotating equipment. Efficient and reliable service from condensers requires more care in both operations and maintenance than the care that has been taken in current practice. In the present project, those parameters, which directly or indirectly influence the performance of a condenser, have been studied. The factors include cleanliness factor, deviation from backpressure, inlet temperature and saturation temperatures, heat transfer coefficients, LMTD, steam flow and seasonal variations. The above parameters have been monitored against problems that arise during operation. The procedure for performance test and the subsequent calculations for the data collected for condenser of stage III, NTTPS. Performance optimization of steam surface condenser is directly related to the problems that arise inevitably in any condenser like fouling, tube leakage and air leakage. These problems along with the remedial measures have been dealt with the processes of exact identification and proper monitoring in online tube cleaning system. Finally, the condenser performance can be improved by monitoring the heat transfer coefficients, LMTD, cleanliness factor, deviation of backpressure from the calculations by comparing with the design values. The resultant graphs and results are tabulated

INTRODUCTION

The aim of the project is study the performance of surface condenser cleaning system were adopted for condenser cleaning in VTPS the data for analysis was taken from unit V of stage III VTPS the various factor affecting the performance of condenser like inlet temperature , heat transfer co-efficient, cleanliness factor, backpressure , and LMTD etc., were analyzed. The main problem identified in the operation of condenser is fouling, tube leakage and air leakage etc. The online tube cleaning system is the remedy for fouling. The optimum parameters for condenser operation were given in the annexure. The electricity has become an essential commodity rather than luxury now a day.After food, clothing and shelter. Power had become the fourth necessity for human life “without light there is no life.” The basic principle based on which the thermal power plant works is law of conservation of energy which states the energy neither can be created nor destroyed but can be transformed from one form to other. Here in thermal power plants chemical energy and heat energy is converted to thermal energy to mechanical energy is converted to electrical energy.

WORKING OF BASIC STEAM POWER PLANT

Steam power plant operates on Rankine cycle. It mainly consists of boiler, turbine, condenser and pump. High pressure superheated steam leaves the boiler and enters the turbine. The steam expands in the turbine. During this process, the steam does work, and this enables the turbine to drive the electric generator. The low pressure steam leaves the turbine and enters the condenser. Heat is transferred from the steam to cooling water passing through the condenser tubes, converting the steam into condensate. Since a large quantity of water is required, power plants are generally located near rivers or leaks. When the supply of cooling water is limited, cooling towers are used..A pump enables condensate to flow into the boiler and increases the pressure of condensate leaving the condenser. In the boiler, the heat energy of combustion gases is used for converting water to vapour. In most of the boilers, the steam is superheated and thus high pressure, high temperature steam is supplied to the turbine



TROUBLE SHOOTINGS IN THE CONDENSER

Generally the following problems are facing in the condenser in the steam power plants.

1. Fouling
2. Leaky tubes
3. Air ingress

FOULING IN CONDENSER

When the heat transfer apparatus has been to service from some time, dirt and scale deposits on inside and outside of the pipe. As a result the thermal resistance in the path of the heat flow increases, which reduces heat transfer rate. Thus during operation condenser becomes fouled with an accumulation of deposits of one kind or another on heat transfer surface.

The dirt or scale formation is termed as fouling. This results in increased resistance. The resistance offered to the heat transfer by the dirt or scale formation is called fouling factor. This should be considered in calculating the overall heat transfer coefficient. This additional resistance reduces the original value of overall heat transfer coefficient. This additional resistance reduces the original value of overall heat transfer coefficient. The economic penalty for fouling can be attributed to,

- Higher capital expenditure through over sized units.
- Energy losses due to thermal inefficiencies.
- Costs associates with periodic cleaning of heat exchangers.
- Loss of production during shut down for cleaning.

Leaky tubes

Tubes leakage is one of the major problems in condenser application. Tubes may leak,

1. At the tube plate joint due to the improper attachment.
2. Within the length due the pealing of oxide layer.

Effects due to tube leaking:

1. Condenser gets contaminated with cooling water, which effects the operation of boiler and turbine.
2. Vacuum in the condenser decreases interim results in decreasing the power output. If the leaks in tubes are few in number then they just block at the both ends without shut downing the condenser. If there are more in number effect in the operation of condenser then the unit is to be shut down for replacing the leaky tubes.

Deflection of leaking tubes

When turbine is in operation: Condenser has been provided with the divided water chambers thus making it possible locate the leaky tube and plug its end even when turbine is in operation. For locating the leaky tube concerned portion of water chamber should be isolated on cooling waterside and tube plate should be dried commencing from top to bottom by the application of dry air.

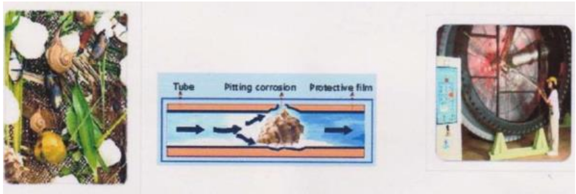


Fig1. Pitting action of tube

Tube opening should be covered with a thin polythene sheet that will get sucked in to failed tube end, alternatively tube ends should be scanned through with a lighted candle stick/smoke generator. The flame/smoke will get attracted into the leaky tube end. Leaky tube can also be detected by the use of U-tube manometer. Plug one end of tube with soft rubber and connect the other tube end with U-tube manometer having colour water. Colour water will get sucked into the tube in case of leaky tube. Otherwise water level will remain unchanged.

CONDENSER ONLINE TUBE CLEANING SYSTEM

Problem: Corrosion and fouling of condenser and heat exchanger tubes are major factor affecting the performance of a plant.

Solution: Online tube cleaning system facilities cleaning of the condenser tubes up the plant in operation, continuously every day without effort thus improving efficiency and wasting no downtime on shutdowns. Your equipment essentially becomes self cleaning. The systems automatically maintain a fouling factor below the manufacturer's design specification.

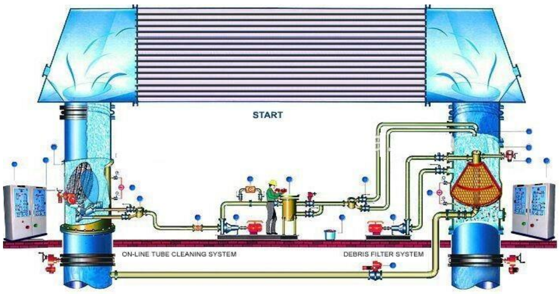


Fig2. Online tube cleaning of surface condenser

The online tube cleaning system is actually three different variations on a similar concept, each engineered specifically for a given application. All systems require no special operator effort and no interruption in day to day equipment performance

BALL TYPE: Elastomeric rubber balls are injected into the supply line and forced the condenser heat exchanger tubes by the cooling water flow. Special injection method and the ball type used achieve proper ball distribution.

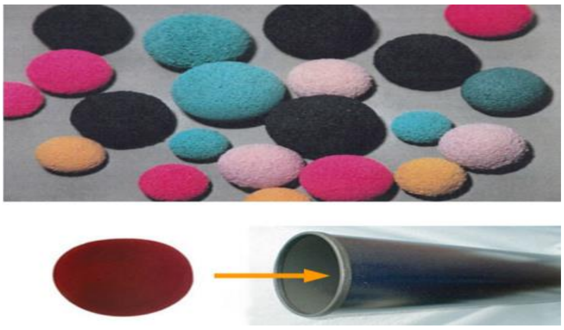


Fig 3 Different sizes of sponge balls

Being slightly larger than the inside diameter of tubes, ball actually wipe the tubes clean. The balls are separated from the cooling water by a strainer section, extracted by a pump, passed through a ball collector, and re circulated into the cooling water supply line in a closed loop manner. Patented vortex and turbulence promoters are installed at the strainer outlet point to enhance the ball recovery. Provisions are made to turn the screens to the back wash position to clean accumulated debris. A differential pressure monitor displays the pressure drop across the strainer section.

Options of continuous, intermittent, or manual cycles are provided. Optional features are also available to monitor the number of balls in circulation and indicate the quality of worn balls.

Major components and auxiliary equipment's of sponge ball type

Universal debris filter

Ball separator

Ball re-circulated skid

Measuring and control system

Ball monitoring system

Ball charge and feeder

Ball injection nozzles

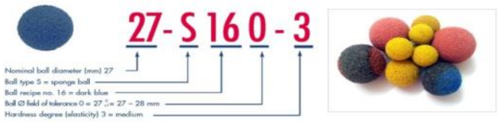


Fig4 specification of sponge ball

GEA India supplies a wide range of cleaning balls to suit every application

Sponge rubber - Hardness selected to suit service conditions.

High temp balls-For application up to 1400°C

Abrasive balls - Ring coated for removal of hard deposits.

Granulated coated balls -For use in titanium tubes.

CONDENSER OFF LINE TUBE CLEANING SYSTEM

Condenser tube cleaning by using specially designed imported patented bullets: Cooling water sources cause different tube fouling problems, affecting the heat transfer and life expectancy of heat exchanger and condenser. Power stations, refineries, petrochemical and other industries in the developed countries employ "Bullet cleaning" as an effective and efficient method to clean the condenser tubes.

Technique: Spring loaded tube cleansers are shot through fouled condenser tubes using specially designed water guns at 10-15 Kg/cm pressure. The bullets moving through the tube from one end to the other scrape off the deposits and corrosion scales. Water from the gun flashes out the scraped deposits resulting in a clean inside surface of the tube ideally good for heat transfer. Tube cleaners which exit at the other end of the condenser are collected cleaned and used again. Normally a bullet can be used 15 to 20 times.

Time and cleanliness factor: By bullet shot method, we can easily clean over 4000 tubes in a single day depending upon the hardness of the scale. Hence your shut down time will definitely be reduced. This cleanliness factor achieved will be close to the design parameters.

Power and water consumption: The pump to generate the 10-25 Kg/cm^2 pressure to propel the bullets through tube is driven by 10 HP motor and hence the power consumption during the cleaning of the tube is very less. The water consumption is very less with bullet shot technique. The geometrical configuration of the bullet blades is so designed that the head of the blades have uniform smooth curvature and there is no sharp end. Moreover, the curvature of the blades is such that its diameter is a few microns less than the inner diameter of the tube. The spring action of scraper takes place due to flexibility of the blades. This ensures that there is absolute safe to your condenser tubes.

ADVANTAGES:

1. Big cost saving
2. Very limited shut down time
3. Long tube life
4. Improved plant availability
5. Improved power generation
6. Low consumption of power and water
7. No environmental pollution

Efficient, reliable service from condenser requires considerably more care in both operational and maintenance that has been current practice. Generally acceptance tests and routine operational tests are conducted to have an idea about the performance of the condenser.

CONDENSER PERFORMANCE TESTING AND MONITORING

OBJECTIVE AND SCOPE: The scope is limited to condenser. This test procedure shall determine the condenser performance with regard to one or more performance indices as follows.

1. Absolute back pressure deviation from expected.
2. Cleanliness factor.
3. Heat transfer coefficient.
4. Circulating water velocity in tubes.
5. Circulating water temperature rise.

Evaluation of test: In this performance test we collected data in alternate months for a period of one year from February 2008 to January 2009 the readings of load, flow of feed water and main steam, main steam temperature and pressure.

Cold reheat (CRT) steam pressure and temperature at high pressure turbine (HPT) exhaust, hot reheat (HRH) steam pressure and temperature at intermediate pressure turbine (IPT) inlet, saturation temperature, HPH 6 feed water inlet and outlet temperature and pressure, economizer and HPH 5 inlet feed water temperature, input casing exhaust steam pressure and temperature and HPH 6 drip temperature are taken for this test.

The condenser duty, CW flow, tube velocity, LMTD, U-actual, U-theoretical, cleanliness factor, expected values of LMTD and T_{sat} are calculated.

CONDENSER PERFORMANCE: Some of the factors to be considered while discussing the performance are:

1. High condenser pressure caused by tube/shell side fouling.
2. Reduction of effective heat transfer surface because air removal capacity has become degraded or actual air in leakage exceeds the installed capacity.
3. High condenser pressure because of inadequate cooling water flow.
4. High condenser pressure because of large number of plugged tubes.
5. Excessive sub cooling because of non-condensable binding or failure to achieve proper venting or cold inlet water temperature.
6. Excessive condensate oxygen levels caused by non condensable binding or failure to achieve proper venting.

PERFORMANCE ANALYSIS: Performance analysis of steam surface condensers in complicated by difficulty in measuring critical parameters such as heat rejection rate, circulating water flow rate, and circulating water outlet temperatures. However these difficulties can be overcome by modified instrumentation and deduction analysis.

Instrumentation:

The condition and calibration of all instrumentation for the condenser, condenser system and circulating water system should be revived. Similarly instrument type and location should be assessed to determine whether changes could be made which will improve measurement consistency and accuracy. Instrument for performance monitoring and trouble shooting is installed on both steam side and cooling water side of the steam surface condenser.

The test instrument required for the must be assembled, installed and opera ability verified. Following aspects will be taken care.

Pressure measurements:

1. Taping on condenser should be close to the joining connecting turbine and condenser.
2. There should not be any protruding obstructions near the tubes.
3. Minimum two taps on each half of condenser should be connected to form a grid and terminated at convenient location for transmitter installation.
4. Transmitter installation point and sensing line free from excessive vibrations.

Data sheet for condenser:

1. Condenser cooling water temperature - 36^0c
2. Cooling water temperature raise - 8.1^0c
3. Cooling water flow quantity - 30600 m^3/hr
4. Condenser back pressure - 89mm of Hg
5. Cooling water side pressure drop - 3.1 Mwc
6. No of cooling water passes - 1
7. No of tubes
    a) Condensing zone - 22294
    b) Air cooling zone - 1640
8. Tube dimensions
    a) Outside dia × thickness - 19mm×1mm
    b) Tube ordering length - 9.9mm
9. Tube material - 90/10 Cu/Ni
10. Percentage of tube thinning - 7%
11. Water box design pressure - 3.3 kg/cm^2
12. Water box hydraulic test pressure - 4.5 kg/cm^2
13. H.P turbine pressure - 150kg/cm^2
14. Condenser volume - 200 m^3
15. De aerator - 138 m^3
16. Hot well - 21.3 m^3
17. Flooded weight - 600T
18. Water weight - 145T

Condenser surface = 314×D×L×Num of tubes
= 3.14×19×9.9×1000×(22294+1640)
= 14,000 m^2

The following table denotes the input parameters required for the performance analysis of condenser.

SL No.	PARAMETER	UNITS	Before Bullet Cleaning	After Bullet Cleaning
1	Load	MW	209.8	217
2	Feed water hourly average	TPH	665.3	688
3	R.H spray	TPH	13.6	26.84
4	Main steam flow	TPH	651.6	665
5	M.S pressure after strainer	Kg/cm^2	147.5	149.3
6	M.S temp before E.S V1/ E.S V2	^{o}C	535.5	538.4/ 540

7	H.P turbine 1st blading pressure	Kg/cm^2	135	137.3
8	CRH steam pr. At HPT exhaust	Kg/cm^2	36.75	38.1/39.6
9	CRH steam temp at HPT exhaust	^oC	354.5	349.1
10	HRH steam pr at IPT inlet	Kg/cm^2	33.9	36.2/37.1
11	HRH steam temp at IPT inlet	^oC	538.5	537/539
12	LP turbine exhaust hood temp	^oC	45.7	43
13	Number of ejectors in service	Nos	2	1
14	HP heater 5 inlet feed water temp	^oC	169.8	168
15	HP heater 5 outlet feed water temp	^oC	257.5	247
16	HP heater 6 inlet feed water temp	^oC	202	204
17	HP heater 6 inlet feed water pr.	Kg/cm^2	172	180
18	HP heater 6 outlet feed water pr.	Kg/cm^2	171	177
19	Economizer inlet feed water temp	^oC	239	241/242
20	CW temp at condenser inlet/outlet	^oC	32/39.5	32/38
21	Steam pressure at ejector nozzle	Kg/cm^2	8.3	8
22	Hp heater 6 extraction steam pr.	Kg/cm^2	36.8	39.6/38.5
23	Hp heater 6 extraction steam temp	^oC	354.7	353.4
24	IP casing exhaust steam temp	^oC	337.8	319.3
25	HP heater 6 Drip temp	^oC	227.5	214.1
26	IP casing exhaust steam pr	Kg/cm^2	7.1	6.3
27	Steam temp at ejector nozzle	^oC	203.02	213

FORMULAE FOR THE CONDENSER PERFORMANCE ANALYSIS AND SAMPLE CALCULATION

1. Determination of condenser duty:

The amount of heat to be removed by the condenser from the steam in a given time is the condenser duty.

Condenser duty = {(heat added MS + heat added HRH + heat added spray)-860(P_{gen}+P_{gen} losses+heat loss rad)}×(4.18/3600) ={ (371568.75 + 65515.82 +15261.76) – 860(217 + 21.7 +2.17)(4.18/3600)

=384.70 KJ/s

Where

Condenser duty = KJ/s

Heat added MS = flow MS (h_{MS}-h_{FW})

= 665×(827.75-268.7)

= 371568.75 K Cal/Hr

Flow MS = 665 Tons/Hr

h_{MS} = 827.75 K cal/Kg

h_{FW} = 268.7 Kcal/Kg

Heat added HRH = flow HRH (h_{HRH}-h_{CRH})

= 673.2(837.32-740)

= 65515.82 Kcal/Hr

Flow HRH = 673.2 Tons/Hr

h_{HRH} = 837.32 Kcal/Kg

h_{CRH} = 740 Kcal/Kg

Heat added spray = RH spray (h_{HRH}-h_{FW})

= 26.84(837.32-268.7)

= 15261.76 Kcal/Hr

P_{gen}= 217MW (Gross Generation Output)

Heat Loss Rad = 0.1% of P_{gen} (Radiation Lossoes) MW

= 0.1×217 = 21.7 MW

P_{gen} losses= (Mech Losses+ Iron Losses – I Losses)

= 0.01% of P_{gen}

= 0.01×21.7 = 2.17MW

Generally P_{gen} Losses are taken as 0.01% of P_{gen}.

2. Determination of Condenser Flow:

The volume rate of flow of cooling water required to attain the condenser duty is given by CW flow.

$$\text{CW Flow} = \frac{\text{CONDENSER DUTY}}{\text{D} \times \text{C}_\text{P}(\text{T}_\text{out} - \text{T}_\text{in})}$$

= (287.7×1000)/(1000×4.18×(38.66-32))

= 10.3 m^3/s

Where

Condenser duty = 284.70 KJ/hr
C_p = 4.18 KJ/Kg °C
D = 1000 Kg/m^3
T_{out} = 38.6 °C
T_{in} = 32° C

3. Water Velocity in Condenser Tube:

The velocity of water is an important factor while designing the condenser tube diameter.

Water velocity

$$= \frac{\text{CW flow rate} \times 10^6}{\text{Tube area} \times (\text{No of tubes} - \text{No of tubes unplugged})}$$

= $(10.3\times10^6)/[(\pi/4)(17)^2(23934-0)]$

= 1.62 m/s.

Where

Water velocity = 1.62 m/s
CW flow rate = 10.3 m^3/s
Tube area = 226.98 mm^2

4.Log Mean Temperature Difference:

The logarithmic mean temperature difference (also known as log mean temperature difference or simply by its initialism LMTD) is used to determine the temperature the temperature driving force for heat transfer in flow systems.

$$\text{LMTD} = \frac{(\text{T}_\text{out} - \text{T}_\text{in})}{\text{Ln}\left({}^{[\text{T}_\text{sat} - \text{T}_\text{in}]}\big/_{[\text{T}_\text{sat} - \text{T}_\text{out}]}\right)}$$

= (38.2-32)/ Ln[(43-32)/(43-38.6)]

= 7.3 °C

Where

LMTD = 7.3 °C
T_{Sat} = 43 °C

5. Determination of cleanliness factor: It is the ratio of actual heat transfer coefficient to that of theoretical heat transfer coefficient, which is commonly, used in diagnostics as an indicator of thermal fouling of the heat exchange surface.

$$\text{Cleanliness factor} = \frac{\text{U}_\text{act}[\text{actual heat transfer coefficient}]}{\text{U}_\text{tht}[\text{Th. heat transfer coefficient}]}$$

= (2396.84/2936.84)×100

= 81.61%

$$U_{act} = \frac{(condenser\ flow \times C_P \times [T_{out} - T_{in}] \times Density\ of\ Water)}{(Surface\ area \times LMTD)}$$

= [(10.3×4.18×(38.6-32)×1000)]/(14000×7.3)

= 2.78 KJ/s m^2 °C

= (2.78×3600)/4.18 = 2396.84 Kcal/hr m^2 °C

Where

U_{act} = 2396.84 Kcal/hr m^2 °C
Density of water = 1000 Kg/m^3
Surface area = 14000 m^2

U_{tht} = U×T_{in} correction factor×tube correction factor×4.88=593.5×1.07×0.945×4.88×(4.18/3600)

= 3.14 KJ/s m^2 °C.

Where

U_{tht} = 2.12 KJ/s m^2 °C
U = 593.5

Heat transfer coefficient in Btu/hr sqft 70°FC.W . inlet temperature,18 and admiralty metal.

T_{in} (CF) = 0.669
Tube correction factor = 4.88

//C PROGRAM// FOR PERFORMANCE CALCULATIONS:

```
#include <stdio.h>
#include<conio.h>
#include<math.h>
Void main()
{
    Double h_ms,f_ms,h_fw,h_hrh,h_crh,f_hrh,f_rhs,H_ms,H_hrhH_rhs;
    Double U, A,CF T_in,CFT,CF,CD,P_gen,P_los,C_p;
    Double D,z,e.ft,fq,LMTD exp,eff,T_satexp,T_in,T_out,Fcw,Vt;
    Double Nt=23934,Ntp=0,d,LMTD,T_sat,U_act,U_tht,Ac=14000;
    Double T_satD=491,CDD=28068,VtD=1.56,LMTDD=8.4,V_th=89, V_act,V_eff;
/*Design values*/
    Clrscr();
    C_p=4.18;
    d=17;
```

```
    D=1000;
    Printf("/n/t/t/t***Enter the following values***/n");
    Printf("/n/tload in MW");
    Scanf("%if",&Pgen);
    Printf("/n/t Main steam flow rate in TPH");
    Scanf("%lf",fms);
    Printf("/n/t Enthalpy of Main steam in Kcal/Kg");
    Scanf("%lf",&hms);
    Printf("/n/t Enthalpy of  feed water in Kcal/Kg");
    Scanf("%lf",&hfw);
    Printf("/n/t Enthalpy of hot reheat steam in Kcal/Kg");
    Scanf("%lf",&hhrh);
    Printf("/n/t Enthalpy of cold reheat steam in Kcal/Kg");
    Scanf("%lf",&hcrh);
    Printf("/n/t Hot Reheat steam flow rate in THP");
    Scanf("%lf",&FHrh);
     Printf("/n/t Reheat spray flow rate in THP");
     Scanf("%lf",&Frhs);
     Printf("/n/t outlet temperature of CW in °C");
     Scanf("%lf",&Tout);
     Printf("/n/t inlet temperature of CW in °C");
     Scanf("%lf",&Tin);
     Printf("/n/tU");
     Scanf("%if",&U);
     Printf("/n/tCFTin");
     Scanf("%if",&CFTin);
     Printf("/n/tCFT");
     Scanf("%if",&cft);
/*tube correction factor*/
     Printf("/n/t actual vacuum in condenser in mm of Hg");
     Scanf("%",&Vact);
     hms= fms(hms-hfw);
     hhrh= fhrh(hhrh-hcrh);
     hrhs= frhs(hhrh-hfw);
     Plos= Pgen(0.0011);
/* Generator losses and radiation losses */
     CD= [(hms+hhrh+hrhs)-860(Pgen+Plos)](Cp/3600);
     CWF=(CD×1000)/(Cp×D×(Tout-Tin));
     A= (22/7)(d×d/4);
/*Tube Area*/
    Vt= (CWF*10^6)/(A*(Nt-Ntp));
    Tsat= Tout+5;
    LMTD= (Tout-Tin)/[log(Tsat-Tin)/ (Tsat-Tout)];
    Uact= CWF*Cp*(Tout-Tin)*D/(Ac*LMTD);
/*Condensing surface area*/
    Uth = U×CF Tin×CFt×4.88×(Cp/3600);
    CF = (Uact/Uth)×100
    Ft = pow[(Tsat-LMTD)/(TsatD-LMTDD,0.25)];
    Fw= pow[(Vt)/(Vtd),0.5);
    Fq=(CDD)/CD;
    LMTDexp=LMTD*ft*fw*fq;
    E=2.718;
    Z=(Tout-Tin)/LMTD exp;
    Eff=(Tout-Tin)*100/( Tsat-Tout);
    Tsatexp=(Tin-Tout*pow(e,z))/(1-pow(e,z));
    Veff=(Vact/Vth)*100;
    Printf("/n/n/t/t/t****RESULTS****");
    Printf("/n/n/t/t condenser duty:%if Kcal/hr",CD);
    Printf("/n/n/t/t CW flow:%if m^3/s",fCW);
    Printf("/n/n/t/t Tube velocity:%if m/s",Vt);
    Printf("/n/n/t/t LMTD:%lf degree C",LMTD);
    Printf("/n/n/t/t cleanliness factor:%if% ",CF);
    Printf("/n/n/t/t LMTDexpected:%if deg C",LMTDexp);
    Printf("/n/n/t/t Saturation temperature expected:%if deg C ",Tsatexp);
    Printf("/n/n/t/t condenser effectiveness:%if %",Eff);
    Printf("/n/n/t/t Vacuum efficiency:%if% Veff",);
    Getch();
}
```

OUTPUT:

```
****Enter the following values****
Load in MW                          :  217
Main steam rate                     :  665
Enthalpy of main steam              :  827.7
Enthalpy of feed water              :   268.7
Enthalpy of hot reheat steam        :   837.3
Enthalpy of cold reheat steam       :   740
Reheat spray flow rate              :   673.2
Out let temperature of CW           :    26.8
Inlet temperature of CW             :    32
U                                   :    593.5
CF Tin                              :    0.669
CF t                                :    4.88
Actual vacuum in condenser              :    662.23
```

******Results******

Condenser duty : 284.74 KJ/s

CW flow : 10.3 m^3/s

Tube velocity : 1.62 m/s

LMTD : 7.3 °C

Cleanliness factor : 0.81

LMTD expected : 7.2 °C

Sat temperature expected : 43 °C

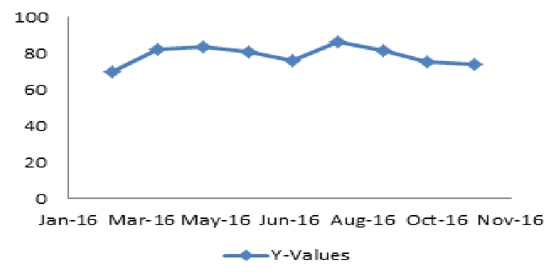
Condenser efficiency : 57.9%

Vacuum efficiency : 558%

RESULTS AND DISCUSSIONS

Some of the graphs are drawn here, which illustrate the relation between the different variables of the condenser. The various parameters were taken from the control room of the NTTPS stage-3. These graphs tell us the performance of the condenser at different conditions.

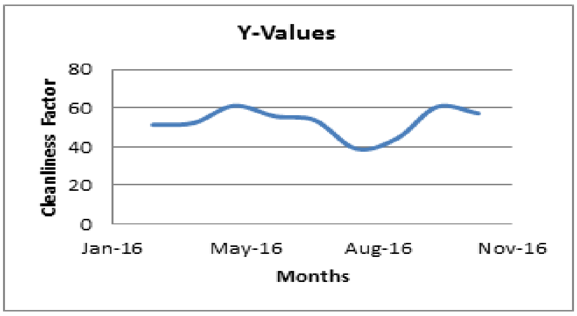
THE EFFECTS OF TIME DURATION: The effects of time duration on condenser back pressure and cleanliness factor



Effects of time duration on condenser back pressure

Months	Mar 16	Apr 16	May 16	Jun 16	Jul 16	Aug 16	Sep 16
Back Pressure	69.5	82.7	83.6	80.7	75.9	86.5	81.4

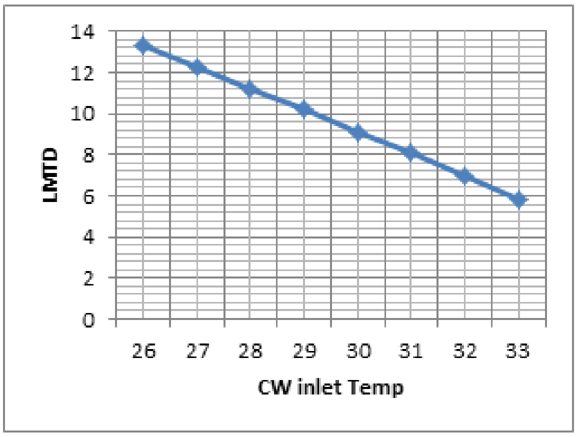
The back pressure increases after overall of plant and then gradually decreases, because of the dirtiness of condenser tubes.



Effect of time duration on cleanliness factor

Month	Mar 16	Apr 16	May 16	Jun 16	Jul 16	Aug 16	Sep 16	Oct 16	Nov 16
CF	51.43	52.45	61.31	55.83	53.75	39.00	44.43	55.57	60.77

THE EFFECTS OF CONDENSER WATER INLET TEMPERATURE: The effect of cooling water inlet temperature on the out parameters that is LMTD, heat transfer coefficients, cleanliness factor and effectiveness of the condenser may be seen.



Effects of condenser inlet temperature on LMTD

T_{in}	26	27	28	29	30	31	32	33	
LMTD	13.3	12.3	11.26	10.22	9.16	8.08		6.98	5.84

The LMTD decreasing while CW inlet temperature increasing as shown, the reason for this is the heat is transferring between the close temperature differences, so LMTD is decreasing

CONCLUSION

In this project the various parameters varying after bullet cleaning of condenser tubes are noted. And also need for main steam surface condenser performance analysis in a power plant is discussed. Bullet cleaning process is implemented in stage-III condenser, first time in annual overhaul of unit during the year 2016. After overhaul it was observed that various parameters are improving like condenser duty, cleanliness factor, back pressure, efficiency and are hereby decreased LMTD. Finally it can concede that bullet cleaning of condenser tubes is best method for cleaning tubes.

The various factor like condenser duty, flow of cooling water and its velocity, heat transfer coefficients, cleanliness factor, back pressure and temperature effect the condenser performance changes have been seen. For the study the parameters were taken were from unit 6 of stage III

NTTPS.In results and discussions how the cleanliness factor and back pressure of condenser vary with time duration is seen. The effects of inlet temperature, saturation temperature of main steam on the cleanliness factor, effectiveness, LMTD and heat transfer coefficients are discussed. From all these optimal conditions for the operation of a condenser are taken. For condenser performance main problem is fouling and corrosion when compared to other like tube leakage and air leakage. So to overcome this problem the online tube cleaning system with the help of 1) sponge balls cleaning 2) reversed water cleaning. Working of the system was from the above it can suggest that sponge ball cleaning is the best method.

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