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Potassium Carbonate Pump Failure – High Axial Movement due to Uncontrolled (unbalanced) forces.

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Abstract

Potassium Carbonate Pump Failure – High Axial Movement due to Uncontrolled (unbalanced) forces.

Pump Multi stage pump
Service Solution Pump
Suction pressure = 1.5 barg ,Discharge pressure = 36 barg , Suction temperature = 105 C , Flow = 1000 m3/hr

A multi stage pump 1.4 MW was in operation till 4 years, the pump stand still for mean period without any failure symptoms , all last measurements (casing vibration, pressure ,flow) was OK , when the pump operated again after two weeks from stand still and during one day sudden failure was occurred due to high axial movement which established from axial thrust without any track alarm (No Online monitor system as axial probe ,bearing temperature or discharge pressure ,,,all parameters are local) , This axial thrust typically effects of Benfield process, the axial thrust was followed by damage of drive end mechanical seal, this failure result in silicon carbide powder to enters between DE throat Bushing with shaft , the overheating initiated at mechanical seal area causes melting and stuck for DE throat Bushing with shaft sleeve of the mechanical seal i.e.. The shaft

Our case study talks about the root cause analysis and how to deal with potassium carbonate pumps
Also it talks about the reasons of damage , how to solve the problem and repair the damage parts also the corrective actions which has been taken to avoid repeating this failure in the future

Problem statement

On 3-9-2015 - A 1.4 MW two stage potassium carbonate pump had been in operation for 4 years when sudden failure occurred. The pump was off line a few days and then started. The motor experienced overload; the pump was checked for rotation, and was stuck

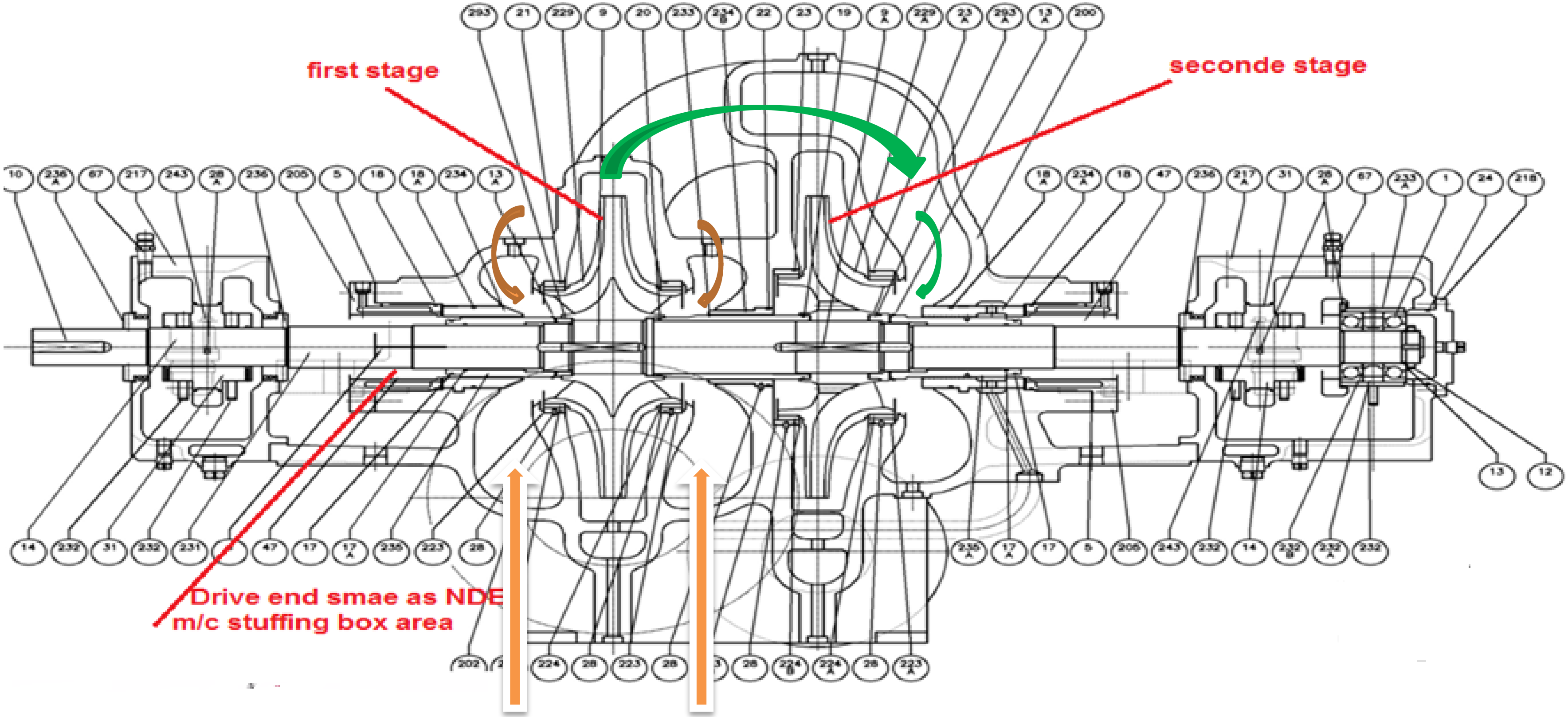
Prior to any analysis by the authors

- Vibration measurements and spectrum analysis for pump was checked for the two weeks running period prior to shut down , vibration was within tolerance and no faults were detected

- Solidification due to the stand still period for the potassium carbonate in the pump was considered. The pump casing was warmed up by low pressure steam to ensure melting the solidified solution until it was determined clear by observing the pump casing drains

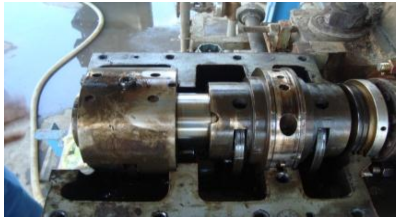
- After ensuring that all solidification solution is melted we try to rotate the pump again by hands but it still stuck

- It became the author's goal to determine the root cause of pump failure, including identification of any mechanical defect due to changing in process or other failure mode. It was decided to inspect and check the pump internally.

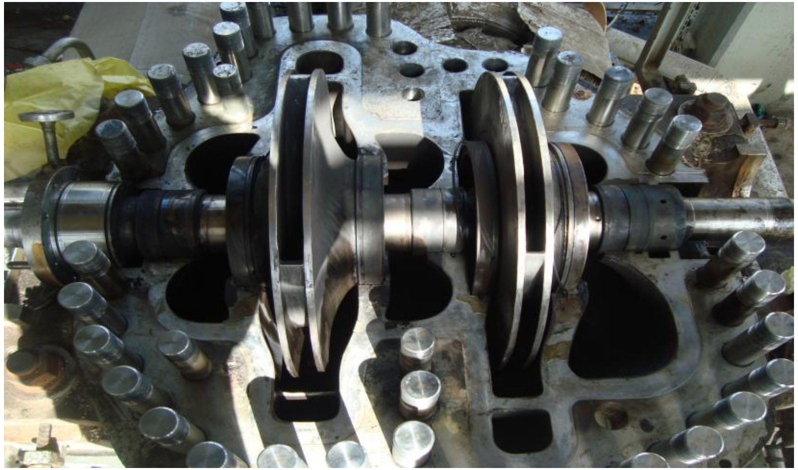

first stage
seconde stage
Drive end smae as NDE
m/c stuffing box area

Pump inspection observations

Huge rub for hydrodynamic journal bearing for DE /NDE
Plus black color in oil for NDE bearing



Inner side casing wear ring
of first stage impeller



Huge rub for casing wear ring of outside second stage impeller with pump casing due rotation for half cycle

DE throat bushing stuck on shaft

Wear in thrust bearings end cover by about 3 mm

Damage of DE Mechanical seal

Deformation in casing housing for DE throat bushing
first stage Casing Wear ring inside

Analysis Method and Steps Taken

- Reviewing all previous available measurements for pump , it is only casing vibration as there is no online vibration system

- Reviewing all previous pump parameters (flow-pressure-temp) also all instrumentation measuring devices are local except flow is online

- Reviewing pump mechanical seal condition parameters (Water seal flush flow – seal temp /pressure)

- Reviewing with operators the previous pump shutdown condition before latest standstill and accident

- Check pump parts as found to get the failure mode sequence and result- that lead to this damage

Observed and catch information

1- The pump was not completely drained before the stand still period since it stopped last time , i.e. formation of potassium carbonate solidification was present.

2- Seal flush flow at DE mechanical seal was nil and appeared to be lost previously (days before) directly during pump shutdown before stand still.

The pump stopped and the seal flow was isolated, so due to pump not drained the potassium carbonate solutions entered the seal faces area of DE mechanical seal and solidified inside causing seal faces damage. After running the pump again mechanical contact occurred for mechanical seal parts leads to melting between DE throat bushing and rotary sleeve of mechanical seal as we discover powder of silicon carbide between them which comes from seal faces damage

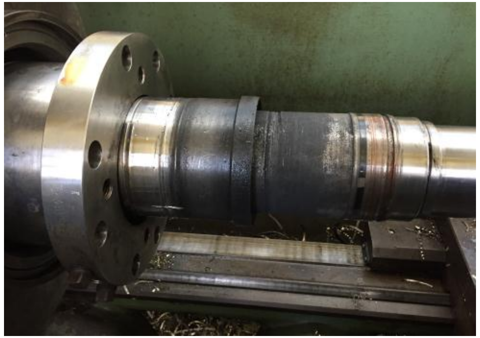
3- High axial movement for the rotor about 3 mm

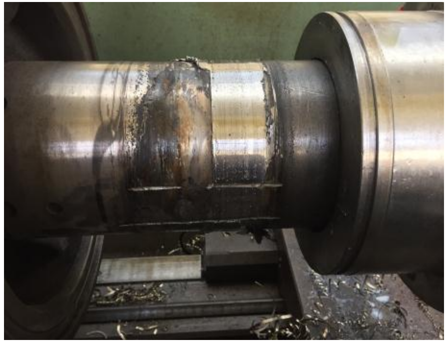
- Huge rub for hydrodynamic journal bearing
- Huge rub for casing wear ring of outside second stage impeller with pump casing; observed half cycle rotation from original location.
- Huge rub for casing wear ring with impeller wear ring and impeller of inside first stage impeller
- Damage for washers of locking nuts for both stages
- Wear in thrust bearings end cover by about 3 mm

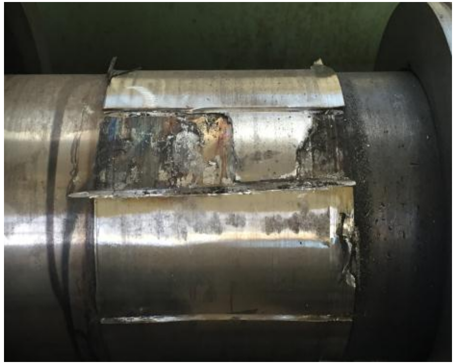
Root cause analysis

The multi stage pump sudden failure occurred due to high axial movement from axial thrust. These are typical effects of Benfield process; it has been proven that uncontrolled forces occur in second stage impellers of solution pumps, due to liquid instability in high pressure environment (gasification, foaming and solidification). The pump used for Potassium Carbonate is very sensitive to temperature as it should be monitored during stagnant periods. The fact that the pump was not drained completely, lead to forming Potassium Carbonate solidification, i.e. when the pump operate again it leads to high axial movement as the fluid pressure established in first and second stage impellers and couldn't out from the pump diffuser due to solidification i.e. unbalance forces acted on rotor, this causes mechanical seal failure and DE throat Bushing stuck with mechanical seal rotary sleeve because of the powder result in failure of silicon carbide face . It also caused wear and damage of casing wear rings and first stage inside impeller wear ring

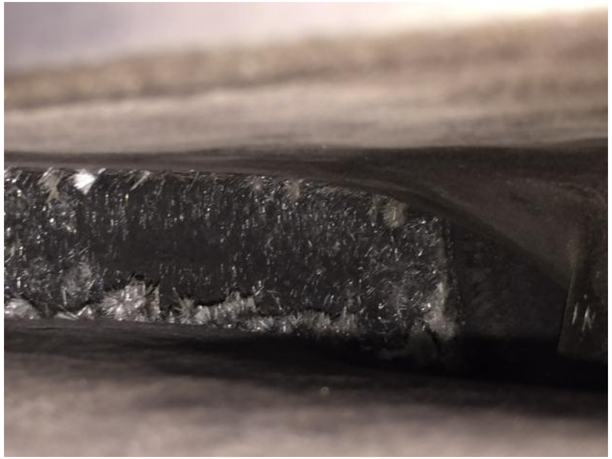
DE Throat Bushing stuck with M/C rotary sleeve







Potassium Carbonate solidification inside impeller



Action and assembly activity

- The rotor parts were assembled and balanced

- The new impeller wear ring of first stage impeller was machined in work shop to get the optimum clearance and size

- All new casing wear rings machined in our work shop to get the optimum size

- The pump casing was deformed in lower and upper parts in two locations. Some machining activity was done for the new DE throat bushing also for inner casing wear ring for first stage impeller. Some lapping was done to get the optimum surfaces established for these items with casing and shaft to get the optimum clearance

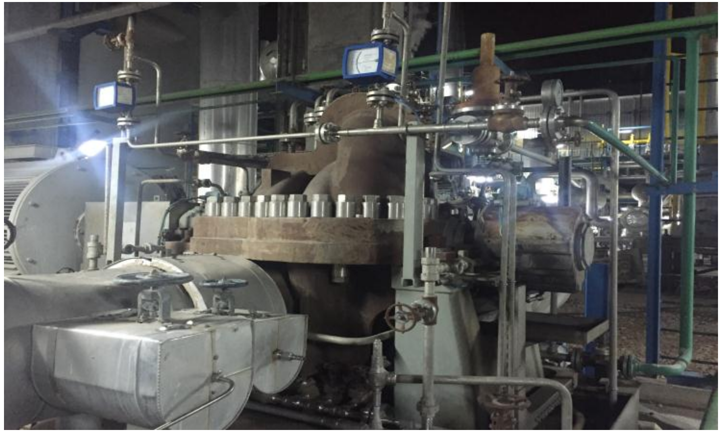
- Assembling the rotor complete with all parts with measuring all clearances , it was all after machining according to standard

- Assembly a new mechanical seal for both DE and NDE according to optimum dimensions

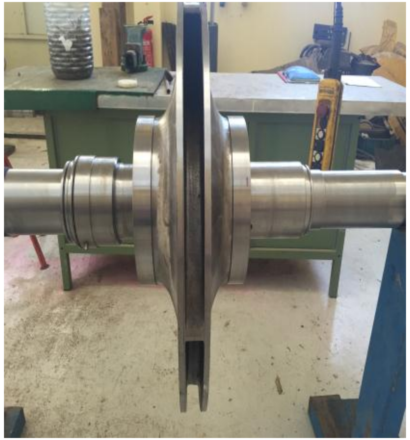
- Assemble a new hydrodynamic bearing with the optimum clearance

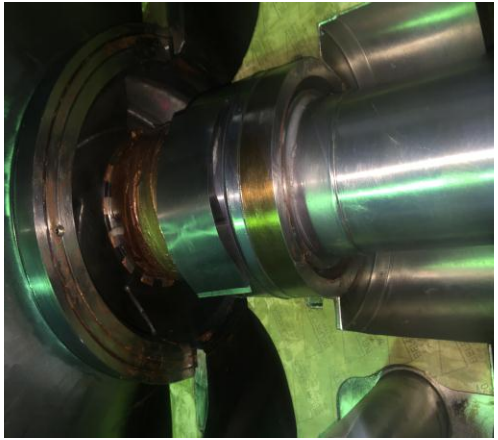
- Assemble a new thrust bearing with the optimum clearance

- Assemble the pump casing

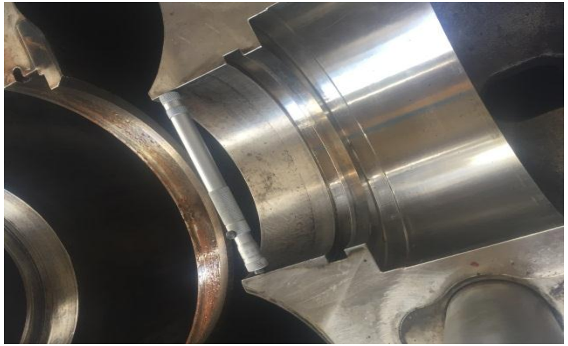
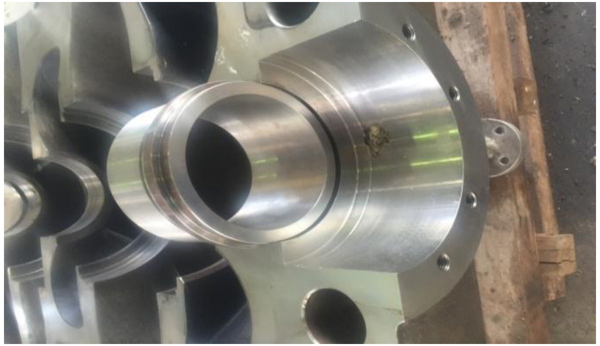


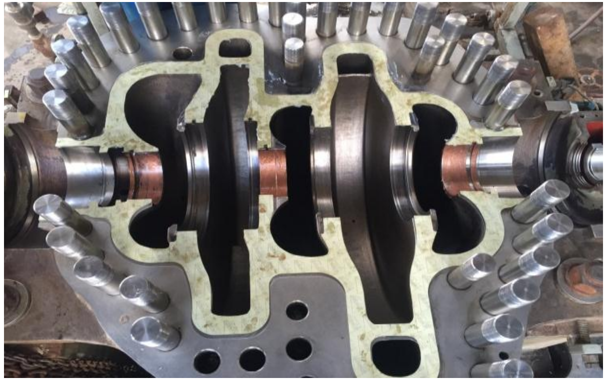
Rotor assembly and balancing , check casing wear rings and throat bushings clearances measuring



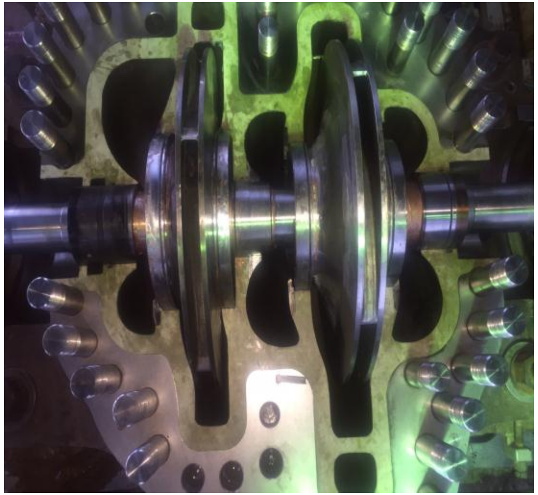
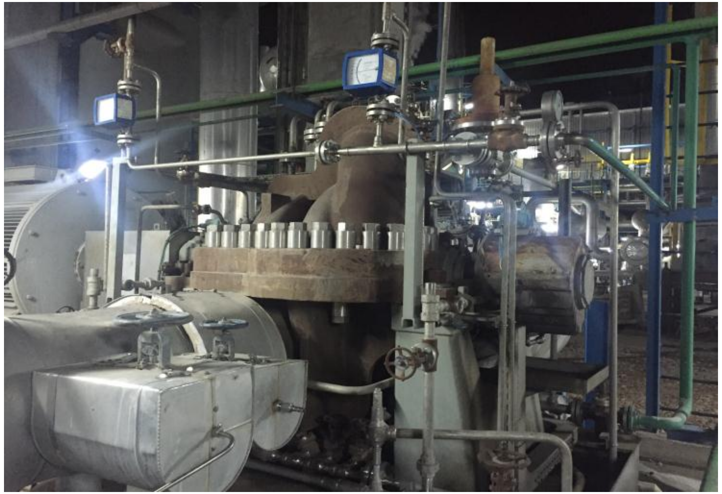


Casing deformation measuring and adjusting upper and lower half with casing wear rings and throat bushings

- Rotor assembly with casing , all clearances (journal ,thrust , casing wear rings and throat bushing final check)
- shaft position check and adjust
- install upper casing and mechanical seal assembly
- install all piping and instrument devices

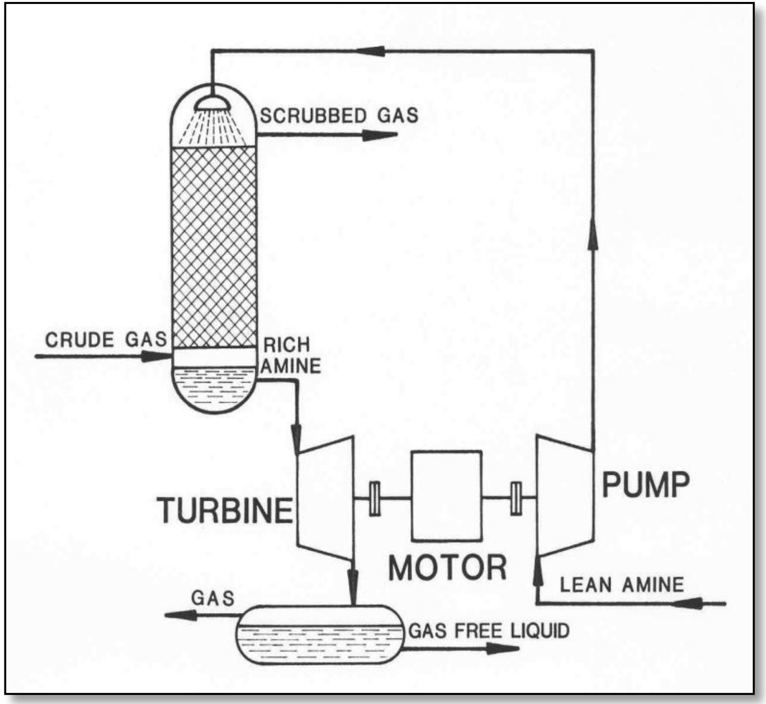
- Preparing the pump and executed all required, inspect all parameters and check it and put it in operation
- The pump in operation since 10-11-2015 with optimum dynamic behavior and condition
- Vibration measurements all in tolerance with max absolute casing value 1 mm/ sec

Pumps in Carbonate Services

Most of flow in fact is subject to SEVERE UNSTABILITY because of variation of status (due mainly to presence of CO_2 gas) around the 2nd stage impeller.

• Easily pumped fluid develops foaming, but also solidification, in an uncontrolled way

• Changes in properties, as well in media density, generate or amplify high frequency pulsation peaks and waves, which are transmitted within media itself, stressing all what is flooded by it (wet areas, impellers in particular)



It should Increase reliability – Solution pump

As the following a check list should increase

- Vibration analysis should be monitored in short periods
- Mechanical seal condition should be monitored continuously especially the seal flush flow as it must be in limits to avoid failure of mechanical seal
- Pump medium condition should be always monitored daily

PROPOSED SOLUTION

• Operating the pump near BEP ; flow angles near impeller and volute angles minimizing the formation of stall and gas release. Typically 80 to 110 % of BEP.
• Strict control of pump operation (IPS – APEX system)

Always ensure draining the pump from potassium carbonate solution

Questions ?