

## **REPORT ON FAILURE OF VACUUM COOLER CIRCULATION PUMP (01.113) IN PAP ON 07.04.2014 AT 21:15 HRS**

**Dated: 10/04/2014**

A committee comprising of following members was nominated by competent authority to investigate the incident of failure of vacuum cooler circulation pump (VCCP) 01.113 in PAP on 07.04.2014 AT 21:15 HRS in evening shift:

- 1) Mr. C. N. Shah, JGM (Process),
- 2) Mr. D. K. Nema, DGM (Maint.)
- 3) Mr. V. N. Suthar, Mgr (Inspection)

Committee visited site in the morning of 09.04.2014 to get the first hand information and for collection of relevant documents / details required for:

- To investigate the reasons for failure of vacuum cooler circulation pump (VCCP) in PAP on 07.04.2014 AT 21:15 HRS and
- To give recommendations / suggestions to avoid reoccurrence of such failure incident in future.

### **1.0 Plant Condition during the failure**

PAP was operating at reduced load with 100 % Peru rock with 3 No. circulators and 4 filters in line. After failure of VCCP 01.113 plant was operating with 2 No. circulators and 4 filters in line.

### **2.0 Failure incident investigation**

Following Documents are collected to investigate the incident of vacuum cooler circulation pump in PAP on 07.04.2014 AT 21:15 HRS in evening shift:

- Data sheet and Performance curve of the vacuum cooler circulation pump supplied by Ensival – Moret, Belgium (OEM): attached as Annexure-1 and Annexure-2.
- Data sheet, Technical Specification and MOC of vacuum cooler circulation pump being procured from indigenous vendor: attached as Annexure-3A & 3B.
- Historical report of DCS alarms for VCCP 01.113 attached as Annexure -4.
- Current trend for motor of VCCP 01.113 attached as Annexure-5.
- Vacuum trend of VCCP 01.113 attached as Annexure-6.
- Reactor level trend of VCCP 01.113 attached as Annexure-7.
- DCS graphics for Reactor Section showing VCCPs attached as Annexure-8.

- PAP Panel 1 amperage log book attached as Annexure-9.
- Shift Engineer (PAP) log book attached as Annexure-10.
- Control Room (PAP) log book attached as Annexure-11.
- Field operator (PAP) log book attached as Annexure-12.
- Start up, Shut down and Operation procedure of reaction section attached as Annexure-13.
- Vibration Monitoring Record for VCCP 01.113 attached as Annexure -14.
- Specification of the rock screen for procurement attached as Annexure-15.
- History of the VCCP 01.113 attached as Annexure-16.
- Alloy analysis Report attached as Annexure-17.
- Thickness measurement report for casing, liner, impeller as Annexure-18.

### **3.0 Failure Related documents and Sequence Event Recording by DCS**

#### **3.1 DCS alarms history record (Annexure -4)**

<b>Date and Time</b>	<b>Description</b>
07.04.2014 08:14:45      20HS610	VACC CIR PM 01.113 STOP
07.04.2014 08:31:10      20HS610	VACC CIR PM 01.113 START
<b>07.04.2014 21:15:07      20HS610</b>	<b>VACC CIR PM 01.113 STOP</b>

As per the above, VCCP 01.113 motor was stopped at 21.15 hours after its failure at 21.13 hours.

#### **3.2 Current trend of the VCCP 01.113 (Annexure -5)**

- As per the current trend the current drawn by VCCP 01.113 motor had suddenly increased from 18 Amp to > 20 Amp at shift change time of about 1400 hours (Annexure-5 sheet 5 of 6).
- It continued to operate at higher Amperes of about 20 amps till its failure up to 21.13.07 hours as shown in the Annexure-5.
- VCCP 01.113 motor came to no load current level of 11.48 Amp at 21.14.07 hours.
- VCCP 01.113 motor was stopped manually from DCS at 21.15.07 hours and motor current came to zero at 21.16.07 hours.

#### **3.2 Vacuum trend of the VCCP 01.113 (Annexure -6)**

As per the vacuum trend, vacuum in the vacuum cooler flash chamber was normal till failure of VCCP 01.113. There was trend of absolute pressure increasing as

soon as VCCP stopped and there was nearly atmospheric pressure within 15 minutes of failure of VCCP 01.113.

### **3.3 Reactor level trend of the VCCP 01.113 (Annexure -7)**

The reactor level was nearly steady throughout the period before and after the failure of the pump. During the period, VCCP 01.110, 112 and 113 were in operation and 01.111 was under maintenance. As the reactor level was steady, there is no chance of cavitation failure of the VCCP 01.113.

### **3.4 Log book of panel 1- amperage / Shift in charge / Control room / Field Operator: (Annexure -9 / 10 / 11 / 12)**

As per the log a book, VCCP 01.113 has failed after 2100 hours and it was stopped mentioning that its pulley got broken.

### **3.5 Vibration Monitoring record (Annexure -14)**

Vibration of the VCCPs is being monitored fortnightly. Vibration data of the pumps was checked for last six months and vibration level was normal.

## **4.0 Testimony statements**

Following Personnel of respective sections present in shift and responsible for operation and maintenance were interviewed.

### **4.1 Mr. Manoj Hansaraj, Dy. Mgr (PAP- Process), Shift In charge, PAP**

- ❖ They have not heard any abnormal sound from the VCCP 01.113 in their shift before it failed.
- ❖ During charge take over, A shift in charge had not communicated about increase in current drawn by the 01.113 motor or any abnormality in VCCP 01.113.
- ❖ 18 to 22 Amp being the normal current drawn range of VCCP motor, they did not thought of any abnormality in the VCCP 01.113.
- ❖ Field operator informed at about 21.15 hours about abnormal sound from VCCP 01.113, damage to the pump pulley and asked to stop the motor from DCS.
- ❖ Field operator takes round to check pump vibration, abnormal sound during operation, seal water pressure etc.

- ❖ Panel operator keeps watch on motor current, vacuum reading, motor ON – OFF status etc. There is pump start / stop alarm in DCS.

#### **4.2 Mr. V K Mishra, Sr. Manager (Elect.), PAP – Electrical,**

- The absorbed power of VCCP pumps at normal load is 182.4 kW. The VCCP motor is operating at much lower load than its rating.
- The recommended motor rating as per pump supplier is 280 kW. 270 kW rating motor is provided for 01.113 and other pumps.
- Normal current drawn by the VCCP pumps remain in the range of 18 to 22 Amps. Vacuum cooler circulation motor running indication and current drawn by motor are given in DCS.
- Over load trip setting for the motor is 31.6 Amp. Hence, the motor did not trip, as the current drawn was in range of 18 to 21.5 Amps.
- Electrical Department is not having continuous monitoring of the power drawn by the important motors either at MCC or Load Management system. The job of including the details of all motors in Load Management system (LMS) is in progress.

#### **4.3 Mr. Anuragn Saxena, DGM (PAP Mech.), Mr. Digvijay Singh, Dy. Manager (PAP Mech.), Mr. Vijay Joshi, Asst. Manager (PAP Mech.),**

- All VCCPs are being checked every day by Mechanical Maintenance for vibration, lubrication, bearing condition, seal condition and seal water pressure, casing leakage, belt condition, foundation bolt tightness, casing bolt tightness, cleanliness etc.
- There is weekly schedule for greasing of the bearings.
- Vibration monitoring is done fortnightly by Inspection for running VCCP. Vibration of 01.113 was normal.
- There is very high pump maintenance of pumps due to erosion and corrosion and it is a routine maintenance job for all VCCPs as shown in the history of the VCCP 01.113 attached as Annexure-17.
- The erosion in all the VCCP pumps is due to stone / pebbles or other foreign material coming along with the Phos acid slurry. Replacement of 16 mm thick, 904 L wear ring (liner), repairing of casing for leakages, replacement of pump impeller etc. are frequent maintenance jobs as shown in Annexure-16.
- Trommel screen of 8 mm / 10 mm is installed by Maintenance Department to separate pebbles from rock slurry at ball mills outlet.

<b>Sr. No.</b>	<b>Repair Job Description:</b>	<b>Date of repair</b>
	<b>01.113</b>	
1	Casing patch welding	24.09.13, 02.11.13, 08.01.14, 08.02.14, 24.02.14,14.03.14, 07.04.14,
2	Impeller replacement	24.09.13, 08.02.14, 14.03.14, 07.04.14

- VCCP 01.113 failure may be due to erosion of the 904 L liner / wear ring (last replaced on 24.02.14) and which would have loosened in the casing of running pump, leading to pump impeller sticking up in the liner leading to jamming of the pump. This would have broken the pulley of the pump into pieces as motor was in running condition. This also led to bending of the pump shaft. The eroded and buckled liner can be the reason of pump failure.
- Maintenance technicians and Engineers were working on the VCCP 01.111 and they had not heard any abnormal sound during operation of 01.113 pump in B shift on 07.04.2014.
- After failure of pump, on opening the pump, no foreign material was found in the casing.
- As per Maintenance, it is not feasible to install suction common strainer in the reactor for all VCCP pumps suction as opening of the mesh may get choked with gypsum particles and hinder the flow to the pumps.
- Original pump supplier was Ensival Moret. Due to very high cost of the pump and spares by OEM, pumps are indigenized by RECO India Ltd. Coimbatore.

#### **4.4 Mr. K C Dubey, CM (Inst.), Mr. Shalabh Gupta, Dy. Mgr (PAP Inst.)**

There is no trip logic for the Vacuum cooler circulation pumps. Following documents are given by Instrument to analyze the 01.113 pump failure incident.

- ✓ History of DCS alarm showing pump start/stop alarm: confirms pump failure time.
- ✓ Motor current trend: Shows sudden increase in motor current from 18 Amps to > 20 Amps at about 1400 hours and failure of the pump and motor stoppage time
- ✓ Vacuum of the vacuum cooler flash vessel: showing normal vacuum during normal operation and fast reduction in vacuum with failure of pump.
- ✓ Reactor level trend: Shows nearly steady level and there cannot be cavitation problem in the any of the VCCPs.
- ✓ DCS graphics of reactor area showing vacuum cooler circulation pumps.

## 5.0 Observations of committee at site

The constituted committee visited the site in the morning of 08.04.2014 to identify the root cause of the failure of vacuum cooler circulation pump in PAP and following are the committee observations.

- The pump was in open condition, casing has been patched at several locations due to corrosion and erosion.



- Pump was in dismantled condition. One vane of the impeller (RECO supplied) was broken from the root.



- 16 mm thick 904 L liner (wear ring) had wear & tears / thinned and it was in buckled condition. New liner with 16 mm thickness was already provided in the casing.



- The pulley of the fan has broken to several pieces. New pulley was installed.
- The VCCP 113 pump suction line was with several patches of repair.



- PAP was in operation with 100 % Peru rock on 09.04.2014. Small quantity of pebbles was coming out from the reject chute through Trommel screen of the ball mills.
- There was sound from Mills Sludge Tank (MST) pump due to pebbles in the slurry flowing to SST.
- Ball mills A, C and D were in operation with Peru rock since morning shift. The Rock screens of all ball mills were not in line. The Rock screens of all the ball mills seems to be bypassed and not in operation since long.
- Huge quantity of small size pebbles were being collected near the vacuum cooler outlet pipe to reactor and same was being loaded to the tractor trolley.



- The sample of pebbles was analyzed and it indicates + 4 mm size pebbles 68.4 %. The sieve analysis of pebbles sample is given below:

Sieve Size	Sieve analysis of pebbles, % w/w
+6 mm	47.8
+4 mm	20.6
+3 mm	11.0
+2 mm	4.0
+1 mm	6.7
-1 mm	9.9



➤ Thickness of the liner:

Description	Original thickness, mm	Thickness @ failure, mm
904 L Liner / wear ring	16	5.92 to 8.53
Impeller blade	26.2 to 26.9	7.39

## 5.0 Possible reasons for failure of the Vacuum cooler Circulation pump

Corrosion and Erosion due to pebbles / stones along with the slurry.


## 6.0 Conclusion


The current drawn by the pump 113 had increased just after 13:58:07 hours on 07.04.2014 from about 18 Amp to > 20 amps may be due to the loosening of the liner in pump casing around the impeller due to corrosion and erosion. As the normal current drawn by the VCCP 01.113 remained in range of 18 to 21 Amps, the increase in the current drawn by VCCP 01.113 was ignored by plant people. Pump was operated in whole evening shift with current drawn > 20 amps till it failed at about 21:15 hours.

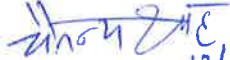


## 7.0 Recommendations by committee

- 1) For lesser corrosion and erosion in VCCPs, as suggested by the consultant Mr. P Smith who came along with the team from Vale International SA Singapore for Peru rock trials, we may consider Duplex stainless steel (654 SMO) for the VCCP.
- 2) The Trommel screen operation for all ball mills shall be checked every hour with respect to rejection of stones / pebbles through reject chute and appropriate corrective action shall be taken by operator / technician if it is not rejecting the oversize stones / pebbles.
- 3) To keep the vibrating Rock screen at SST inlet always in line to avoid pebbles going to the SST and subsequent pumping to the reactor. To avoid chocking of the rock screen and also to avoid overloading of the ball mills, it is suggested to increase the screen size of rock screen from existing opening of 10 mesh (1.615 \* 0.991 mm) to 7 mesh (2.794 mm). This can avoid > 2.8 mm size pebbles going to reactor (about 80 % stones going to reactor may get reduced)..
- 4) To take up the matter with Jordan rock supplier to get rock phosphate with No / minimum stones / pebbles.
- 5) To check feasibility to install a 7 mesh (2.794 mm) screen with strong supporting in reactor at pump suction up to 2 m height to avoid higher size pebbles / stones and any other foreign solid material going to vacuum cooler pump suction.
- 6) Due care shall be taken in welding of the 904-L liner in the pump casing to avoid detachment of liner.
- 7) Proper record of periodic checking for all equipments, history of equipments, log sheet for field instruments etc. shall be maintained.

  
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