High-Efficient Methods of Heat-Exchangers Cleaning

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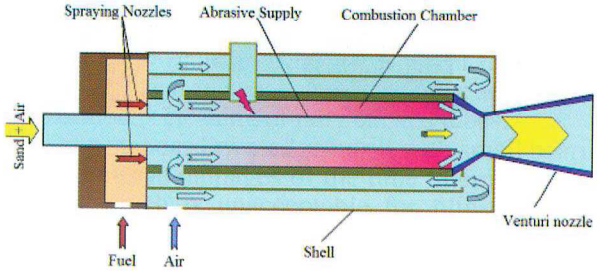
Technical specialists of R&D Institute of Urea started developing solutions for heat-exchange equipment cleaning due to the process conditions breaks at urea plants, corrosion phenomenon and mechanical damages of heat-exchange equipment caused by faulty cleaning of heat-exchange equipment.

Currently R&D Institute of Urea succeeds in the following cleaning methods:
1. Thermo-abrasive blasting (TAB);
2. Vortex blasting;
3. Chemical cleaning (by ortophosphoric acid);
4. Ultrasonic cleaning;
5. Electro-hydro-mechanical cleaning(EHMC);
6. Hydrocleaning;

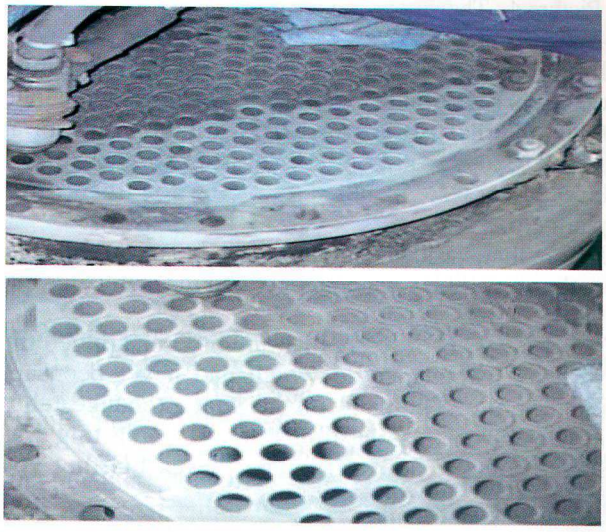
The cleaning methods are described in detail below.

Thermo-abrasive blasting (TAB)

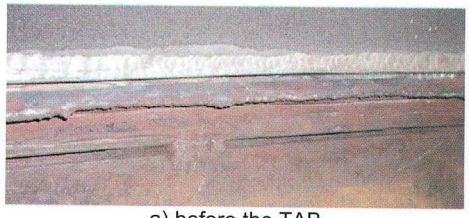
The TAB method is successfully applied for removal of the scales formed on the tube internal surface of the heaters at urea and ammonia plants during their operation and also for removal of fouling and asphaltene deposits of the heat-exchange tubes at petroleum plants. TAB method enables cleaning of the full-length tube surface to bare metal. Using the TAB method due to the abrasive media heating up to 900 0C at the thermo-abrasive blaster outlet (Picture 1) and high exhaust speed of the abrasive particles, a better surface cleaning is achieved (Picture 2) than when standard sand blasting methods are used. Besides, the TAB method takes less time and abrasive medium. The TAB method can be applied not only for heat-exchangers cleaning, but for other equipment cleaning as well (Picture 3).



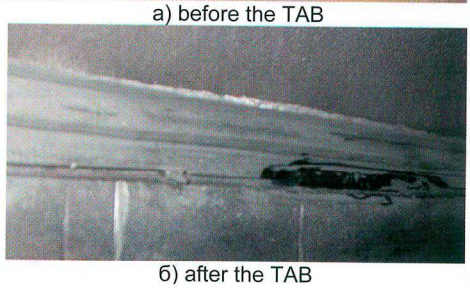
Picture 1 з Thermo-abrasive blaster



Picture 2 з Heat-exchanger tube sheet. The difference between the cleaned and uncleaned areas is obvious.



а) before the TAB

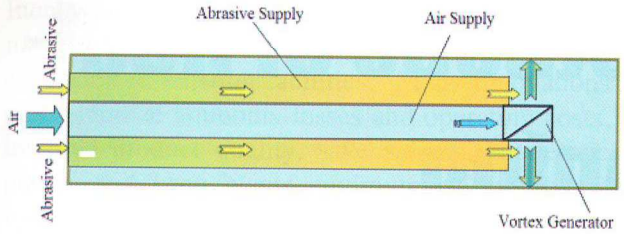


б) after the TAB

Picture 3 - Area of the lining weld-seam cleaned from rust by the TAB method in order to produce high-quality weld-seam during the urea synthesis reactor repair.

2. Vortex blasting

The method is applied for removal of brittle scales. The operation principle of the vortex blasting is the following: at the air line outlet an air-eddy is formed with high rotational velocity where the abrasive sand is supplied (Picture 4). The sand is being thrown onto the heat-exchange tube walls with high-power pulse. The scales are broken away, grinded from the walls and blown out.

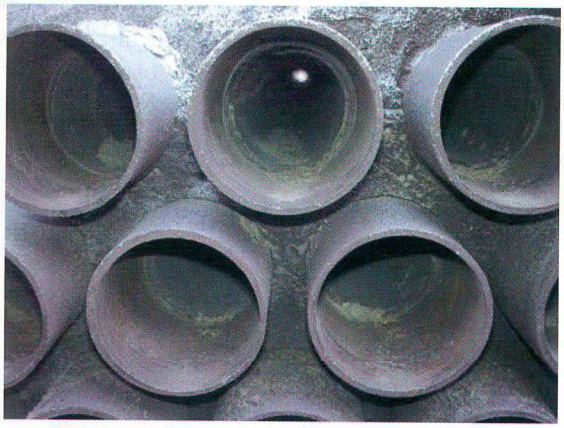


Picture 4 : The vortex blasting operation principle

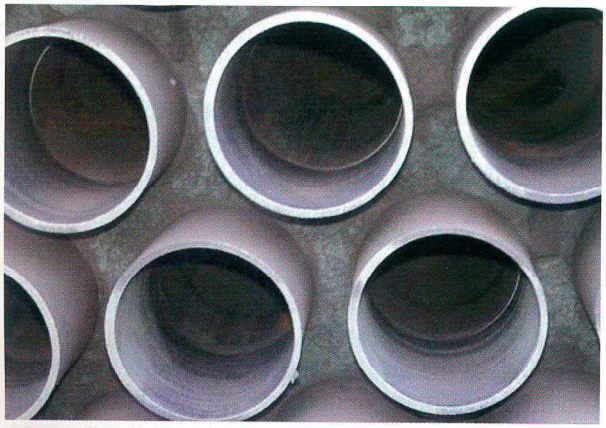
In September 2010 the specialists of R&D Institute of Urea performed blasting of the heat exchange tubes internal surface of MP distillation heaters at Acron (Novgorod) with Snamprogetti technology before they were installed into the second-hand urea plant No. 5

Before that, various companies tried to clean the heat-exchangers by HP water supply and mechanically, but failed.

The specialists of R&D Institute of Urea applied the vortex blasting method which had never been applied before. The state of the heat exchange tubes in heaters pos. T-504 after the vortex blasting was satisfactory. The results of the vortex blasting you can find in Picture 5.



a) Heater í-504(2) before the vortex blasting, scales thickness : up to 4mm



b) Heater í-504(2) after the vortex blasting
Picture 5 : Results of the vortex blasting

3. Chemical cleaning

Chemical cleaning by ortophosphoric acid is applied in case if the long heat-exchange tubes (over 6 m) with small ID (under 10 mm) have deposits. Mechanical cleaning can result in tube perforation.

The operation principle consists in washing of the heat-exchange section with ortophosphoric acid solution. In highly acid medium partial dissolving of the deposits takes place, the undissolving deposits become loose and peel off as sludges. The cleaning rate is being controlled by increase of iron concentration in the washing solution. When concentration of iron ions is stable, the washing is being stoped.

The chemical cleaning method has been applied at urea plants for a long time and is widely used for heat-exchange tube bundles of the condensers in distillation sections based on Tecnimont technology and heat-exchangers of the evaporation section based on Snamprogetti technology.

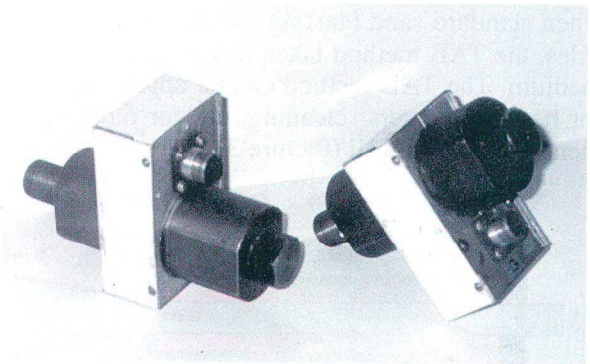
4. Ultrasonic cleaning of the operating unit

Ultrasonic cleaning method is based on excitation of ultrasonic small-amplitude vibrations in heat-exchange equipment and in liquid heat transfer medium. The vibrations

prevent deposits on the heat exchange surfaces caused by liquid heat transfer medium;

reduce thickness of the wall laminar layer which intensifies the heat-exchange process.

The wave propagation systems specially developed for vibrations excitation and welded to the equipment outer surface (for ex. to the tube-sheet side) ensure introduction of ultrasonic waves into the heat-exchange equipment. In this case re-reflection and diffusion are not typical for the method (Picture 6). It helps to achieve the required process effect when the method is applied while the systems are rather small and not heavy and the power consumption is low.



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b) mounting of the vibrations generator onto wave guide

In 2010 at ammonia sulphate unit K-2 at Azot (Cherkassy) the ultrasonic cleaning system was tested at circulation high-speed heater for ammonia sulphate pos. 5302/1.

The test aimed at demonstration how to prevent adhering of ammonia sulphate crystals on the metal while the crystallization unit operating with oversaturated process solutions was running. During the ultrasonic cleaning the operation modes of the heater and ammonia sulphate circulation pump significantly changed:

- the strength of current consumed by electric motor of the circulation pump reduced from 92 A to 80-82 A;
- formation and increase of the crystals in the crystallizer intensified;
- the temperature difference ("t) of ammonia sulphate solution before and after the heater reduced from 5-6! ë to 3~4oc which means optimization of the circulation process;
- the system enabled reduction of the adhesive process in the unit.

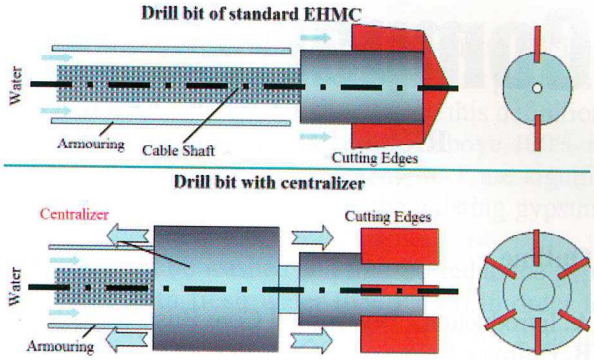
Based on the ultrasonic cleaning results Azot (Cherkassy) purchased three devices for ultrasonic cleaning.

5. Electro-hydro-mechanical cleaning (EHMC)

The EHMC method is applied for removal of scales formed by the salts of various hardness and process scales in the tubes internal surface of condensers, boilers and various heaters. The EHMC method is based on torque transfer from electric or pneumatic unit by means of flexible shaft to a special device which goes through the tube breaking off and simultaneously washing away the scales making the internal tube surface absolutely clean and not damaging it. The advantage of the method is cleaning of fully choked tubes.

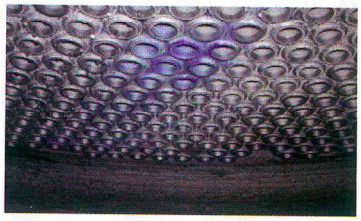
Use of a standard two-edged drill with small bearing area results in damages of the tube internal surface, cut-ins which is unacceptable for film-type units. Besides, the scales in heat-exchangers of the 1st distillation stage at urea plants are very hard and standard drills are not used in such conditions.

Therefore special multi-edged drills with a centralizer and increased bearing area were developed to clean heat-exchangers of the 1st distillation stage which enable scales removal (Picture 7).



Picture 7 ; Standard dill VS multi-edge drill

In 2010 the heat-exchange tubes of HP stripper pos. E-201 at Odessa Port Plant (Ukraine) were cleaned by EHMC method (Picture 8). 30 % of the heat exchange tubes were cleaned due to the time limitations. Notwithstanding the fact, due to the achieved high heat-exchange efficiency, the plant capacity enhanced by 50 TPD (4 % increase).



Picture 8 - Cleaned heat-exchanged tubes of the stripper

6. Hydrocleaning

The method is based on the water jet blow to the deposits. The water flow washes away the deposits from the metal surface. The method is generally used for cleaning of the mud deposits of any thickness in water recycle vessels (Picture 9).

Picture 9 Cleaning of the heat-exchanger shell-side by HP water supply

Conclusion: Reasonable application of various cleaning methods depending on the operation conditions enable the following:

1- preservation of the heat-exchange tube internal surface which is very important for the film formation in vertical film-type heat-exchangers and has an impact on both process parameters and corrosion phenomenon;
2- removal of the deposits which is impossible with standard methods;
3- economic benefits, especially in case of steam saving (cleaning of HP stripper);
4- cost efficiency of the plant due to enhancement of the plant capacity caused by heat-exchange process improvement.