HYDROGEN SULPHIDE BOOSTER COMPRESSORS FOR HWP MANUGURU - OIL RECLAIMATION STUDY - BHEL EXPERIENCE

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1.0 INTRODUCTION:

BHEL undertook the development of Hydrogen Sulphide booster compressor with a view to indegenise this most critical equipment in a Heavy Water plant. After successful design and manufacture of a prototype compressor BHEL was awarded contract for the supply of 5 Nos. booster compressors for KCR-Manuguru project. Throughout the design, manufacture and shop testing of these booster compressors BHEL had close interaction with HWB.

1.1 Features: Smaller pressure ratio requirement made the design single stage, overhang type with axial suction and radial delivery of gas. The conventional oil film bushing seal is provided to prevent the leakage of gas to the atmosphere. Separate lube and seal oil systems are provided tu prevent contamination of lube oil with Hydrogen Sulphide.

2.0 Site operation: Two major problems connected to seal assembly and related system were observed dur'ng the commissioning of compressors.

2.1 First trial runs revealed that LP seal oil drain is not adequate and seal oil is mixing with Lube oil causing operational hazard. The problem was studied in detail and a number modifications were implemented Major actions are listed below:

- Provision of separate drain from intermediate port between SO & LO drains.
- Closing of the opening between intermediate drain port and LO drain
- Reducing the clearance of seal between LO&SO drains by change of seal material from SS to Aluminium.
- Enlarging at LP seal Oil drain area.
- Providing bush with fins on the rotor to deflect seal oil and preventing directly entering of SO to LO side.
- Providing an ejector in the LP seal Oil drain line immediately below the compressor for improved LP seal oil drain.

All these modifications have resulted in proper LP seal oil drain and eliminating the mixing of seal oil with lube Oil. The modifications are shown in Fig. D

2.2 High HP seal oil leakage was observed at site. This resulted in excessive contaminated oil getting wasted.

During the shop tests it was concluded that based on minimum possible HP seal clearances 0.06 to 0.08 and higher than conventional LP seal clearance 0.30 to 0.34 mm it is possible to reduce the HP seal drain quantity to as low as 50 litres per day at a differential pressure of 0.25 ata. It was also felt that the required differential pressure need to be adjusted at site by providing an orifice in the seal oil inlet line.

At site it was observed that differential pressure between the seal oil to reference gas is about 0.9 ata. Further due to the problem of limiting the LP seal oil drain quantity to avoid its mixing with Lube Oil it was necessary to reduce the LP seal elearance to 0.28 to 0.3. As a result HP seal leakage rate has increased and is verying from 200 to 400 litres per day depending on seal clearance, differential pressure and seal oil temperature. Inview of need to avoid the mixing of seal oil to lube oil and also considering the safe differential pressure of 0.5 ata it may not be possible to reduce HP Seal oil leakage below about 150 litres per day. For a long term solution following development projects were takenup at R&D unit of BHEL.

- A process for reclaimation of oil.
- A more effective seal

3. BHEL (R&D) has taken up the problem of regeneration of used oil by following reclaimation techniques at lab level. After optimizing the process parameters, the process may be scaled up to the required level by HWB for site operations.

3.1 Contamination of oil by H2S:

Due to ingress of Oxygen into the system it is possible that part of H2S absorbed by the oil is oxidized to elemental sulphur. H2S may also lead to the formation of mercaptans and other forms of sulphur which are copper corrosive. The reaction of mercaptide with free sulphur may lead to the formation of compounds like RSS^-

$$S + RS^- = RSS^-$$

Thus the contaminated oil in addition to H2S will have contaminats like merceptans, free sulphur (elemental sulphur) and their compounds. The reclaimation process developed should remove all the contaminates with out impairing the original properties of the oil.

3.2 Regeneration and reclaimation:

In petroleum Industry, the contamination of H2S is usally removed by caustic wash which is very effective and cheaper. But caustic wash cannot remove the mercaptans and free sulphur formed during reaction with H2S. Further, alkali treatment may remove the additives which are generally added to improve the performance of oil. Hence various reclaimation process were studied and three processes were selected for experimentation and the results achieved are discussed below.

Reclaimation processes selected were the combinations of Nitrogen sparging, vacuum degassing and treatments namely.

(a) Nitrogen sparging and copper powder treatment
(b) Vacuum degassing and animal charcoal fullers earth treatment.
(c) Nitrogen sparging and animal charcoal fullers earth treatment.

In the process (a) the oil was heated to 90 Deg.C with Nitrogen bubbling for 2 hrs. Then the oil was treated with copper powder at 120 Deg.C under stirring and filtered.

In the process (b) the oil was degassed under vacuum for 2 hrs at 80 Deg.C with stirring. The oil was then treated with animal charcoal followed by fullers earth. The oil was stirred for 1hr more and filtered.

In the process (c) the oil was bubbled with Nitrogen at different rates (120 ml/min., 24o ml/min, 360 ml/min) for 1-2 hrs at temp. 80 to 90 Deg.C and then the animal charcoal / Fullers earth treatment was given as in process (b).

3.3 Analysis of site oil and reclaimed oils:

The physical and chemical properties of oils before processing (as received from site) and after processing by the above three methods are given in (Table: 1) The H2S content was determined as per IP 103 method that is treatment with Cadmium Suplhate and presence of mercaptans by ASTMD 4952-89 that is Doctor Test (Qualitative estimation).

H2S and mercaptans were also quantitatively estimated by following UOP163-80 method that is potentiometrically titrating oil samples taken in toluene, isopropanol mixture with silver nitrate as the titrant. Fig. " A " gives typical potentiometric titration curves for site oil and processed oil. Infrared spectral analysis was also carried out for site and processed sample.

3.4 Results & Discussion:

3.4.1 The results in table 1 indicate that the oil processed by process (a) was becoming darker in colour possibly due to heating at 120 Deg.C and the acid value was also comparatively higher. Although this processes effectively remove the mercaptans, exposure of the oil to 120 Deg.C may not be safe while treating large batches as it is very close to flash point of the oil.

3.4.2 The properties obtained by following the process (b) are encouraging as shown by the acid values and moisture levels and also this process removes H2S and mercaptans to negligible levels.

But this process requires heating under vaccum which may be difficult if the batches are bigger and may needs lot of investment for effective disposal of extracted H2S.

3.4.3 The properties obtained after following the process (c) are equally comparable with the properties obtained by the processes (a) & (b) and can easily be adopted for bigger batches after properly optimizing the process parameters.

3.4.4 The infrared spectra taken for oils before and after processing did not indicate any change in oil structure.

3.4.5 Before any process of reclaimation is scaled up it is essential that the effect of processing on tribological properties of oil and the depletion of additives if any also needs to be studied.

4.0 As a long term solution to the problem of wastage of oil due to contamination with H2S a development project has been initiated by BHEL-R&D for developing 'Zero leak seal'.

Existing seal arrangement is shown in figure - B

4.1 Details of the proposed development of wind-back visco seal are illustrated in figure-C . The screw configuration in the seal transports the fluid in unidirection, dependent on the direction of rotation. The pressure development across the seal is dependent on the screw configuration, the rotational speed, and the properties of the working fluid. By suitable combination of both right and left hand screws L and R formed on the same shaft/sleeve axis, two-way, on-line pumping can be achieved. Plain section P when introduced, as shown between the threaded portions, further enhances the performance of the wind-back seal. An inert non- reacting fluid is normally introduced through input feeder 8 in to this annular zone. Under rotation of the shaft 9, this fluid builds up hydrodynamic pressure and fills the annular zone as shown, thus creating a pressure barrier to withstand the pressure needed for sealing. This sealing principle is well established and is put to use for high speed and high pressure applications elsewhere.

4.2 The anti-leak rings 5, introduced at the ends with-in the housing 1, restrict the process fluid from flowing out, and retain the buffer fluid in the screw configuration. As the performance of the clearance seals is dependent on the motion of the shaft, alternate seal has to be provided for sealing the process fluid while the shaft is under rest. Such a combination seal will work both under static and dynamic conditions. The static seal 4 at the ends as shown, will be effective when no rotation is there, but will not act when the shaft reaches normal rotational speed. The static seals 4, will come in to engagement only during the coast down period when the speed reaches around 100 RPM, and will continue to be engaged until the next start up. During the startup, when the speed increases to around 100 RPM, the static seals will be withdrawn from position by intentionally creating increased clearance along the contacting edges.

4.3 It is proposed to make a scaled down model of viscoseal and test in Tribology laboratory at BHEL R & D.

- Based on feed back a prototype seal to be made and tested at BHEL R.C.Puram.
- Finally the prototype seal shall be assembled in one booster compressor & to be tested at site with H2S gas.

5. CONCLUSIONS:

- The problems faced during commissioning of compressors at KCR-Manuguru have broughtout certain difficienies in the sizing of LP seal oil drain for which adequate provision can be made in new machines.
- Development of a process for reclaimation of oil can be very useful in reducing wastage of contaminated oil.
- Development of on alternate sealing arrangment can be applied to compressors handing gases which are not compatible with oil.

TABLE: 1

PHYSICAL AND CHEMICAL PROPERTIES OF SITE AND RECLAIMED OIL-SAMPLES.

Property	Site sample as received	Process (a)	Process (b)	Process (c)
1. Colour	Pale white	dark brown	straw yellow	yellow
2. Specific gravity gm/cc	0.86	0.86	0.86	0.86
3. Kinematic viscosity cs. at 40Deg.C	45.0	45.5	45.0	45.2
cs.at 80 Deg.C	10.84	11.35	10.89	10.99
4. Moisture ppm	2050	66.0	42.0	46.0
5. Copper strip Corrosion 3hrs/100 Deg.C	Positive	Negetive	Negetive	Negetive
6. H2S, ppm UOP163-80	546	NIL	NIL	NIL
7. Mercaptans ppm UOP-163-80	496	NIL	Negetive	Traces
8. Acid value mg KOH/ gm of/oil	0.09	0.08	0.04	0.05

ESTIMATION OF H_2S & MERCAPTANS

SAMPLE : MANUGURU OIL

CONDITION : AS RECIEVED - BEFORE PROCESSING

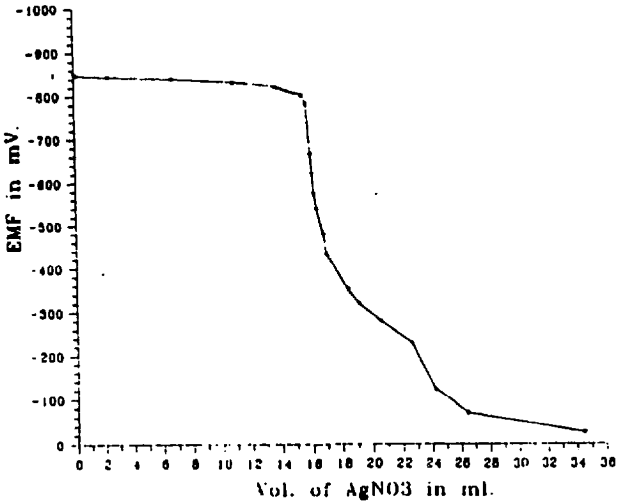

FIGURE-A1

ESTIMATION OF H_2S & MERCAPTANS

SAMPLE : MANUGURU OIL

CONDITION : PROCESSED - PURGING N_2 FOR 2hrs.240ml/min.90°C.

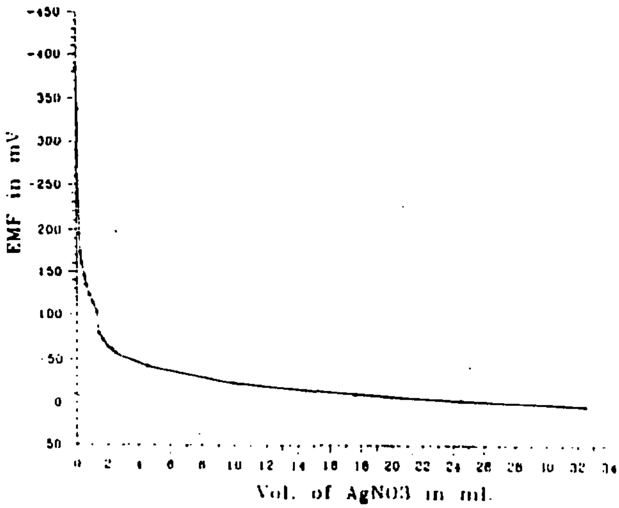

FIGURE A.

FIG-A

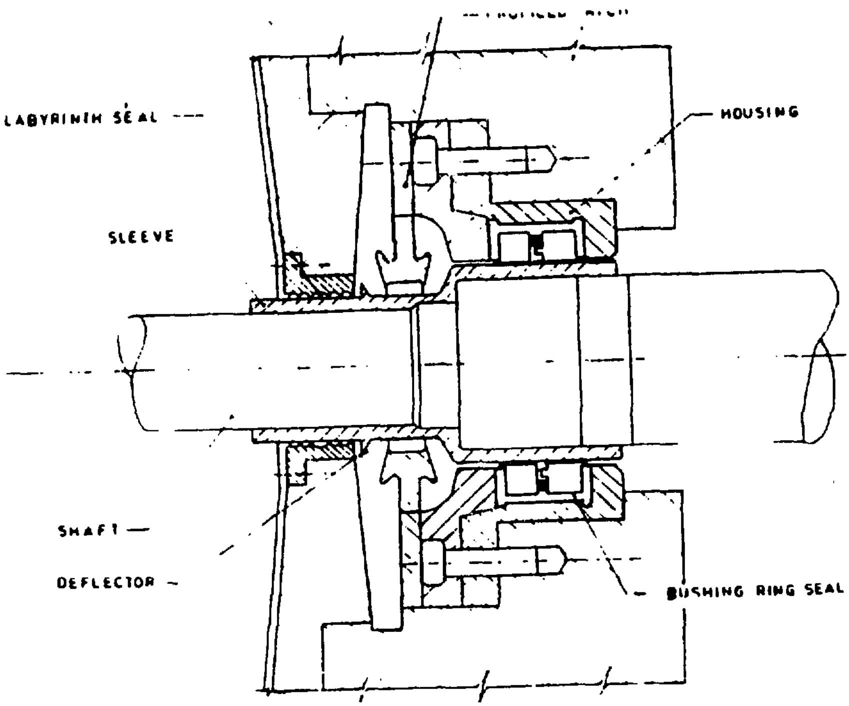

Fig. B EXISTING SEALING ARRANGEMENT

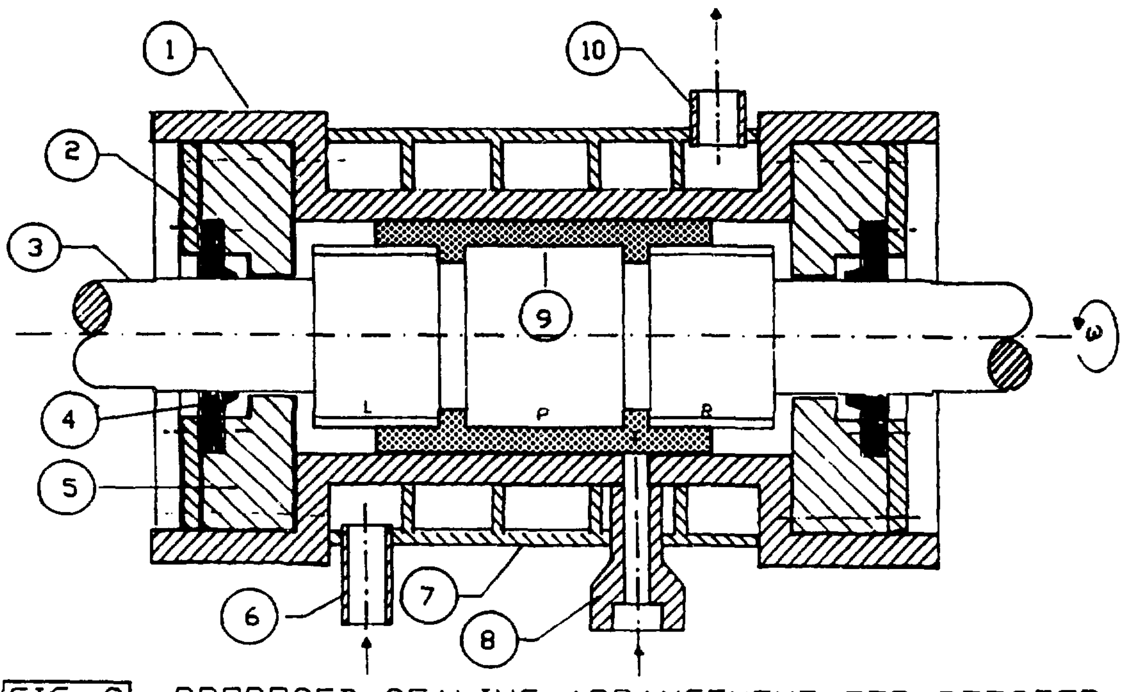

FIG. C PROPOSED SEALING ARRANGEMENT FOR BOOSTER COMPRESSOR HANDLING TOXIC GASES

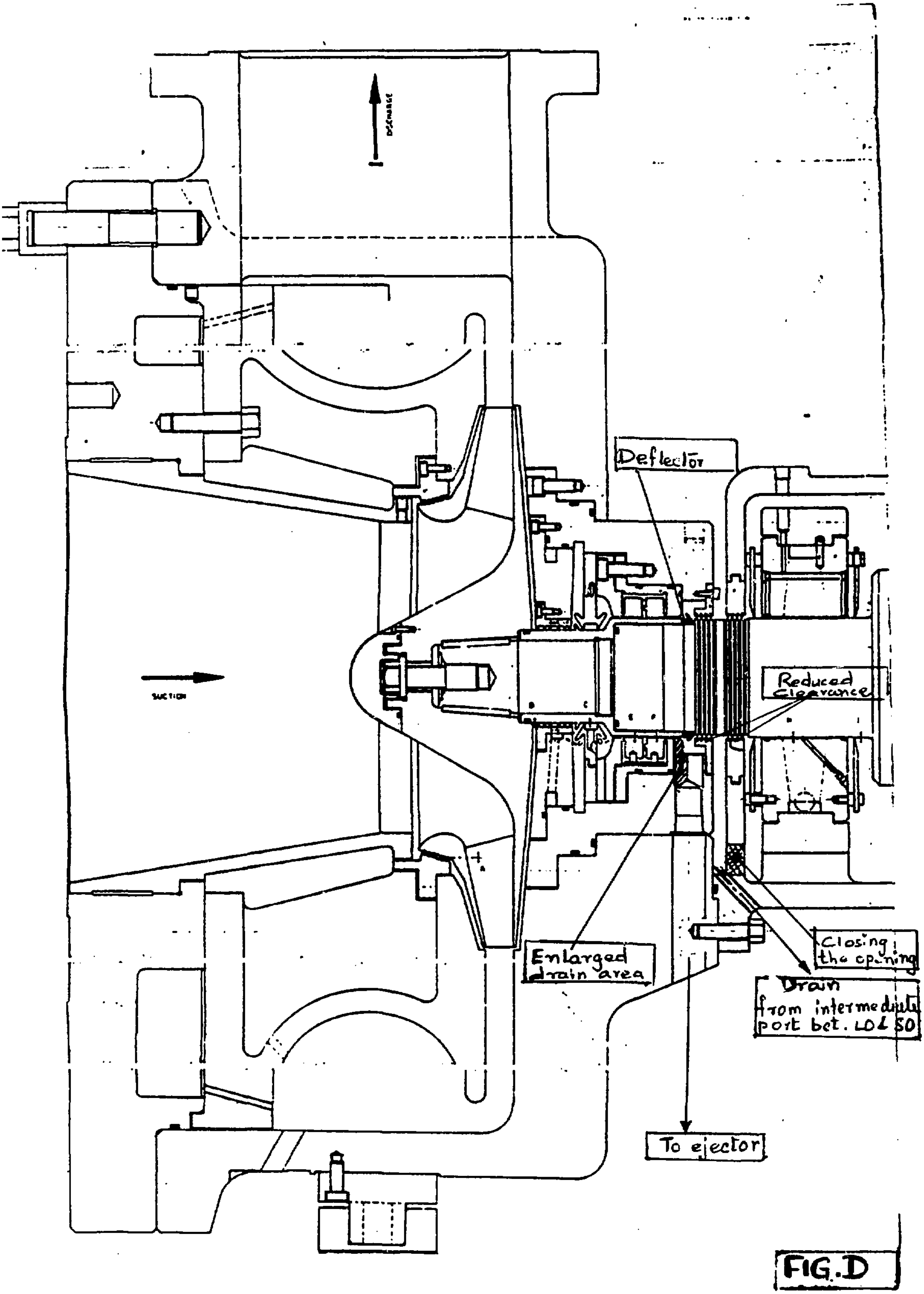
DISCHARGE
SUCTION
Deflector
Reduced clearance
Closing the opening
Drain from intermediate port bet. LO & SO
Enlarged drain area
To ejector

FIG. D