Prevention of Fouling and Incrustation on Heat-Transfer Surfaces

Organic and inorganic deposits, scale, and other corrosive substances cause dangerous fouling on the interior and exterior tube surfaces of tube bundles, primarily in the cooling water area. Such fouling promotes corrosion on the tubes' surfaces, and incrustation quickly undermines the efficiency of tube bundles, or causes units to fail completely. Production processes are disrupted, making expensive repairs and re-tubing of the bundles necessary.

The damage from such fouling is costing refineries and petrochemical and chemical plants billions of dollars each year - a rising trend.

Fouling has a number of causes. The most common types of fouling that are particularly dangerous and conducive to corrosion and incrustation are biological fouling, which is produced by living organisms such as algae, mussels, and microorganisms settling on the tube surfaces, and coking fouling, which is produced by the chemical reaction of solid residues such as oil sludge, salts, and dirt particles, and is one of the most problematic type of fouling. Apart from the biological, chemical, or physical causes of fouling, the flow velocity and the operating temperatures are additional determinants.

Fouling impedes the heat transfer of tube bundles, with capacity being an important parameter. At the design stage of tube bundles, the so-called fouling factor is taken into account. This is the reason that the capacity of the tube bundle has to be increased by up to 20%, depending on the water quality. This approach, of course, incurs additional costs. Tube surfaces become incrusted from fouling, while corrosion to the tube material intensifies. Operators must regularly clean the tube bundles so that the unit can continue to function. The length of the cleaning intervals depends on the amount of deposits accumulated in the tube bundle. Cleaning a tube bundle is particularly costly and time-consuming if incrustation must be removed. In many cases, the unit must be taken out of the plant and be transported to a repair site where it can be re-tubed, which constitutes a considerable cost factor for operators.

Some cleaning cost figures published by refineries in Saudi Arabia, Korea, and southern Italy confirm the high cleaning costs caused by fouling and incrustation. The annual total lies between US$8 and $20 million. depending on the capacity of the refinery. The figures for each heat exchanger range from US$30,000 to $40,000 per year. Under these conditions, treating the heat exchangers with a heat-cured coating is a better alternative and a more economical solution.

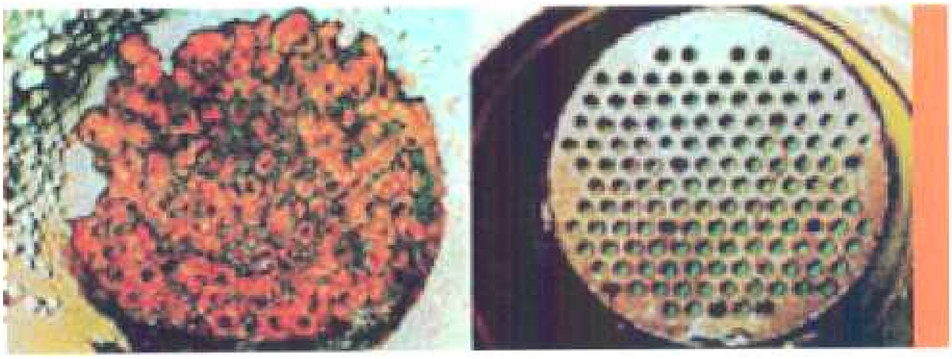
Because of heavy fouling, the units have to be built over-sized, again involving considerably higher investment costs. Although the stronger flow velocity induced by incrustation may remove some of the deposits, it also reduces the cooling performance and thus the efficiency of the tube bundles.

Fouling and incrustation can be reduced by changing the flow velocity, the kind of cooling water, and the quality of other materials. Hence, by adjusting these parameters, the designer can economically optimize a tube bundle.

Technical alternatives offer some chance of reducing fouling, but can never prevent it.

Thermal coating of the tube side of the tubes and, in some cases, the shell side prevents fouling and incrustation to the tube bundles over the long term. Thermal coating obviates the need to take flow velocity, pressure drop, tube surface temperature, and materials into special consideration. These are factors those influence fouling in uncoated tube bundles and those ordinarily have to be considered at the design stage. The only condition is that flow velocity be kept at 1.5–2.5 m/sec.

without and with SÄKAPHEN



Carbon steel can be used as a better, more economic alternative in coated tube bundles.

The following explains why thermally coated tube bundles are essentially superior:

The heat-cured coating is applied in a flooding process, in 6–8 individual layers, each of which is pre-cured at temperatures between 120 and 150°C in special polymerization furnaces. After the last individual layer is applied, final curing is carried out at 220°C. With this coating technology, a homogenous, hydrophobic, rigidly elastic, and non-porous surface of a total thickness of 180–200 µm can be achieved. The coated tube floors and surfaces are inspected with measuring probes. Due to the low total layer thickness, the slightly (7%) reduced heat transfer coefficient can be disregarded in the specification and design of tube bundles (no fouling factor), especially since the heat transfer in uncoated tube bundles can significantly deteriorate due to fouling or incrustation, even after a short period of operation. Furthermore, the friction resistance for flowing media is reduced as well.

2. The heat-cured coating materials Si 14 E and Si 57 E—duroplastic polycondensates that we have developed in-house—are highly anticorrosive against all kinds of water, including sea water and brackish water, and against many chemical media, at temperatures up to 200°C. This high temperature resistance is the result of a special heat-curing process applied to the protective coating.

These heat-cured coatings, which have been used for more than 50 years, are also resistant to many aggressive media.

Depending on the particular type, heat-cured coatings are physiologically harmless, pressure resistant, and can be exposed to continuously high temperatures.

These heat-cured coatings are used in the oil industry, in the petrochemical and chemical industry, in fertilizer plants and in pharmaceutical industries as well as in the food producing and processing industry.

This heat-cured coating technology can reduce investment and operating costs by a significant margin.

in July, 2005

SÄKAPHEN GmbH

complete copy of „Prevention of Fouling“ – HYDROCARBON PROCESSING July 2005

막힘, 부착방지와 열전달 표면

열전달표면의 오염물 부착 및 스케일 방지

침전물이나 스케일 및 다른 부식성 물질들은 이것들이 유기물질이던 무기물질이던 관계없이 기본적으로 냉각지역에서 튜브경판의 튜브표면 내,외부에 위험한 Fouling을 일으킨다. 그러한 오염물 부착, 막힘현상은 튜브표면의 부식을 촉진하고 튜브경판의 효율을 급속히 저하시키거나 장치가 완전히 못쓰도록 한다. 생산공정이 중단되고 수리비가 많이 들거나 열교환기 튜브교체를 요구한다.

이러한 Fouling으로 인한 손실은 정유공장, 석유화학공장, 화학공장들이 매년 수조달러의 비용을 들게 하고 있으며 그 비용 또한 증가추세이다.

Fouling은 원인이 여러가지이다. 특히 위험하고 부식과 스케일을 잘 일으키는 가장 흔한 Fouling 형태는 생물학적 Fouling이다. 이것은 튜브표면에 서식하는 미생물처럼 유기체로 살면서 생기는 것과 오일슬러지, 소금 및 기타 더러운 입자들과 같은 고체찌꺼기들의 화학반응에 의해 생기는 coking Fouling이다.
Fouling의 생물학적, 화학적, 물리적 원인은 놔두고라도 유속과 운전온도도 Fouling을 일으키는 결정요소이다.
용량이 열전달의 중요한 변수가 되듯이 Fouling은 튜브경판의 열전달을 저해한다. 튜브경판을 설계할 때는 Fouling인자로 인한 열효율 저하를 감안해야 한다.
튜브경판 용량은 수질의 영향을 받음으로 인해 20%까지 크게 설계되어야 한다. 이것은 역시 생산비용을 올리는 결과를 초래한다. 부식이 진행되는 동안 튜브표면은 Fouling으로 스케일이 된다.
작업자는 기계가 계속 운전이 가능하도록 정기적으로 청소해야 한다. 청소주기는 튜브에 축적된 침전물의 양에 따라 결정된다. 만약 튜브표면에 물때를 제거해야 되는 경우 많은 비용과 시간이 소요된다.
많은 경우 튜브를 교체 할 수 있는 장소로 기계를 운반해야 하고 이것은 적절한 인건비가 소요된다.

사우디아라비아, 한국, 이태리의 정유회사들이 발행한 크리닝 비용 자료에 의하면 오염이나 찌꺼기로 인한 크리닝비용이 많이 든다는 것을 나타내고 있다. 연간 크리닝비용은 정유공장 규모에 따라 년간 8백만달러에서 2000만달러가 소요된다. 년간 열교환기 1대당 비용은 3만달러에서 4만달러가 소요된다.
이런 조건이라면 열교환기를 열처리가류 코팅 하는 것이 훨씬 더 경제적인 해결책이 된다.

Fouling이 심하여 기계용량을 크게 제작한다면 투자비용이 증대되는 결과를 가져온다.
스케일 때문에 유속이 더 빨라져 일부 침전물을 제거 할 수 있을지라도 그것은 역시 냉각성능을 떨어뜨리고 그럼으로 인해 튜브경판의 효율을 감소시킨다.

유속, 냉각수종류, 튜브재질 등을 변경하여 Fouling과 스케일을 줄일 수 있다 그러므로 이들 변수를 잘 조절하여 기계설계자는 경제적으로 튜브 경판을 만들 수 있다.

이런 기술적인 방법은 어느 정도 Fouling을 줄 일 수는 있지만 결코 방지하지는 못한다

튜브 사이드와 경우에 따라 Shell 사이드에 열처리 코팅을 하면 튜브경판의 Fouling과 스케일을 방지할 수 있다.
튜브를 열처리 코팅하면 유속, 압력강화, 튜브표면온도, 재질 등을 특별히 신경쓰지 않아도 된다.
이것들은 코팅이 되지 않은 튜브경판의 Fouling에 영향을 주는 인자로써 통상 열교환기 설계단계에서 고려되어야 하는 것들이다.
유일한 조건은 유속이 1.5 ~ 2.5m/sec로 유지되는 것이다.

일반튜브관과 사카팬코팅처리 튜브관의 비교

튜브코팅에 있어서 카본스틸을 사용하는 것이 훨씬 경제적인 대안이 된다

다음은 열처리 코팅 튜브관이 왜 본질적으로 우수한지를 설명한다

1. 가열가류코팅은 6 ~ 8 층으로 된 Flooding 공정에 적용되고 각 단계마다 120 ~ 150℃의 중합로 속에서 예비가류가 된다.
   최종코팅이 끝난 것은 220℃에서 마지막 가류를 한다. 이렇게 코팅된 것은 전체두께가 180 ~ 200㎛인 균일하고 유연하고, 비 다공질인 표면이 얻어진다.
   코팅한 튜브 Floor와 표면은 측정 probe로 측정한다. 전체코팅 두께가 스팩보다 7% 이내일 경우 열교환기 사양과 설계시 열전달 계수는 무시해도 된다. (Fouling 인자는 고려대상)
   특히 코팅을 하지 않은 튜브관의 열전달은 Fouling 이나 스케일 때문에 현저하게 떨어질 수 있으며 사용을 얼마하지 않았더라도 유체에 대하여 마찰저항도 마찬가지로 감소한다.

2. 우리는 해수, 염수를 포함하는 모든 종류의 물에 높은 내식성이 있고 많은 화학매체, 200℃ 온도에서도 높은 내식성을 가진 Duroplastic Polycondensates 인 가열가류코팅제 Si 14E 와 Si 57E 를 개발했다. 방식코팅에 적용된 가열가류공정을 거친제품은 내열성이 높다.

50년이상 사용한 이들 가열가류 코팅제품들은 역시 많은 부식매체에 대해서도 저항성이 있다.

이러한 물질들은 생화학적으로 무해하고, 고압에 잘 견디며, 고온에서도 높은 저항성을 발휘한다.

이들의 고온열처리코팅 제품들은 정유산업, 의약산업, 화학산업, 비료산업, 식품산업에서 널리 사용된다.

가열가류 코팅기술은 투자비용과 가동비용을 줄이는 이익을 가져다 준다

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above atmospheric. Thus, compression for re-injection conditions is favored.

The feed steam is mixed with steam and sent to the top of the novel steam reforming heat exchanger/reactor. Endothermic heat from the steam-reforming reaction is provided as exhaust gas from the gas turbine. The up-flowing hot gas passes counter-currently in the shellside of the reactor/exchanger against down-flowing reaction feed vapor. On exiting the exchanger/reactor, the very hot reactor effluent is partially cooled to the inlet temperature by quenching with boiler feed water, which vaporizes to provide additional water for the shift reaction.

The hot mixture is sent to a second heat exchanger reactor for the shift conversion of CO to more hydrogen and CO_2. As in the steam reforming reactor, the vapor feed is sent to the top of the exchanger and distributed down multiple vertical tubes filled with shift-conversion catalysts. The shift conversion is slightly exothermic and requires heat removal to maintain isothermal conditions. The hot shift converted effluent is free of CO and is cooled before being sent to the CO_2 separation section.

After the shift-conversion step, water and CO_2 are removed from the synthesis gas via refrigerated methanol solvent. The recovered CO_2 is dry and can be compressed and exported.

The HyGenSys process can be incorporated into a gas-to-liquids unit as the steam-methane reforming step. Final processing products are hydrogen, ultra-clean transportation fuels and electrical power.

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Mitigate fouling by applying new surface coating

A variety of organic and inorganic deposits, accumulating as scale and other corrosion products, can cause dangerous fouling on the interior and exterior of heat exchanger tube bundles. This condition is especially prevalent for those units in cooling water service. Advanced corrosion on the tube surfaces results in rapid deterioration of heat-transfer efficiency and possibly failure of the exchanger tube bundle.

Anticipating fouling of heat transfer equipment often requires incorporating a fouling factor into the unit sizing. Consequently, heat exchangers in exceptionally dirty service are oversized in anticipation of lost heat-transfer efficiency. Depending on water quality, the exchanger can be sized 20% due to fouling conditions.

However, technical alternatives are claimed to mitigate fouling of tube surfaces. SÄKAPHEN GmbH offers a long-term solution to fouling and incrustation of tube bundles through a thermal coating of heat exchanger tube bundles. In some cases, coating the shell side is applicable. This new thermal coating does not impact flow velocity, pressure drop, tube-surface temperature and materials. Coated carbon steel can be an attractive construction material option for heat exchanger service.

The heat-cured coating is applied in the flooding process, in six to eight individual layers. The coating is cured at 120°C to 150°C in special polymerization furnaces. On the last layer, final curing is done at 220°C. The coating achieves a homogeneous, hydrophobic, hard-elastic and non-porous surface with a total thickness of 180 µm to 200 µm.

The coated tube floors and surfaces are inspected with measuring probes. Low thickness of the coating has a minor impact on the heat transfer coefficient and can be disregarded when sizing the exchanger.

The coating material is a composition of Si 14 E and Si 57 E, which are duroplastic polycondensates. This material is highly anticorrosive for all water types including seawater and brackish water and chemical media at temperatures up to 200°C. These coatings have been used in the petrochemical and pharmaceutical industries.

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High-speed particle imaging and analysis system

Fluid Imaging Technologies has a new particle analysis system, FlowCAM Benchtop II. It takes high-resolution digital images of individual fluid-borne particles, measures particle size, length, width, shape, fluorescence and other parameters, and also records the data in an interactive scattergram for instant display and analysis.

The instrument uses a high-speed imaging technology and digital firewire camera. It is claimed to capture detailed digital images of every particle sample while also providing an advanced array of traditional particle analysis tools.

FlowCAM Benchtop II automatically collects and stores each particle image in a digital library. During analysis, the technology permits integrating images with the corresponding data for instant cross-reference and visual documentation of each particle. The instrument analyzes organic and inorganic fluid-borne particles such as fibers, petrochemicals and microorganisms, where verifying the true size, shape and number of particles is critical.

Thus, it is claimed to be ideal for process engineers, laboratory managers, water/wastewater engineers, environmental compliance officers and others. It operates with discrete samples and/or in situ, permitting continuous monitoring with real-time analysis from a remote location.

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Full gasoline analysis in 75 minutes

AC Analytical Control's Reformulyzer Mark 3 (M3) is a gas chromatograph system that is claimed to complete a full gasoline analysis in only 75 minutes. It is based on a multidimensional column switching technique.

After sample introduction, a set of columns and traps separates the sample into different hydrocarbon groups. This determines carbon number distribution for each group: paraffins, olefins, naphthenes, aromatics or oxygenates. The technology is totally compliant with ASTM D6839 and D5443, EN 14517, IP 526 and ISO/AWI work item 22854.

The instrument is easy to use and provides an intuitive user interface. It has automated validation through quality control samples with the integrated diagnostic tool, and it also has an analysis simulation program. Dedicated connectors make part replacement easy for a quick turnaround. The analyzer's software is compatible with various chromatographic data systems such as Atlas, ChemStation, EZChrom and EZstart.

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Versatile portable viscometer works any place

Sofraser has developed the PIVI portable viscometer for field, factory and laboratory viscosity measurements. The instrument can measure any range from 0.1–100 mPa/s to 100–100,000 mPa/s and handles a wide product variety. It uses vibration principles, which are claimed to make the instrument simpler to use and more accurate and reliable, with no wear parts.

The instrument instantaneously displays the viscosity value, and it can store up to 40 measurements. It also has an RS 232 link. The PIVI can be equipped with a temperature probe and can handle products up to 100°C. When installed on a labstand, it can make numerous measurements per minute due to its easy cleaning.

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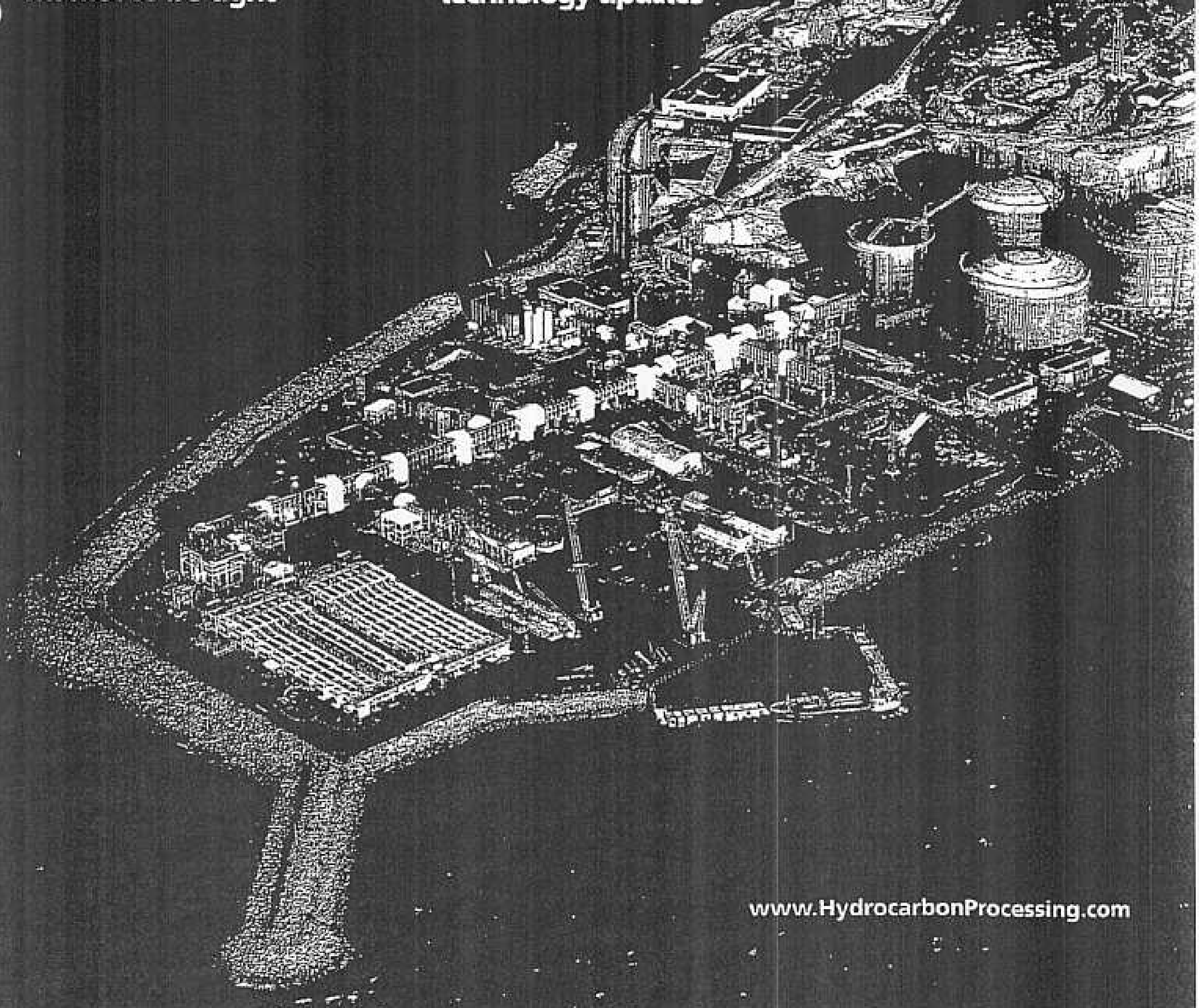

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