CHEMICAL CORROSION AND FOULING IN MEDIUM TEMPERATURE ENVIRONEMENTS. TEMPERATURE < 450ºC (850ºF)
Application fields: • COMBUSTION FUMES CONDENSATION: HEAT RECOVERY AND GAS CLEANING • REFINERY AND PETROCHEM HEAT EXCHANGERS FOR " DIRTY SERVICE" ✓ Nitric Acid Condensers ✓ Overhead Sulphur Condensers ✓ … / …

1. *COMBUSTION FUMES HEAT RECOVERY AND CONDENSATION TECHNOLOGIES*

We designed a basic condenser and installed it in an urban garbage power plant

The next figures show the design of the condenser

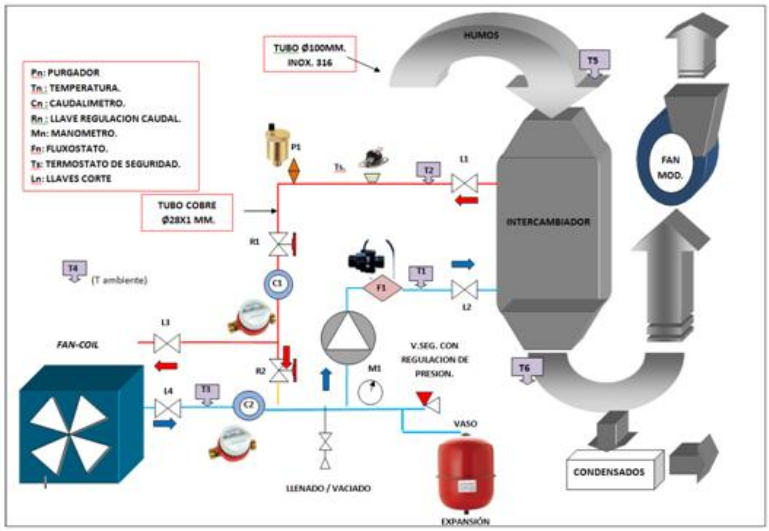


Figure 1. 5kW fume condenser prototype at a Urban Waste Power Plant

The carbon steel tubes installed on the condenser have an internal ceramic coating to protect them against corrosion as it can be seen in the Figure 2

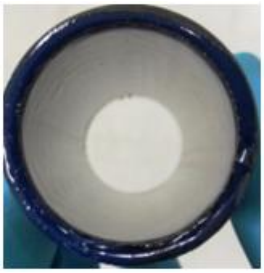


Figure 2. Carbon Steel tubes coated with ceramic coating

After six month working in real conditions, the aspect of the tubes and the turbulator is shown in the next figure.

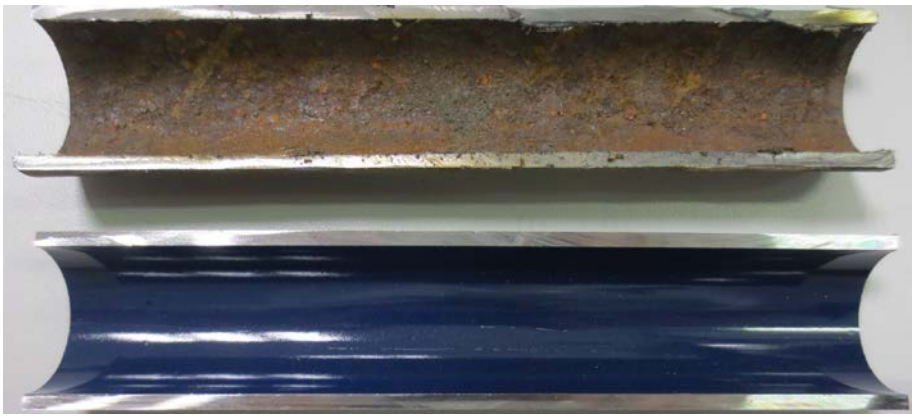


Figure 3. Coated/non-coated elements from the condenser

As it can be seen in the Figure 3, there is amazing difference between the coated and non-coated parts.

The test was a success as the coated tubes did not lose a single mg of its mass, keeping its original shine:

Some data collected in the tests:

Recovered heat : 5kWh

Condensed water: $6lh^{-1}$ for only 5kW…

Water pH before neutralizing: 3'5

Water pH after neutralizing by soda: 8

Fume temperatures: Incoming 120ºC (248ºF), outgoing: 40ºC (104ºF)… ***which implies the full condensation of the water vapor in the fumes***

The major ***advantages*** of this enabling technology are:

- ***The low cost of the resulting condenser:*** using coated carbon steel will allow the building of industrial scale well over 20MWh of recovered heat with short Return On Investment periods
- Recovery of the ***sensible & latent heat*** (by condensation) of the fumes, increasing the ***thermal efficiency of the plant in around a 10%***
- All that heat in the form of hot water (around 100ºC - 212ºF) can be used in other heating needs at the plant (biomass dryers,..etc.) or used for ***District Heating & Cooling***
- *Part of the fumes (basically N_2 + CO_2 + some water) can be used to warm and feed greenhouses*
- ***Acid rain is produced*** in the plant, so fumes are extremely clean and harmless to the environment
- This acid "***New Water***" can be easily neutralized with soda and employed in other industrial applications ***as steam condensation***, irrigation…etc. with ***no need*** (or reduction) of the use of water from grid or nature
- These clean & dry exhaust fumes will be much easier to capture its CO_2 than existing alternatives

Just to give an idea of the water recovery potential we estimate that in a power plant generating 50MW of electricity, the recovered "acid rain water" can be around 12 – 20 Tmh^{-1} depending on the fuel humidity and composition

NEW RESEARCH STEPS:

1. A 5kW Condenser was installed ***before filters*** in order to evaluate the filtering effect of the condensed water in the condensing tubes…. And it worked!! Ashes were trapped by the falling condensate and decanted in a tank
2. A 200kW unit is also being built with the lessons learnt in the first prototype, and will be installed BEFORE FILTERS by beginning 2017
3. A 200kW unit is also being built to be place at the exhaust of the diesel engine on the cargo ship.
4. As these two applications get fumes at > 300ºC a Rankine Organic Cycle downstream could be of great economical interest
5. A 1MWh unit is being designed as a Pre-Industrial demonstration unit connected to a biomass dryer.

200 KW CONDENSER on first trials AFTER filters…. Prior of being installed… BEFORE FILTERS

Selected ship for engine fumes cleaning and energy recovery by Rankine Organic Cy

2. *REFINERY AND PETROCHEM HEAT EXCHANGERS " DIRTY SERVICE"*

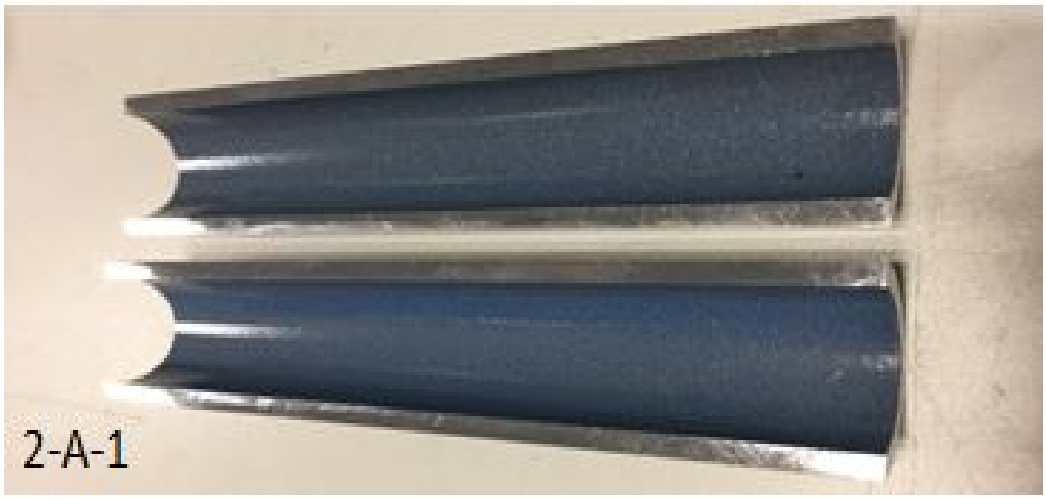
Kera-Coat's ceramics coatings have been specially developed to fight successfully in most corrosive and "dirty" environments in Refineries and Petrochemical Industry.

CERAMIC COATING PROPIETIES

The most important proprieties for these types of units are:

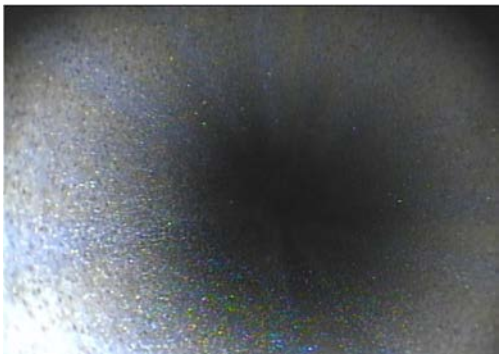
1. Glassy Surfaces with very low roughness (Ra: 0,1 µm) = little or no fouling
2. Water Pressure Cleaning resistance, if eventually needed, up to 2,300 bar. (36,260,00 psi)..due to more than 63 HRC hardness

Equipment

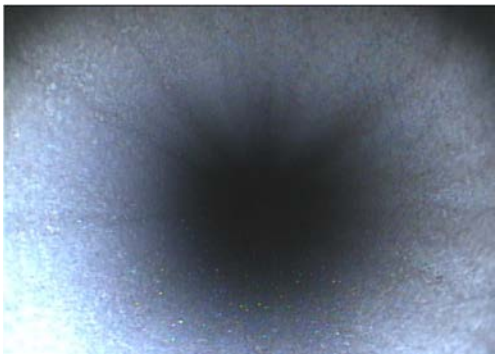


Tubes after Pressure Test – NOT damage

3. Boroscope images of tubes coated with 2 different formulations VP-15 & TC-30

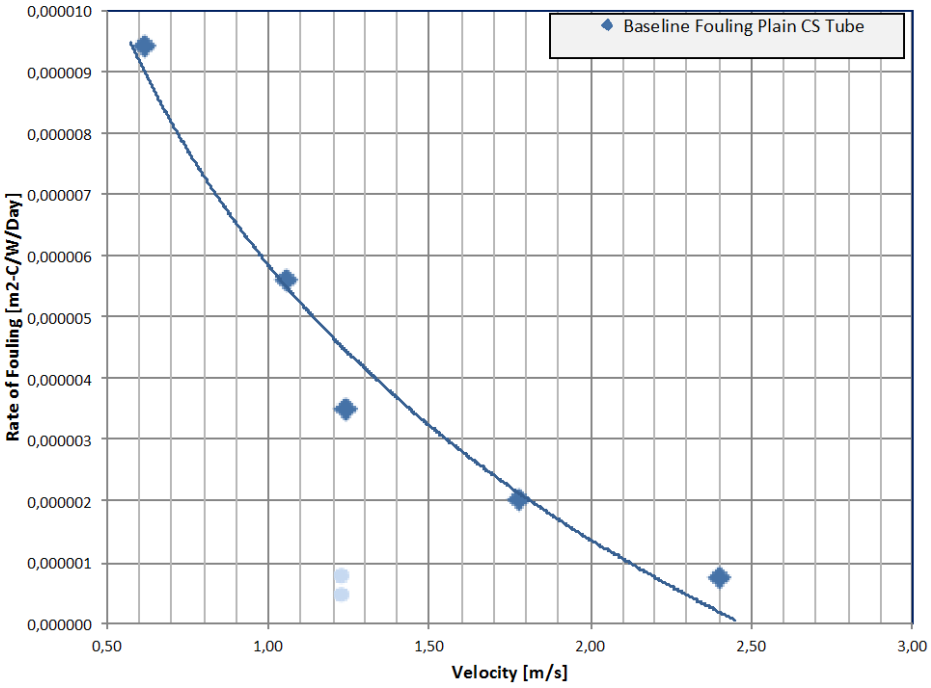


VP-15 , 140 microns thick



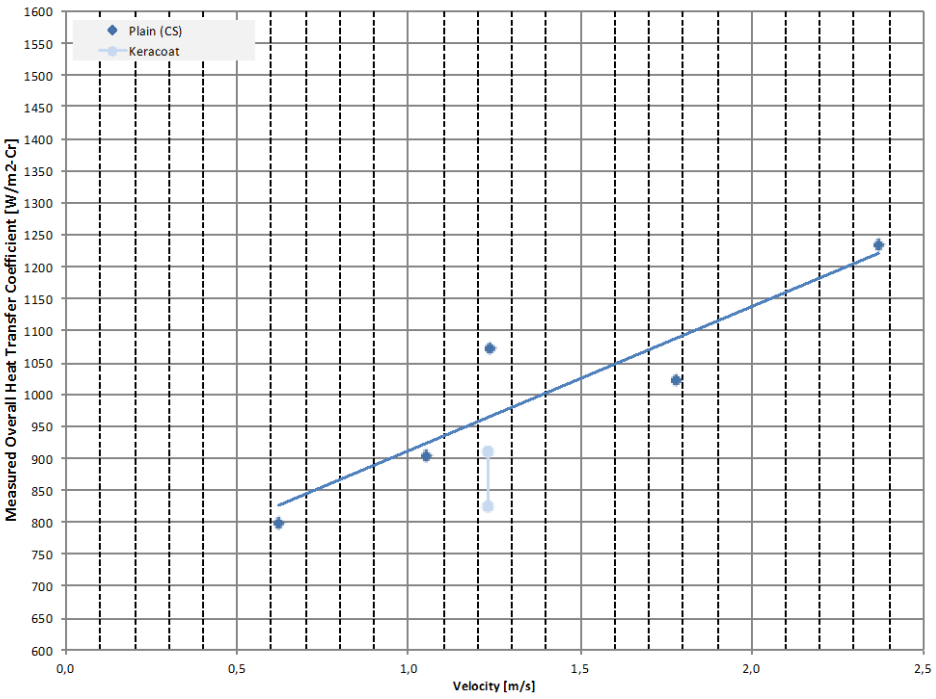
T-30 200 microns thick

4. Four samples shipped to Shell, two different coatings applied to same carbon steel substrate (EN 10216).
   TEST RESULTS After 7 months in testrig (The tests were run for a crude oil at approximately 240ª C, being heated by a heat transfer fluid at 350º C.)



Kera-Coat samples are the 2 small clear blue dots al 1'2 m/s in the graphic

THERE IS A REALLY BIG difference in fouling avoidance and the eventual deposition is not adhered being easily removable with pressurized water



KERA-COAT samples are the 2 clear blue dots at 1,20 m / s. The initially very small thermal barrier is compensated after a fortnight operation due to the much lower fouling rate

5. Chemical Resistance

Hot & Cold Acids (UNE-EN ISO 28706-2: 2012)

Sulphur and Sulphate

Nitric

Chloride

Except HF

Hot & Cold Alkalis (UNE-EN ISO 28706-4 : 2012)

Except concentrate (OH) Na & (OH) K

Water Hot & Steam (UNE-EN ISO 28706-2: 2012)

High concentrate Salt Water.