High-efficiency coalescers for analyser protection

Coalescers are designed to either separate liquid aerosols from gas streams or to break liquid/liquid emulsions. Both liquid/gas and liquid/liquid coalescer technologies have been successfully applied to analyser technology

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On-line process analysers are now commonplace in industrial plants and are being increasingly used in refineries. Over the last few years, they have become more complex and sensitive to contaminants in the inlet feed. One of the most critical issues with the use of on-line sensors is their vulnerability to fouling and the potential harmful outcomes of inaccurate measurements such as non-optimised process control, leading to loss of revenue. Also of concern is the need for costly replacement parts due to corrosion and maintenance related to frequent repairs or cleaning.

However, advances in the separation technology of liquid/gas coalescers and liquid/liquid coalescers and their application to sensor protection are changing this situation. The use of specially engineered polymeric media has advanced the state-of-the-art for separating liquid aerosols from gases and breaking emulsions in liquid systems.

This case history of the OMV refinery in Burghausen, Germany documents a small-flow, high-efficiency liquid/liquid coalescer system installed to optimise analytical devices including a near infrared (NIR) spectrometer and pH sensor. In one case, water and particles had affected the on-line measurement of different hydrocarbon streams. In another, hydrocarbons in the water had damaged the pH sensor, making an on-line measurement impossible.

The use of high-efficiency liquid/liquid coalescers made it possible to remove any harmful traces of water from hydrocarbons or hydrocarbons from water, enabling the analysers to operate at peak performance and provide accurate and reliable measurements. This in turn allowed the process equipment to be adjusted using the sensor information, enabling both continuous process control and improvements in operation efficiency. The cost of each small-flow, high-efficiency liquid/liquid coalescer system for this application was less than $5000 and resulted in a quick return on investment (ROI).

OMV is the leading oil and natural gas group in Central and Eastern Europe. It is active in exploration and production worldwide and has integrated chemicals operations. OMV Deutschland, a subsidiary company of the international OMV Aktiengesellschaft, processes mainly low-sulphur crude. This crude is transported in the Trans-Alpine Pipeline (TAL) from Trieste to the Steinhöring tank farm and from there to Burghausen.

The OMV Burghausen refinery is strategically located in the heart of Bavaria's chemical industry. This refinery processes some 3.4 million metric tons of crude oil annually and produces the basic petrochemicals ethylene and propylene, as well as extra-light heating oil, diesel and aviation fuel, and coke for the aluminium industry.

Coalescer technologies

Coalescers are designed to either separate liquid aerosols from gas streams or to break liquid/liquid emulsions. They can be constructed from fibres made of various materials, including glass, metal, polymers and fluropolymers. The coalescer media can be configured as pleated sheets or as a depth type, but have in common a pore gradient that goes from smaller to larger sizes in the flow direction and an outer coarse sleeve material to complete the coalescing process. In principle, coalescers can operate indefinitely as long as they are not exposed to solid contaminants. In practice, coalescer systems, with proper pre-filtration, typically achieve service lives varying from six months to two years. They operate in three stages:

— Separation of solids
— Coalescence of small drops into larger drops
— Separation of the large drops from the purified continuous stream.

During the coalescing process, the inlet drop sizes are in the sub-micron to low-micron size range; after passing through the coalescer, they are in the millimetre range. Both liquid/gas and liquid/liquid coalescer technologies have been successfully applied to analyser technology.

With the liquid/gas coalescer, poor liquid separation, which eats away the profit margins, can be eliminated. Liquid aerosols dispersed in gases attack several critical areas within the process: compressors and turbo-equipment, amine-glycol contactors, burner and combustion equipment, and desiccant and absorbent beds. This can result in any or all of the following:

— Compressor valves that need changing out more than once every two years
— Turbo-equipment servicing more than once a year
— Plugging of reboiler heat exchangers or trays in contact towers
— Frequent replacement of amines and glycols
— Frequent foaming incidents
— Loss of efficiency in burner and combustion equipment
— Frequent desiccant regeneration or replacement.

Liquid/gas coalescers are the latest development in the history of liquid/gas separation units. Their performance is superior to knockout drums, vane separators, mesh pads, and combinations of filter separators and vane or mesh packs. These older devices rely on internal separation mechanisms and work well for larger aerosol droplets (>5μm), but lose efficiency at reduced flow rates.

High-efficiency, vertical liquid/gas coalescers have been used extensively in gas processing in the last decade. They offer the advantage of increased removal capability of fine droplets (down to 0.3μm in size and to levels as low as 3ppb) and are able to operate efficiently at low flow rates. A recent innovation in liquid/gas coalescer design is to use a surface treatment to prevent the wetting of the coalescer media with aerosol liquids, thereby increasing the allowable

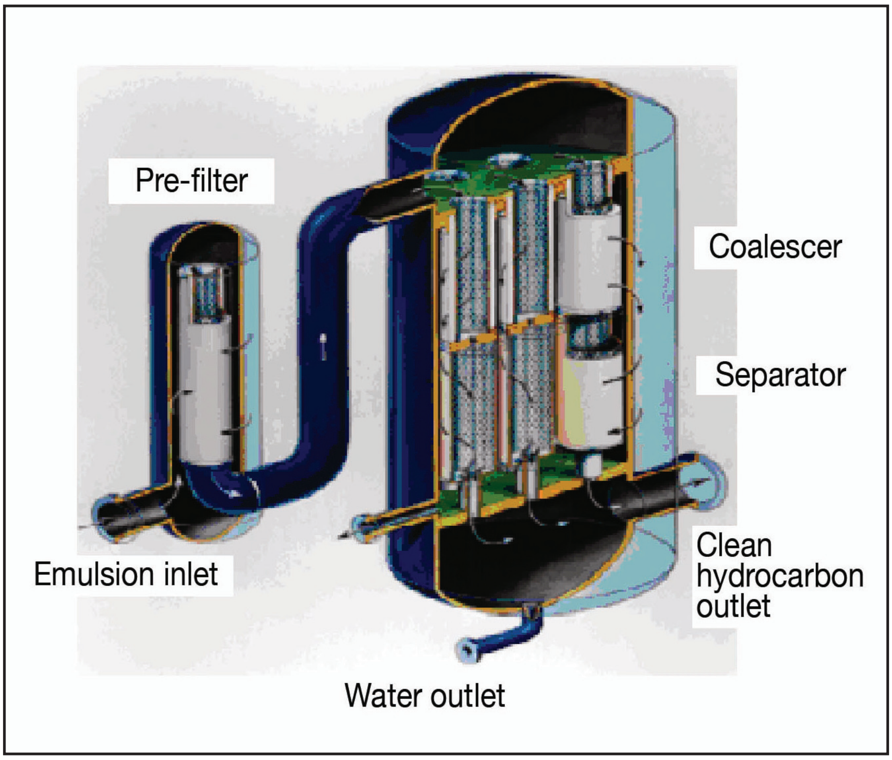

Figure 1 Vertical liquid/liquid coalescer

flux, decreasing fouling tendency and lowering pressure drop losses.

Liquid/liquid coalescer systems are frequently used to dry jet fuel and are finding increasing applications for refinery and chemical process streams. These systems can be divided into two broad categories: vertical with separator stage and horizontal with gravity separation. Schematics of typical vertical and horizontal configurations are provided in Figures 1 and 2.

Both configurations employ a coalescence stage. In the vertical configuration, a hydrophobic barrier repels the coalesced aqueous drops in a second separation stage. The vertical design is used to separate water from hydrocarbons when the interfacial tension is greater than 3dyne/cm.

In the horizontal configuration, a settling zone achieves separation by gravity. This configuration is used when the interfacial tension is less than 3dyne/cm or for the separation of oil from the water phase. Typically, the main stream leaving the liquid/liquid coalescer will have a concentration of less than 15ppmv of undissolved contaminant. The liquid/liquid coalescer can only remove the free/undissolved contaminant phase.

Traditional coalescers have used glass fibre media, which works well for emulsions that have interfacial tensions greater than 20dyne/cm. New coalescer media, constructed with advanced formulated polymers and fluoropolymers, are effective for emulsions having interfacial tensions as low as 0.5dyne/cm. Newer designs of vertical liquid/liquid coalescers have the coalescers stacked on top of the separators. In older designs, the separators are located in a separate section of the housing. The new designs improve the flow distribution and, consequently, increase separator use. The new coalescer media enables better liquid/liquid separation to optimise the process and cure a variety of costly problems that may not be obvious. These include:

— Hazy product (not bright and clear)
— Sodium levels in gasoline above 1ppm
— High solvent losses downstream of liquid/liquid extraction units
— High caustic carryover from gasoline, LPG or kerosene treating unit
— Carryover of amine in LPG
— Oil and hydrocarbon in water and other aqueous streams.

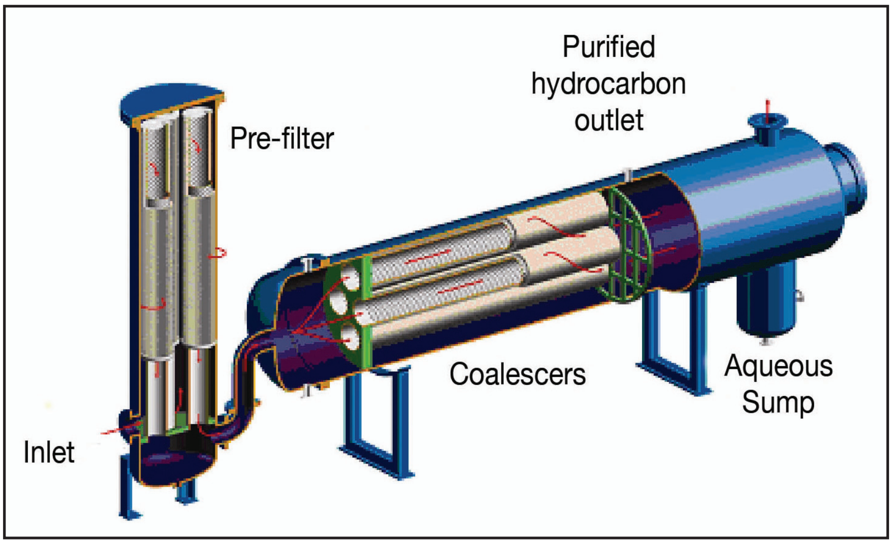

Figure 2 Horizontal liquid/liquid coalescer system

Problems created at liquid/liquid interfaces

Surfactants are naturally present in crude oil and, as a result, in refined petroleum products. During the oxidation process and the caustic recirculation in sulphur-removal processes, surfactants can be concentrated to high levels.

Surfactants that have been identified in caustic treaters include sulphides, mercaptides, naphthenic acids, cresylic acids and phenol homologs. Petroleum naphtha sulphonates have been identified as naturally-occurring petroleum surfactants that are especially detrimental to conventional glass fibre coalescers. The surfactants can adsorb at the solid/liquid interface (coalescer fibres) or at the liquid/liquid interface (water/oil).

"Disarming" occurs when surfactants concentrate on the coalescer fibres. These fibres are shielded from passing aqueous droplets, resulting in poor separation efficiency. Generally, disarming does not occur unless the interfacial tension between the water and fuel is less than 20dyne/cm. However, when specially formulated polymeric coalescer medium was used instead of glass fibre, disarming did not occur at all. The performance of this medium can be greatly enhanced by the modification of surface properties that cannot be accomplished with the glass fibre medium.

Surfactants can also concentrate at the water/fuel interface, leading to very small droplets and stable emulsions. A survey of caustic hydrocarbon emulsions showed the interfacial tensions varied from 0.5–12.4dyne/cm. To separate these types of emulsions, special consideration

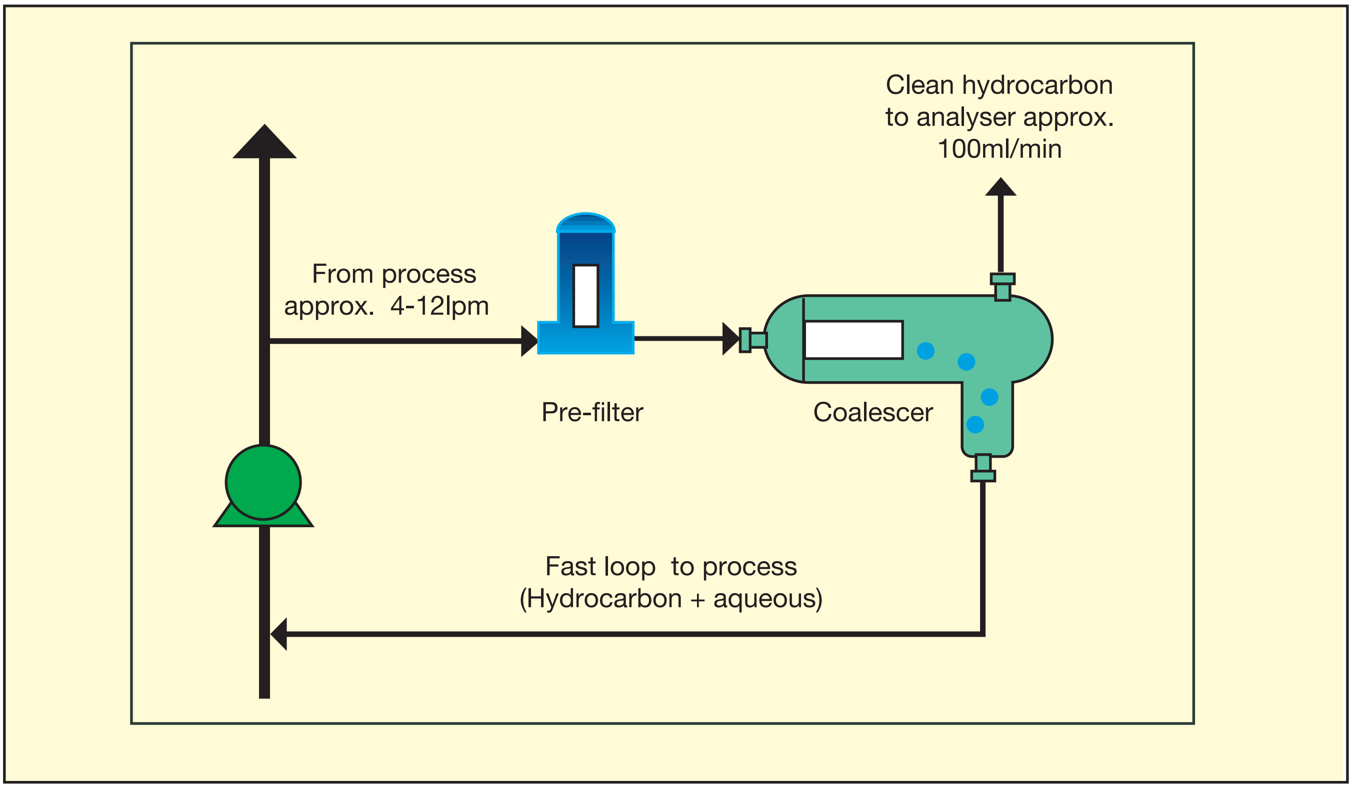

***Figure 3** Fast loop for liquid/liquid coalescer*

must be given to the pore size and distribution in order for the coalescer media to intercept and coalesce the small droplets.

Equipment for small flow rates

To apply coalescing technology to analyser protection, scaled-down versions of the industrial systems are required. The use of fast loop sampling systems is critical to ensure that representative (fresh) fluid is analysed for real-time optimal process control. Here, a high flow rate is maintained in a loop that goes through the pre-filter and coalescer and is than re-routed back to the process (Figure 3). A smaller stream of the purified fluid is drawn off for analysis.

An important distinction between the use of coalescers in analyser protection and full-scale industrial applications is that the contaminant phase re-routes back into the process stream during analyser protection. This configuration allows for less instrumentation, as it is not critical to monitor the separated contaminant fluid for level control because it is continuously purged back to process. This leads to a different flow path in the coalescer housing, where the fast loop flow rate is passing through normal coalescer sump connections back to the process, while a smaller sampling flow is leaving the normal main outlet port.

For the small-flow systems, Pall created a small coalescer cartridge (6in long with 3–3/4in diameter) used in a standard stainless steel housing. To protect the fine coalescer media, an absolute-rated pre-filter is needed (ie, Beta 5000 greater or equal to the rating as determined using a modified OSU-F2 laboratory test). Therefore, a 5μm (99.98% retention of 5μm particles) rated proprietary Nylon Profile filter is used. The pre-filter cartridge is 10in long with 2.5in diameter. The filter material is compatible with hydrocarbon streams up to 150°C. The coalescer media is the same as for the process applications (Table 1).

Case 1

Separation of water phase from hydrocarbons

The OMV Burghausen refinery installed six small-flow liquid/liquid coalescer systems, each consisting of one pre-filter and one vertical coalescer housing equipped with one pre-filter element, one coalescer and one separator element (part number and design characteristics shown in Table 1) to protect their NIR analysers (analyser type: ABB Bomem FTSW100).

NIR analysers are a relatively new technology for refineries to monitor main product, intermediate streams and unit feed. The specially designed Pall coalescer media is suitable for use in different streams with a large variety of interfacial values. The analyser is offered as a low-cost alternative to traditional gas chromatographs or distillation analysers. With the new generation of NIR spectrometers, a large number of typical and characteristic fluid values can be calculated (T10, T95, Cloud

Part numbers/design parameter

Cartridges:

Part number	Description	Max. temperature	Initial pressure drop*	Recommended change-out dP
RGN1FN050	Nylon Profile filter	150°C	20mbar	3.4 bar
LCS06B1AH	AquaSepPlus Coalescer	65°C	140mbar	1 bar
LSS06F1H	Separator	65°C	140mbar	1 bar
LCS06H1AH	PhaseSep Coalescer	65°C	140mbar	1 bar

* The initial pressure drop values are likely to vary case to case.

Housings:

Part number	Max. temperature	Max. pressure	Material
1PH4F1F11	140°C	16 barg	316L SS
1AQ4F1F11	140°C	16 barg	316L SS

Table 1

Burghausen refinery is able to make a continuous and correct on-line measurement of its hydrocarbon streams. With the result of these measurements, the refinery controls its column properly and is able to produce 5–6% more kerosene. The Pall system will remove free liquid contaminant to levels of 15ppmv and below over a wide range of conditions such as:

— Inlet liquid contaminant concentrations as high as 10%

— Interfacial tensions as low as 0.5dyne/cm.

The use of the fast loop configuration with the small-scale liquid/liquid coalescer system has resulted in simple separation systems that do not require level controls or automated discharge valves.

Converted data available per individual stream

Stream	Flow through coalescer	Flow through NIR	Converted data
HDS diesel outlet, l/h	40	3–8	Cloud Point; T10; T95
HDS inlet, l/h	40	3–8	Cloud Point; T10; T95
Gas oil I outlet, l/h	40	3–8	Cloud Point; T10; T95
Coker gas oil outlet, l/h	40	3–8	Cloud Point; T10; T95
Heating oil outlet, l/h	40	3–8	Cloud Point; T10; T95
Kerosene outlet, l/h	40	3–8	Freezing Point, Flashpoint

Table 2

Point, Freezing Point and Flashpoint). In order to apply the best efficiency, a fast loop sampling is installed as previously described in Figure 3.

For the correct measurement of NIR spectra, it is critical to have water- and particle-free samples. The transmission value (how clean and anhydrous the cell is) is needed to know if the product is in the given spectrum. Water and particles disturb the measurement and must be removed. Without a continuous transmission, no on-hand readings can be done.

In the past, OMV used a salt filter. The major disadvantages were that there was no control of these values and the filter had to be changed every two to three days. The content of the water was not verified during this time. With the installation of the coalescer system, the lifetime of the filter system has increased, the samples are reproducible, and the water content is controlled effectively.

The Bomen Gran ABB NIR spectrometer has six "in channels" and is connected to the refinery's computer system. With reference spectra, it is possible to calculate the Cloud Point, T10, T95, Freezing Point and Flashpoint (Table 2).

With better control of the column, the OMV refinery could increase the output of kerosene by 5–6%, which offers a fast ROI. This is due to the optimisation of production through advanced control in the gas oil and coker gas oil streams.

Case 2

Hydrocarbons from water phase

The aim is to protect the pH sensor from hydrocarbons being used in the cooling water cycle for dosage NaCl constant to the system. Hydrocarbons destroy the sensitive pH meter. In the past, only off-line measurements were possible (point-wise measurement) and the sensor was damaged by long-term contact with hydrocarbon in the stream. The usage of a new pH sensor was required every three months.

By using the small-flow liquid/liquid coalescer system, a constant on-line measurement is possible and the pH sensor does not need to be changed for more than one-and-a-half years. The flow rate of the described installation is 10l/hr by the pH sensor.

Results

Due to the installation of six small-flow liquid/liquid coalescer systems, the OMV

Nylon Profile filter, AquaSepPlus Coalescer and PhaseSep Coalescer are trademarks of Pall Corporation.

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