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CHEMICAL METHODS FOR PROCESSING PLANTS MACHINES SLAG CLEANING

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ABSTRACT

Paper deals with slag formation in compressors and applicable measures to prevent it. Mechanical and chemical depositions cleaning are discussed and evaluated. Technology for its elimination under application of chemical agents is presented in details. In conclusion regulations for safety operations with acids and alkali has been formulated.

SLAG PROBLEM IN SOME PROCESSING PLANTS' MACHINES

Compressed air for some subsidiary technological procedures in ore processing plants is required. For that reason compressors for low pressure are used. Processes with great amount of heat liberation take place in such machines and need for cooling arose consequently. Cooling is a process of heat transfer from hot walls and maintaining the temperature in special limits. More often water is applied as cooling liquid and as a result on pipelines and machines walls hard depositions are accumulated which cause difficulties in normal cooling process. It can be worsen so severe that the temperature of exit compressed air can reach 190-200°C (in comparison with maximal admissible – 170°C). This circumstance could be precondition for explosion if hot residue particles from vacuum valves burn oil deposits. This could become accidental situation with high-risk degree for workers and equipment.

In the processing plant "Elatzite – med" JsC, village of Mirkovo near Sofia are used traditional piston compressors as well as special compressors for air conditioning system, which role is to maintain constant temperature for computer remote control center. From there technological parameters and processes are controlled remotely. Both types of compressors operate in continuous regime that make the problem discussed in this paper immediate and topical.

Information about slag

Many soluble types of brine make slag depending on their type. For instance calcium bicarbonate $Ca(HCO_3)_2$ make soft depositions, while calcium sulfate $CaSO_4$ – hard one.

Main reason for slag formation is separation of less soluble brines from their saturated solutions in case of temperature increase. Little increase in water temperature is enough to evaporate little amounts water and saturated solutions in regard to calcium and magnesium bicarbonates - $Mg(HCO_3)_2$, due to their little solubility.

According to its chemical composition slag could be classified as:

- Carbonates consisting more than 50 % $CaCO_3$;
- Gypsum – up to 50 % $CaSO_4$;
- Silicates – over 25 % SiO_2;
- Mixed – consisting calcium and magnesium carbonates and silicates.

Water ability to form slag is called water hardness and is due to soluble in it brines of calcium and magnesium.

It is well known that slag heat transfer coefficient is several times less compared with steel and cast iron - material of cooling walls. By that reason even in presence of thin deposition layer cooling efficiency decrease rapidly.

PRETPEATMENT OF WATER FOR SLAG FORMATION PREVENTION

Several methods for water treatments are known, based mainly on reagents adding into it. These reagents hamper crystallization processes or change concentration of soluble elements. Such treatment is reasonable only if the water is turnover and the process is linked with cooling towers construction. Recent practice in processing plants show that pretreatment of water is not profitable and that is why industrial water is used there.

METHODS FOR SLAG ELIMINATION FROM MACHINES, COOLERS AND PIPELINES

Accumulated depositions on cooling systems' walls can be eliminated either in mechanical or in chemical way.

Mechanical way

This method requires disassembling operations in order to ensure access to the accumulated slag. Mechanical removal means to scrape off the residue with steal scrapers and wire brushes at reachable places. In practice such surfaces are very limited in number. That is why mechanical way is not applicable for full cleaning especially at hard to reach places. There exist another problem – a risk to damage the metal in thin walls installations.

Chemical way

Slag is eliminated by solving with appropriate reagents such as hydrochloric acid, chom acid, alkaline, natrium fosphatus etc.

Acids are applied to carbonate depositions, while the alkaline – for sulfate or silicate ones. The action of such chemicals transforms the slag into slurry by its shagging. Reagents effect is achieved by circulation of the chosen solvent or by its presence for certain time inside the equipment. Special supplements called inhibitors are added in order to prevent metal walls from corrosion. These are substances able to slow down or prevent metals from corrosion in aggressive acid environment.

SLAG ELIMINATION FROM COMPRESSOR WITH HYDROCHLORIC ACID

Conditions forcing cleaning

In the process of compressor operation when:

- Water is sufficient and its outlet temperature is 30-35°C;
- Compressed air outlet temperature precedes the norms (170° C) with 8-10°C

these are serious indirect arguments for bad cooling due to slag accumulation. Cleaning is requirement. Its postponing will lead to further depositions formation and even more difficult removal afterwards.

Technological operations required by chemical cleaning of slag are discussed below.

Cooling system disassembling

Compressor is normally cooled at the following places: cylinder water mantel from I-st degree, intermediate cooler between II degree and cylinder water mantel II degree and I. More often low-pressure compressors (mainly such types are used in processing plants) are linked in one cooling system, where water is supplied. That is why disassembling of pipelines, joining these areas, need to be done as first operation. Then the coolers and cylinder mantels covers are removed. Outside inspection of these spaces is performed and washing with water through hose with pressure 0,1-0,2 MPa in order to wash out mechanical and oils depositions, sands etc.

Taking samples for depositions tests

Samples from cleaned water mantel (cooled space) mechanical depositions are taken in order to test its composition. This is required only at first cleaning of equipment. Such sampling is not obligatory in further cleaning if water composition has not been change and no reason for slag structure changing exists.

Depositions analysis predefines reagent usage. Our research shows that slag is mainly with carbonate composition, which lead to hydrochloric acid (HCl) application for its cleaning.

Technical means for cleaning

Equipment needed for this action are: containers for solutions, electrical pump, hoses and tabs, as shown on fig. 1.

Container 1 serves as place to make the solution. Ordinary 200 l barrel with removed upper cover can be used.

Container 2 is similar to 1, but at its lower part tab 3 for slurry discharge and tab 4 (link between barrel and pump) are mounted.

Pump 5 is normal centrifugal pump and there is not need to be acid-proof. Its motor is one phase electrical unit.

Hoses 6 and 8 are with diameter $1\frac{1}{2}''$ or $2''$.

Preparation of solutions

If the reagent has been already chosen (in our case hydrochloric acid, it is needed to define its concentration. References show that carbonate slag are removed by application of 2 to 12% hydrochloric acid water solutions. Hydrochloric acid concentration depends on metal wall depth of cooling space and on depositions depth. Design requirements for water mantels depth are serious (over 10 mm) and by that reason solutions with great concentration can be applied (10÷12 %). When cleaning of intermediate cooler, built from sheaf of pipes with wall depth of 2 - 2,5 mm, hydrochloric acid concentration should be less - 4 - 5 %.

Optimal concentration depends also on slag depth. Depositions with great depth should be treated with less concentration but with great time duration. Higher concentration of acid lead to strong chemical reaction, to big particles elimination which hamper circulation of cleaning liquid. Pipes from intermediate cooler are very narrow, which predefines thicker slag layer and consequently application of solution with less concentration.

Hydrochloric acid is produced with 37% concentration. In order to count how much acid with appropriate concentration should be ordered simple calculations should be done. For example 100 l water solution with 5% hydrochloric acid concentration should be made by adding 13,5 l hydrochloric acid (37%) into 86,5 l water.

Acid is added to water gradually under constant mixing

Different inhibitors are added to thus prepared solution. Composition and quantity of these substances are chosen under technical and economical reasons. When cleaning procedure is performed for installations with thick walls higher concentrations should be used and vice versa. Our research shows that application of inhibitor Urothropine is very appropriaate in dosage of 10 g per 1 l solution for cylinder mantel cleaning and 25 g per 1 l for intermediate cooler.
Solution amounts depend on cooling space volume need to be cleaned.

Cleaning technology

It is recommended that slag cleaning should start from that cooling space where lowest concentration is required, in our case intermediate cooler. The purpose of this is in case some amount hydrochloric acid remains unused to be applied for next objects.

Slag cleaning can be performed in two ways:

- Filling of whole cooling space with solution and its remaining there for 10-12 hours;
- Solution is constantly added into the space by pumping (circulation way of cleaning).

Advantages of the second method (circulation) are out of any doubts and such technology is strongly recommended.

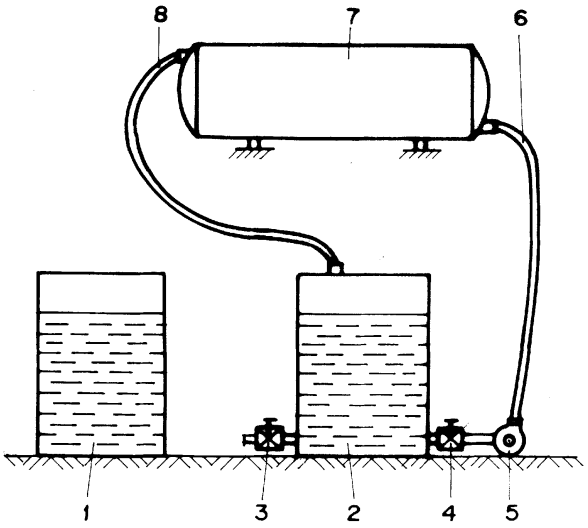

Figure 1.

Depositions cleaning itself is shown on figure 1 on the example of intermediate cooler. Into reservoir 2 needed solution (120-150 l) are added and by pump 5, hose 6, cooler 7 and hose 8 continuous solution circulation is achieved, which consequently lead to slag cleaning. Regularly solution status is tested. If the solution forms foam the process is in normal condition. In case foam forming stops it can mean one of the following:

- Slag is eliminated and the cleaning is over;
- Hydrochloric acid is spent out, but still there is slag remaining on the walls.

Testing of cleaning process is performed in the following way. 40-50 ml from cleaning liquid are pour in a glass and several drops of 10 % argenium nitrate solution are added. If white depositions appear it is certainly that hydrochloric acid has not been spent off completely and slag has been cleaned. The absence of white deposition shows that the acid has been spent off and cleaning should continue with new amounts of solution.

Duration of cleaning operation depends on several factors and normally prolong 3-4 hours.

Washing of cooling space

On end of cleaning process solution is collected into the vessel. If whole hydrochloric acid has been utilized the solution is drained into wastewater canals. If some acid has not been used the solution is further applied for preparation of other cleaning solutions.

The vessel is cleaned with flowing water, which with slurry drains out through tab 3. After washing the vessel is filled with technical water and by pump for 15-20 min washing of cooler is in progress. On the end of washing procedure some sodium alkaline or caustic lime solution is added so that neutralize acid remains on walls.

Slag cleaning from cylinder water mantels and from water transporting pipelines, water reservoirs etc. is performed in similar way

LABOR SAFETY IN SLAG CLEANING CHEMICAL TECHNOLOGIES

Great amounts of acids and alkaline are used in such technologies that impose serious requirements for safety operations. Some specific rules are:

- Acids concentrates are transferred from one vessel to another through siphons with rubber pump and tab placed on the vessel. Pouring out of acid should be done regularly and only $\frac{3}{4}$ of vessel volume is filled;
- Dilution of concentrated acid is performed by adding the acid into water;
- Plastic gloves with long cuffs and safety glasses should be ware always for acids are highly mordant;
- Acid solutions are drained only after their dilution.

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