TECH BYTES

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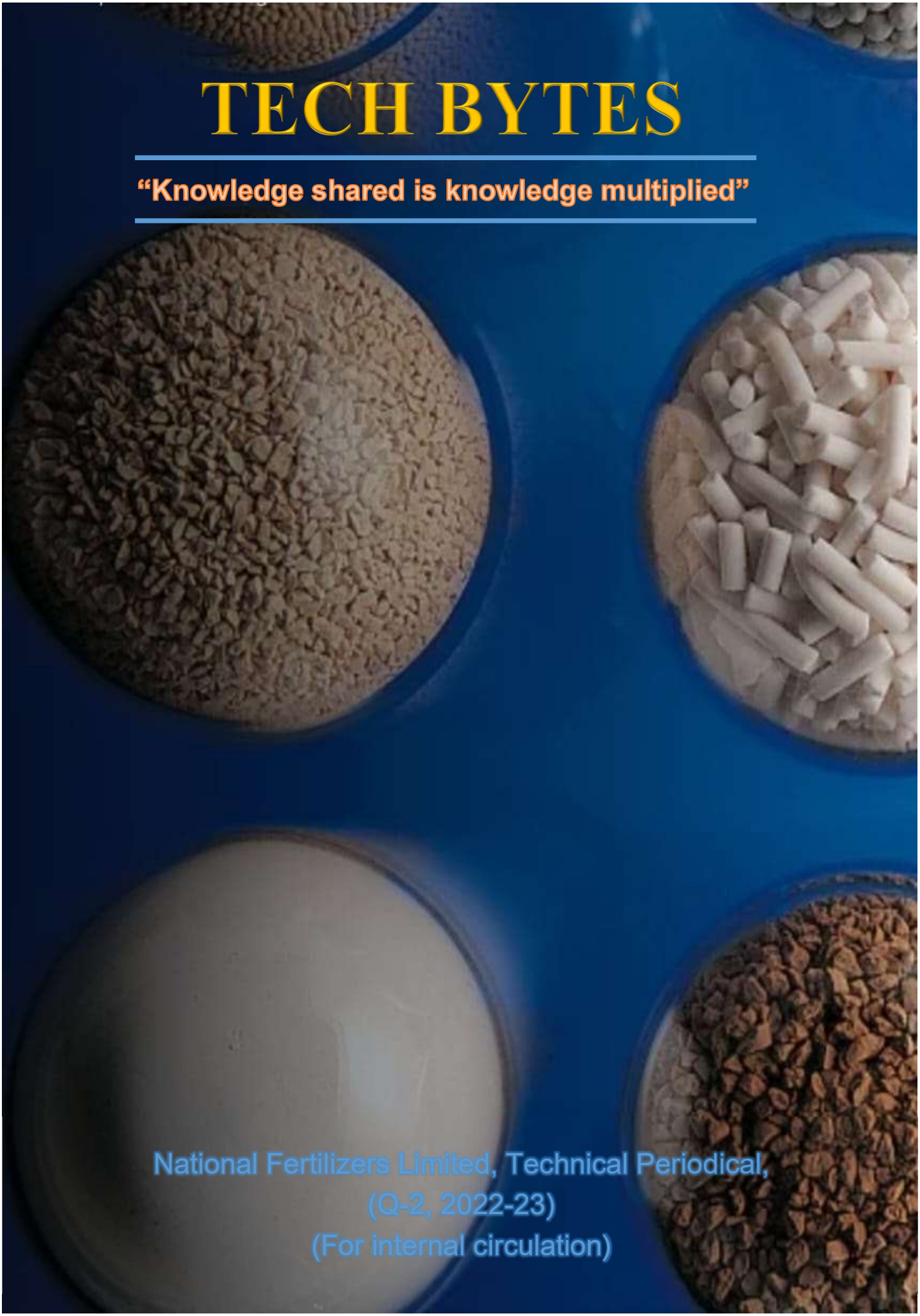

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Vijaipur Unit

Malfunction of IGV's LVDT and Tube Failure in the Hydraulic Oil Circuit of GTG-2 at N.F.L. Vijaipur

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Abstract:

Hydraulic Oil circuit in Gas Turbine Generator (GTG) machine plays a very pivotal role for operation of IGV (Inlet Guide Vane) and Fuel control valves. Any problem in the hydraulic oil circuit due to Linear Variable Differential Transducer (LVDT) malfunction will result in hydraulic oil pressure fluctuation, which in-turn shall hamper the operation of IGV and may subsequently cause failure in the hydraulic oil tubing. This case study highlights the root cause analysis for malfunction of IGV's LVDT and failure of tubing of hydraulic oil circuit at the machine GTG-2 of CPP Plant.

Introduction:

M/s GE designed Frame V Gas Turbine Generator GTG-1 and GTG-2 (Model: PG 5361 P) are installed at CPP plant of NFL Vijaipur. The hydraulic oil system of the machine provides the fluid power to operate the Fuel control valves and the Inlet Guide Vanes (IGV's). IGV is installed on the turbine to provide compressor pulsation protection during startup / shutdown and is operated during normal operation depending on load and exhaust temperature.

The IGV actuator is a hydraulically actuated assembly having closed loop feedback to control the Inlet guide vane angles for throttling the amount of air going to the axial flow compressor of the GT. The vanes are automatically positioned within their operating range in response either to the control system exhaust temperature limits for steady state operation or to the control system pulsation protection limits during the start-up and shutdown sequences.

The main hydraulic oil pump (PH-1) is installed at Accessory Gear Box (AGB). The pump is gear box driven and outlet of the pump goes to hydraulic filter FH2-1 / FH2-2 via hydraulic filter transfer valve (VM-4). Prior to filters excess pressure of oil, if any, is relieved by VR-21 (set relief pressure in range of 93 kg/cm2 to 97 kg/cm2 approximately). There is a provision of inbuilt pressure compensator (VPR3, set pressure in range between 88 kg/cm2 to 91 kg/cm2 approximately) in the main hydraulic oil pump (PH-1) to control the PH-1 pump pressure (refer Figure A).

The modulated IGV actuating system includes the following components: Servo valve 90TV, Position sensors (LVDT) 96 TV-1, 96 TV-2, and IGV flow control valve VC-1 (refer Figure B).

Oil from hydraulic filter FH2-1 / FH2-2 goes to Servo valve 90 TV. The outlet of the 90 TV servo goes to IGV hydraulic cylinder through IGV supply tubing of 3/8 inch size (18 BWG) and return to 90 TV servo through return tubing of same size. IGV flow control valve VC-1 controls the excess oil flow by draining oil through this valve (refer Figure B).

The Inlet guide vane in this machine varies from 42 degree to 85 degree. The IGV are automatically positioned to minimum IGV position during start up and shutdown sequence of the machine to avoid gas turbine compressor pulsation / surge. During the steady state operation of the machine, the IGV position is throttled depending upon load and exhaust temperature.

Observation:

During operation of GTG-2 in the month of September and October 2021, failure of hydraulic oil supply tubing (going from 90 TV to IGV cylinder) was observed.

Due to the leakage of the tube, forced shutdown of the GTG-2 was taken to attend the failed tubing. Both the supply and return tube is 3/8 inch size (18 BWG).

During the failure of tubing, hunting in the hydraulic oil pressure was also observed in the range of 89 kg/cm2 to 94 kg/cm2 approximately.

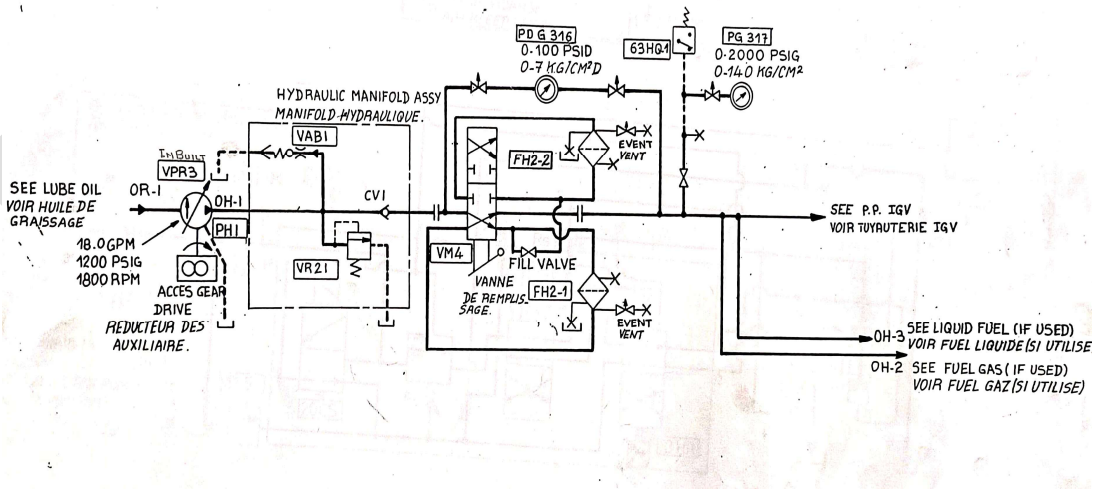

Figure A: Diagram Schematic for Hydraulic Oil Supply

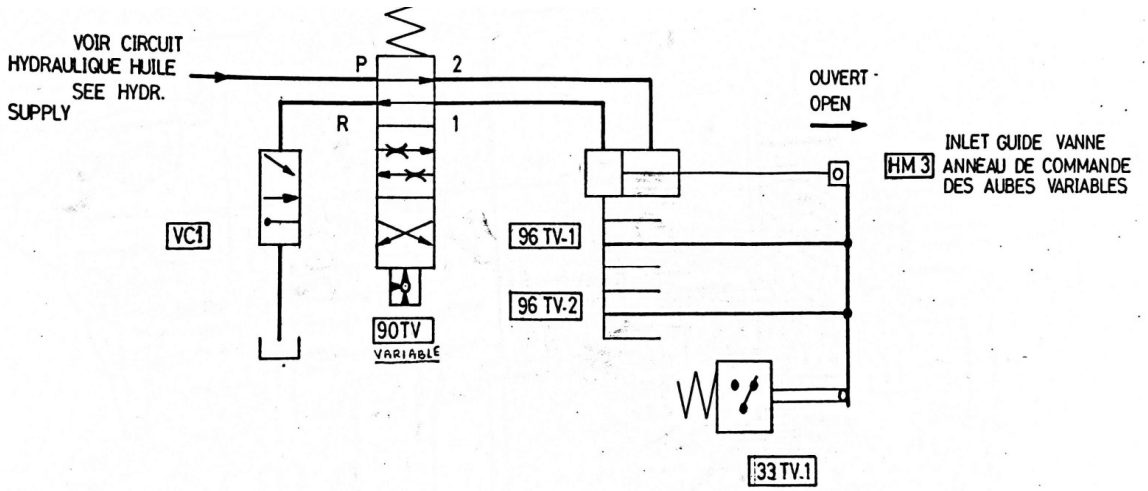

Figure B: Diagram Schematic for IGV Hydraulic Oil Supply

Diagnosis & Action Taken:

- ✓ Occurrence of similar problem regarding the subject oil pressure hunting and tubing failure has not been observed in any other fertilizer industry.
- ✓ The problem of hunting of hydraulic oil pressure and tube failure was analyzed. After detailed introspection and discussion with OEM, probable list of reason for oil pressure hunting and tube failure were listed and the same mainly included:
  - A. Malfunction of servo valve 90 TV.
  - B. Problem in Hydraulic pump (PH-1) with compensator VPR3.
  - C. Problem in the hydraulic filter FH2-1 / FH2-2.
  - D. Internal recirculation of Hydraulic cylinder.
  - E. Malfunction of VC-1.
  - F. Erratic feedback command of both i.e. IGV's LVDT 96 TV-1 and 96 TV-2.
  - G. Aging effect on supply and return tubes due to oil fluctuation.
- ✓ As per the shutdown opportunity, 90 TV servo valve and Hydraulic pump (PH-1) with compensator VPR3 were replaced with new one along with replacement of hydraulic oil filter FH2-1 / FH2-2 and failed portion of tubes.
- ✓ After running the machine with above replacement, the problem of intermittent hydraulic oil hunting was still persisting.
- ✓ ***As problem of hydraulic oil pressure hunting was not resolved with above step, detailed analysis of IGV's LVDT was done***.
- ✓ On close observation during the hunting period in GTG-2, it was found that the LVDT (96 TV-1 & 96 TV-2) feedback has difference in one of the three installed

controller (R,S,T) and diagnostic alarm of R voting mismatch for the same appeared in Mark IV control panel. It was thought that the same may be the reason for fluctuation / hunting in hydraulic oil pressure due to erratic response of one LVDT controller.

- ✓ It is worth mentioning here that the IGV of the GT has two LVDT (Linear Variable Differential Transducer) installed on the IGV hydraulic cylinder. The position of the IGV cylinder piston is measured by LVDT. The forward and backward movement of the piston causes the opening and closing of the IGV respectively.
- ✓ The LVDT measures the linear moment of the IGV cylinder piston and converts this linear movement into voltage output. This LVDT voltage output is further converted into IGV opening angle by the processor / controllers (R,S,T).
- ✓ Any difference in R,S,T controller feedback values shall cause alarm for mismatch in controller value. The actual IGV angle (CSGV) depends on output of these three controllers.
- ✓ Also any difference in the value of these controllers shall result in erratic linear movement of the cylinder piston and ultimately fluctuation / hunting of hydraulic oil pressure.
- ✓ Due to erratic feedback of LVDT controllers and hydraulic oil pressure hunting, the supply and return tubing shall be subjected to vibration as well as stress / fatigue and the same may result in failure of tubes as a result of cyclic loading (i.e. frequent oil hunting).
- ✓ OEM of the GTG was also contacted to identify the root cause of failure of these tubing's and reason of oil hunting.
- ✓ After in depth analysis of the problem and discussion with OEM, it was decided to change the LVDT.
- ✓ Both the LVDT were replaced with new one. After the replacement all the three controller feedbacks were found to be same and hunting problem after running the machine was not observed. The same was closely monitored thereafter and is running well since then.
- ✓ Hence, ***it was concluded that due to malfunction of IGV's LVDT, problem of oil pressure fluctuation was being faced and it was resulting in the failure of hydraulic tubing due to vibration and stresses on tube***.
- ✓ Also in parallel, it was planned to change the old tubes to superior quality hydraulic tubes (like Sandvik make) along with standard fitting of Swagelok only. Superior quality hydraulic tubes (like Sandvik) will ensure absorbing these vibrations due to oil fluctuation, reliable life of tube and operation of GT.

- ✓ The supply and return tubing in the hydraulic oil circuit are installed and running since commissioning of the machine.
- ✓ It is prudent to mention here that the subject supply and return tubing is installed in the confined zone beneath the IGV compartment. The same is not accessible during the running operation of machine and some tube fitting near IGV cylinder are difficult to approach even in stopped machine condition.
- ✓ The installed tubes were checked and found that there was aging effect on the tubes and due to oil fluctuation, these tubes may have developed stresses.
- ✓ The supply and return tubing was replaced with superior quality Sandvik make hydraulic tubes along with standard fitting of Swagelok.
- ✓ The quality of Sandvik make hydraulic tubing is established in the industry and suitable for such critical application for such high hydraulic oil pressure. Also various leading gas turbine users are using superior quality hydraulic tubes (like Sandvik) only.
- ✓ Another important observation made during the replacement of these tubes was that only clamp support is provided to these tubes. However during running and fluctuation of the hydraulic oil pressure, these tubes and its ferrules / fitting are subject to vibration and some dampening arrangement is required to relieve the vibration and stresses in these tubes.
- ✓ Hence, after detailed analysis of the tubing layout, the original support design was modified to extra additional flexible packing support at various locations (especially before the fitting and ferrule joints).

Conclusions & Recommendations:

Based on the learning from the above malfunction of IGV's LVDT and failure of tubes, following recommendation were made:

- ❖ Smooth operation of LVDT of IGV is critical from operation point of view. Hence the LVDT inspection / calibration need to be done regularly in every available shutdown opportunity for reliable operation of IGV's. Although LVDT's are frictionless devices, but reliable only if properly installed and maintained.
- ❖ In case of any vibration being observed in the hydraulic tubing due to hydraulic oil fluctuation, the tube should be replaced with superior quality hydraulic tubes along with standard fitting ((like Sandvik / Swagelok makes, etc). In addition, proper support system to be ensured and checked for these tubing's to provide proper dampening in case of vibration / oil hunting.

Hence for reliable and trouble free operation of the Gas Turbine, healthiness of IGV's LVDT may be ensured to avoid any hydraulic oil pressure hunting and subsequent failure of the hydraulic oil tubing.

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Nangal Unit

Implementation of Auto Ramp down logic for BOMAFA Valve - PV9702-A/B (91/64 letdown valve) & feedback transmitter for Quick opening valve PV-9702B.

By Senthil Kumaran R, A.M. (Inst.)

Introduction:

In Ammonia Plant, two 91/64 ata steam let-down valves PV-9702A/B operate in such a way that one of the valves is kept on PIC (Pressure control) mode which maintains 64 ata Steam header pressure during normal plant operation and the other one is kept in Quick Opening mode (QOV) which comes in line immediately when the synthesis compressor trips.

QOV (PV-9702B) opens to supply 64 ata steam equivalent to the extraction flow of synthesis turbine to make up for the shortage in case of a Synthesis compressor trips and prevents the tripping of Ammonia front end i.e. Reformer and other equipment/sections consuming 64 ata steam . Once opened it has to be closed by the operator gradually by keeping a watch over 64 ata header pressure.

Observations:

Extreme care is being taken by the Panel operator while closing the Quick opening valve- PV-9702B manually in increments when Synthesis compressor trips as pressure fluctuations in 64 ata steam header pressure causes disturbance to the running of Process Air Compressor (PAC) and other downstream equipment. There was an instance where PAC had tripped on high delta-P across the turbine due to fluctuations in 64 ata header pressure.

Action taken:

So a proposal to ramp down the Quick opening valve PV-9702B automatically without operator intervention was put forth and was approved by the Competent Authority after due deliberations. The following modifications were done:

1. A new control module in Honeywell DCS was created to implement auto ramp down of PV-9702B.The module will continuously monitor the running of synthesis compressor. Once the compressor trips PV-9702B will open as per the calculated memory signal based on extraction flow. After a delay of 3 seconds the newly created module will start to ramp down the opening of PV-9702B at the rate of 0.6% per second.

2. The control module also compares the 64 ata header pressure with the set point and holds the ramping when the pressure goes below the set point. It resumes to ramp down the valve once the header pressure goes above set point.
3. Also an ENABLE/DISABLE ramp switch has been provide in the graphics page so that the operator can toggle between manual mode and Auto ramp down mode as per need.
4. Position feedback transmitter is installed in PV-9702B to monitor the actual opening of the control valve. A new feedback lever and a suitable mounting assembly for installing the transmitter were fabricated in the local workshop to connect the valve stem and the position transmitter.

Conclusion:

Logic for the said modification was developed and tested in house. It was implemented in DCS in June 2022. After implementation of the modification, it is expected to work successfully as and when required. The automated process will reduced manual intervention of panel operator thereby minimizing the error of manual operation.

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Panipat Unit

Implementation of Changeover Facility between 2X18.75MVA STGs (CPP) & 1X40MVA GTG as an Operational Solution for Power Evacuation at NFL Panipat

By Imran Mateen, M (Elect.)

Introduction:

The Gas Turbine (Siemens, SGT-700) operation caters to complete plant load requirements (17MW) of Panipat unit. In compliance to the New Urea Policy-2015 (NUP-2015) this unit was taken into plant operation on 8th January'22 & Old Steam driven turbines (CPP) operation were stopped. Several major modifications in 132kV & 11kV Electrical Power system were made to interconnect the GTG with existing Electrical power system that was in the scope of LSTK. However, the scope for restarting of STGs, during outage of GTG, was not envisaged. As this requirement had arisen first time during the GTG testing phase, it became a challenging task to restore back old Electrical Power system within minimum possible time frame.

The paper deals with technical provisions & methodologies that has been successfully implemented at Panipat Unit as Plant Load Changeover Facility between 2X18.75MVA STGs (CPP) & 1X40MVA (GTG) within minimum time (10 min) with Grid.

Observations:

The scope under LSTK for interconnection of Gas Turbine Generator with existing Electrical power system was:

a. The existing 11kV bus ducts of 132/11kV, Transformers MT-1 & MT-2 that were emanating from CPP-STG's (11kV Panel) were permanently removed from CPP End & new 11kV Cable Terminal Box was placed in place of 11kV bus-ducts to accommodate new 11kV power cables from GTG plant.

b. The Unit Protection scheme i.e. Transformer differential Protection (87T), Restricted Earth Fault(64R) & Standby Earth fault Protection of Transformer MT-1 and MT- 2, (132kV & 11kV side) at CPP were isolated & shifted to GTG plant.

c. Transformer MT-1 and MT- 2, Internal Protection & Fault annunciation (Oil Temperature, Winding Temperature, Oil Surge Protection & Buchholz Protection) at CPP were isolated & shifted to GTG plant.

d. On-load Tap Changeover Control (OLTC) & Automotive Cooling Fan Provision at CPP were isolated & shifted to GTG plant.

e. 132kV Grid Line-1&2 Synchronization provision available at CPP was isolated & shifted to GTG plant

With afore-mentioned modifications in Electrical Systems, it was not possible to restore the STGs back into operation. However, to establish the guaranteed parameters of GTG, during RRT/PGT & further plant operation, it was required to shift the complete running plant load between STG's & GTG without plant interruption.

Diagnosis & Action taken:

Implementation Redesign - Before the commencement of GTG commissioning, following in-house modification actions were taken to facilitate the Load changeover between STG's & GTG–

a. 11kV Cable Terminal Box at Transformers MT-1 was modified & retrofitted with in-house prepared 11kV adaptor bus-bar chamber, such that the CPP-11KV bus-ducts emanating from CPP-STG's (11kV Panel) were connected to 11kV Cable Terminal Box of GTG. Subsequently, the facility for evacuating power from TG's was made available.

b. New 132kV Special Double Core PS-class CT's were installed at MT-1 & MT-2 132kV circuits. One core of CT was used for CPP & another to GTG plant such that Unit Protection scheme of Transformer (87T,64R) was available at both CPP & GTG end.

c. Provisions in Parallel Connections were made at 132kV Grid Line-1&2 Synchronising systems such that Grid Lines may be synchronized with any of STG's or GTG.

d. Modification in control circuit of MT-1 was made such that, during each changeover only disconnections/ connections were required in control circuits of OLTC, Transformer Internal Protection & fault annunciation circuits.

e. Hence, with above modifications, both MT-1 & MT-2 is available during GTG operation. And during STGs operation MT-1 is available for CPP & MT-2 for HRSG operation.

Refer Figure-1 for illustration of interconnection under LSTK vs Implemented changeover facility (next page)

CONCLUSION-

The advantages of implemented modifications for load changeover facility integration of GTG and STGs are as follows:

a. Risk Mitigation

The complete power evacuation at Panipat Unit is dependent upon newly commissioned GTG. However, the availability of STGs is critically necessary till GTG continual operation is established. The provision of load changeover between GTG & STG's has been operated twice after GTG plant handover &

thrice during PGT/RRT testing. The objective has been successfully achieved with in-house with technical efforts & modifications, along with maintaining continuity of running plant.

b. Saving Opportunity Loss of Production

With Implementation of load changeover facility, the dependency on Grid has been reduced to as low as within 5 minutes. Hence, for avoiding any supply disruption, 100% reliability of Electrical Power System has been ensured at Panipat Unit.

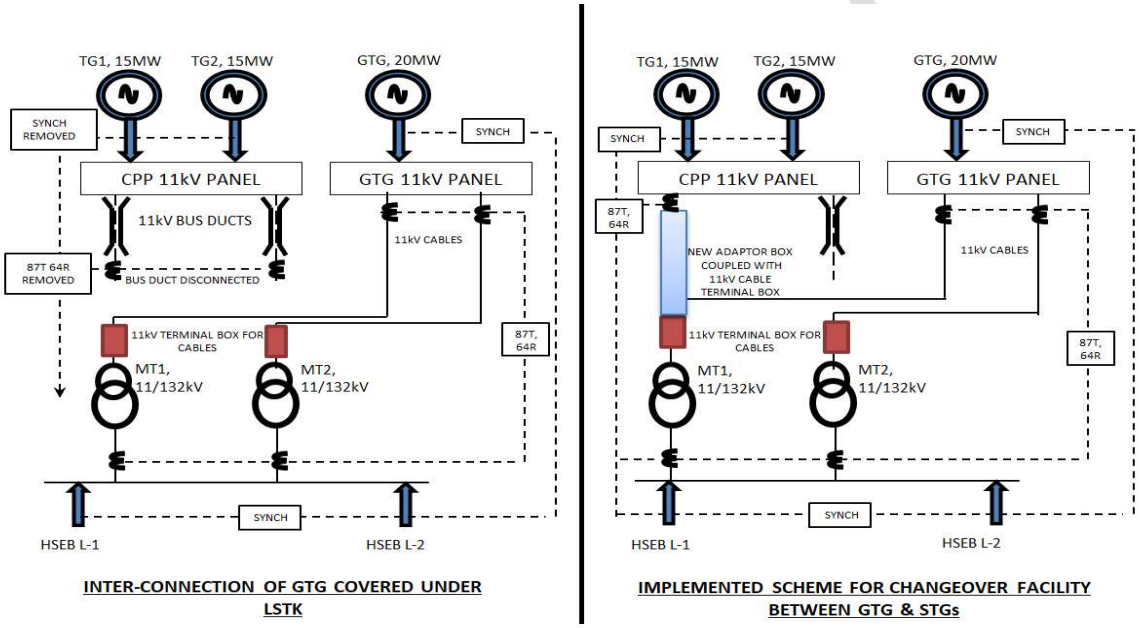

FIGURE-1

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Bathinda Unit

Maintaining continuity of PGR section in Ammonia plant by local fabrication.

By Vicky Singla, M (Mech.),
Pushap Kumar, CM (Mech.)

The article discusses how a local fabrication and erection of a serpentine cooler heat exchanger in parallel to choked Rich & Lean Ammonia solution heat exchanger Exchangers (E-551-1&2) has led to continuous operation of Purge Gas Recovery (PGR) section without undergoing shutdown.

PURGE GAS RECOVERY SYSTEM

Purge gas from Ammonia Synthesis Loop is sent to the Purge Gas Absorber (F-551) wherein the Ammonia get absorbed in lean Ammonical solution and Ammonia free Purge Gas is sent to Primary Reformer fuel system. The rich Ammonical solution from the bottom of F-551 is sent to Distillation column (F-553) via pump P-551A/B. The said solution is heated up to 160^{o}C via Rich/lean Ammonia exchangers E-551-1&2 before entering into the distillation column F-553. In the distillation column, the vapor ammonia is recovered & condensed and sent back to Horton Sphere. The bottom lean Ammonical solution from F-551 is again recycled to top of the Absorber as absorbent completing the cycle of absorption. The Ammonia content in the Purge Gas outlet at normal value runs @ 100ppm.

PROBLEM

In the end of Apr-2022 the Ammonia content in the purge gas outlet started increasing beyond 100 ppm and it was observed that the pressure drop across the E-551-2 was on increasing trend (> 5.0 kg/cm2) and the rich Ammonical solution flow started decreasing from 6000 kg/hr to 4950 kg/hr through the exchanger E-551 and the outlet temperature decreased to 145 ^{o}C

In the month of May-2022 the Ammonia content in purge gas outlet increased above 350 ppm due to further deterioration in pressure drop and **reduction in** flow through the exchanger E-551-2. The NH3 content in the purge gas outlet was maintained within the limit of 200ppm by adjusting following parameters:

By draining Rich Ammonical solution from the bottom of the Absorber (F-551) to increase top flow for better absorption. Partially bypassing of E-551-2 by laying down additional line and Reduction in Purge gas flow to PGR section.

APPROACH TO PROBLEM

By applying above minor steps the load on PGR section was reduced from 10500 Nm3/hr to 8500Nm3/hr and the Ammonia content in the purge gas outlet brought down in the range of 150 to 200 ppm.

In the start of July 2022, the Ammonia content in the purge outlet again increased to 360ppm due to further deterioration in E-551-1&2 (i.e. pressure drop is 7.42 Kg/cm2 & rich flow is 4500Kg/hr).

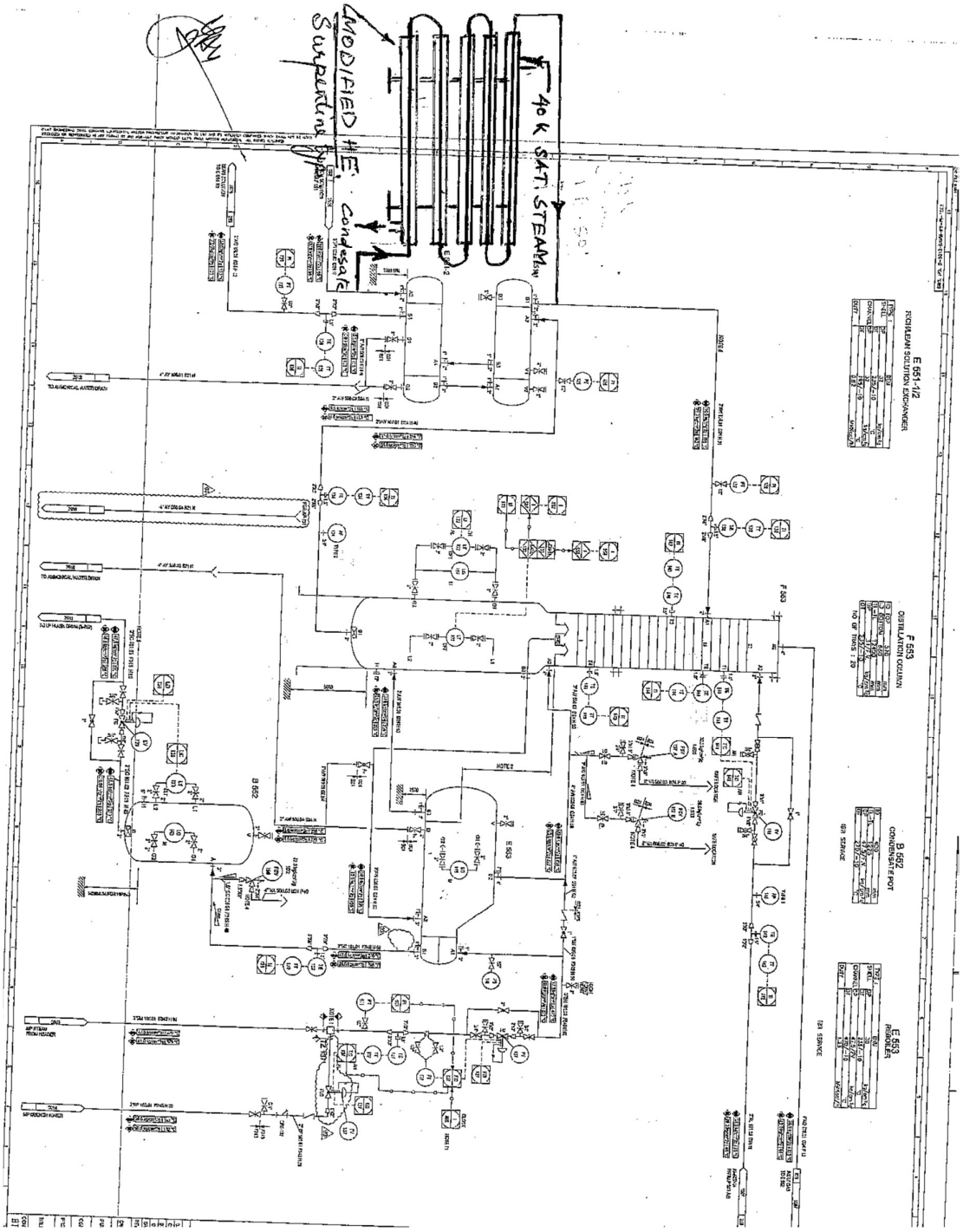
It seemed difficult to run the PGR section as such. But Stopping of PGR section for tube cleaning of both the exchangers E 551-1&2 would have resulted in loss of total energy of approximately 1200 GCal.

During in-house discussion, it was discussed to install some arrangement, so that load on E-551-1/2 can be reduced. To achieve this, a portion of the redundant economizer coil of Boiler with extruded fins was taken and its extrusions was removed. Fabricated Coil segment was tested hydraulically to 40 kg/cm2g to ensure healthiness of the same and found no leakage for the fabrication of heat exchanger. Heat exchanger was fabricated by using above mentioned economizer coil with provision of steam tracing for the straight portion of coil. Heat duty of fabricated exchanger of 5.19 m2 was expected to meet the plant requirement.

By putting the in-house fabricated steam jacketed serpentine heat exchanger following outcome have been achieved:

- ***The Ammonia content in the Purge gas outlet decreased from 360ppm to 150ppm.***
- ***Flow of Rich Ammonical solution increased from 4500kg/hour to 6000 kg/hr.***

Stopping of PGR section for tube cleaning of both the exchangers E 551-1&2 was avoided and Plant is running normal at 105% load.


MODIFIED H.E.
Superheated
40 K SAT. STEAM IN
E 651-1/2
RICH AMINE SOLUTION EXCHANGER
F 653
REGENERATION COLUMN
B 652
E 653
REBOILER

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