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A versatile and cost-effective liquid-liquid separator for the Oil & Gas industry

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Introduction

ZerOil® separation system yields an extremely efficient separation of oil dispersions in water. The system is based on a peculiar process internationally patented by Italtraco, which exploits the physical properties of oil, water and a specific liquid-liquid interface support to create a surface barrier against the passage of oil droplets. Separation efficiencies can reach extremely high levels, even in presence of quasi-stable emulsions with droplets of submicrometric size.

The present poster describes the main features of the ***ZerOil***® system, and shows some results concerning its separation efficiency in the treatment of production and run-off waters in the oil industry. Italtraco's Integrated Treatment for production water, which involves other patented technologies developed by Italtraco to treat oil, aromatic solvents and solid dispersions in water, is also briefly outlined.

Process description

The process underlying the ***ZerOil***® system is based on the observation that an additional interfacial tension between oil droplets and water arises from the mutual interaction between oil, water and a proper liquid-liquid interface support. This additional interfacial tension leads to the rejection of oil droplets on the top of the liquid-liquid interface support, eventually ending into a surface coalescence of oil drops. Rejection takes place only when the relative velocity between oil droplets and the two-phase filtering layer remains below a certain threshold which is directly dependent on the flow rate, on the droplet size and on the physical properties of oil and water. An additional deep bed filtration effect on submicrometric droplets which are able to pass through the interfacial tension barrier has been also observed.

A threshold flow rate is therefore determined and verified at design level for the required separation efficiency, given the size distribution and the physical characteristics of the oil dispersion to be treated. In any case, as the pressure drop introduced by the liquid-liquid interface support is minimal (around 0.01 bar), separation can be usually performed at high flow rates: in some applications, flow rates up to 60 m^3/h per m^2 of two-phase filtering layer can be adopted.

Figure 1 shows a typical ***ZerOil®*** system, where the two successive stages are intended to exploit both the deep bed coalescing effect on the first, coarser two-phase filtering layer, and the rejecting barrier of additional interfacial tension generated, at different levels, both on the first and on the second, finer two-phase filtering layer. Rejected oil is recovered from the top of both separation chambers. Level controls operate in order to maintain the pressure level on the two-phase filtering layer within the desired range: this range allows the plant to deal with sudden reductions in the incoming flow rate, as well as with a sudden increase in oil concentrations with no effect on the separation efficiency of the system.

Owing to the physics of the separation system, the correct determination of the water velocities on the top of the two-phase filtering layer plays a key role at design level. Italtraco adopts numerical techniques to simulate water flows (*Figure 2*) inside standard and custom-made ***ZerOil®*** configurations.

Separation results

ZerOil® separation system has been tested on several cases of treatment of oily waters, in industrial and environmental streams. Concerning applications to oil industry cases, *Table 1* shows separation results for a field case of run-off water at AGIP Oil Center in Cavone: oil is removed almost completely (separation efficiency overtakes 99.9%) while the two-phase filtering layer proves to be also an effective barrier against suspended solids.

The production water sample whose diameter distribution is illustrated in *Figure 3,* was instead generated at ELF EP facilities and consisted in a dispersion of a Sahara light oil (45.9 °API), with a mean drop diameter of 5.1 µm, in salt water with a salinity of 40 g/l: *Figure 4* shows that, during a test run lasting for 930 minutes with an average inflow oil concentration of 574 ppm, oil concentration at the outlet was never more than 9 ppm, with an average value of 5.3 ppm, meaning a mean separation efficiency of 99.1%. Similar separation results have been obtained also in the trials with Escravos Nigerian oil (37 °API) and Vic Bilh heavy oil (22 °API).

Integrated treatment for production water

As shown in *Table 1*, ***ZerOil®*** system proved to be effective also in the separation of solid particles from oily water dispersions. However, this case needs a special care in the design of the back-washing system and in the following treatment of the discharged back-washing water (Self Cleaning ***ZerOil®***).

SPR (Solvated Particles Removal) system (*Figure 5*) is a purification process of polar liquids containing colloidal dispersions of solvated particles, internationally patented by Italtraco and based on the addition of a natural, food-grade, non-soluble molecule. ***SPR*** improves the efficiency of the removal of suspended solids to almost 100%, minimizing the amount of dissolved aromatic components: *Table 2* shows the excellent separation results obtained in the treatment of produced water from AGIP Oil Center in Cavone, where the average particle size of suspended solids was around 7 µm (*Figure 6*).

An improved ***SPR*** system allows also the removal of heavy metals and bacteria from the treated water. This system can be efficiently integrated with ***ZerOil®*** to obtain a final treatment for production water for: discharge into environment, re-injection or direct delivery to R.O. for steam production purposes.

Figure 1 *– Typical modular Self Cleaning ZerOil®.*

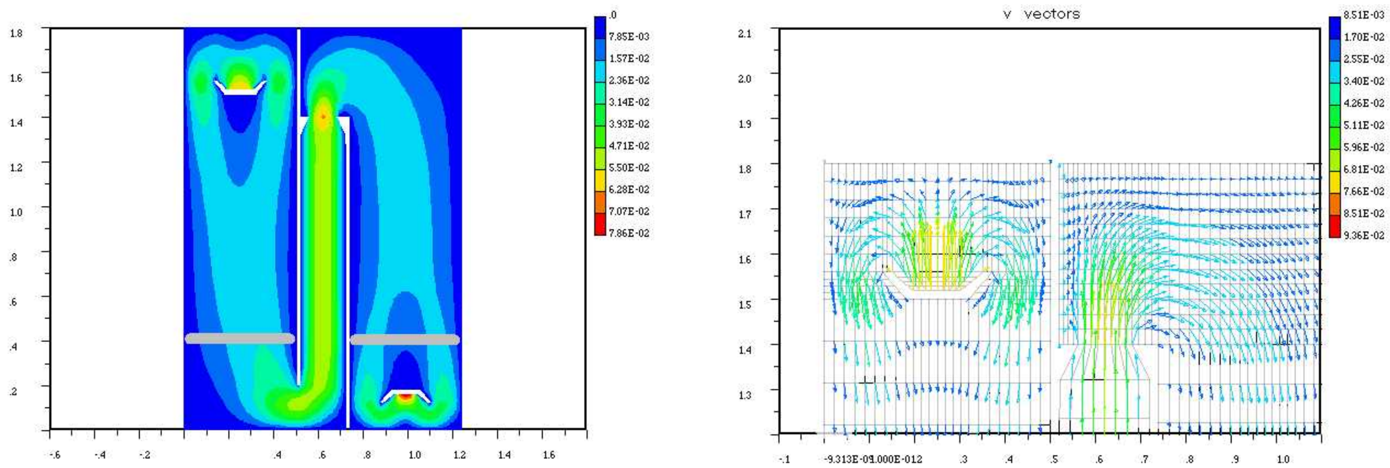

Figure 2 *– Numerical simulation of water flow in a typical two-stage ZerOil®.*

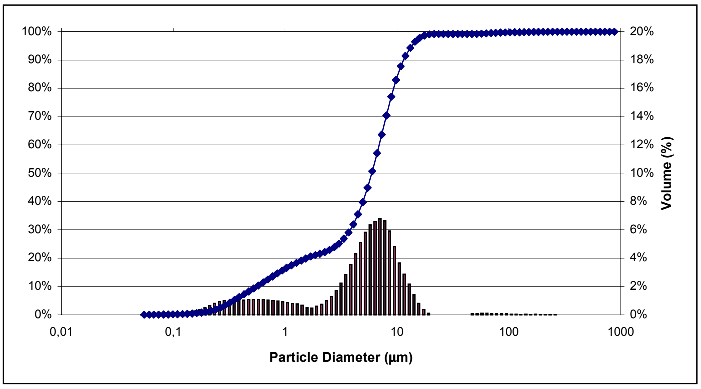

Figure 3 *– Oil droplets distributions from "ZerOil® pilot" trial in ELF EP facilities in Pau.*

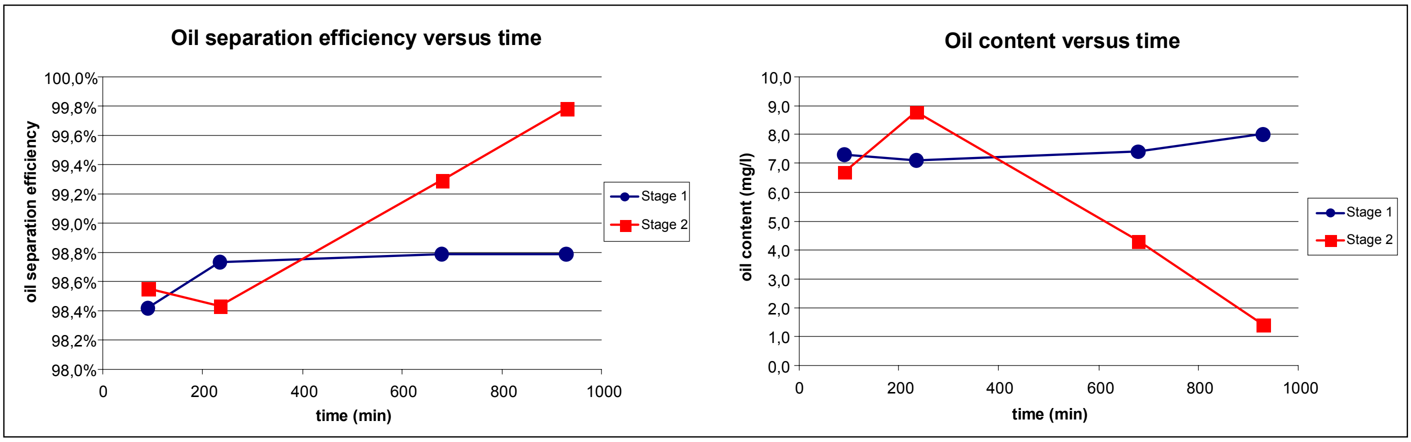

Figure 4 *– Results from "ZerOil® pilot" trial in ELF EP facilities in Pau.*

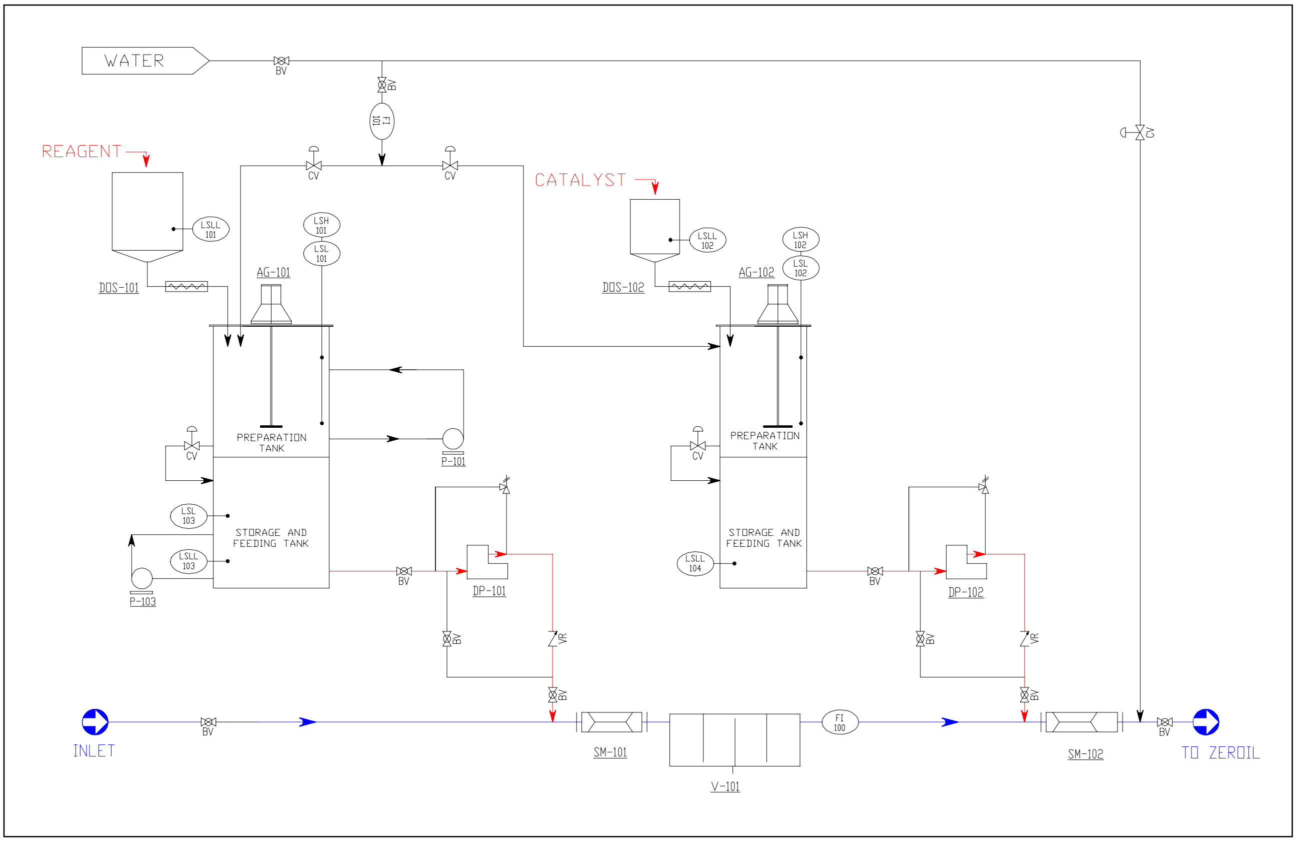

Figure 5 *– Flow sheet of a typical SPR system.*

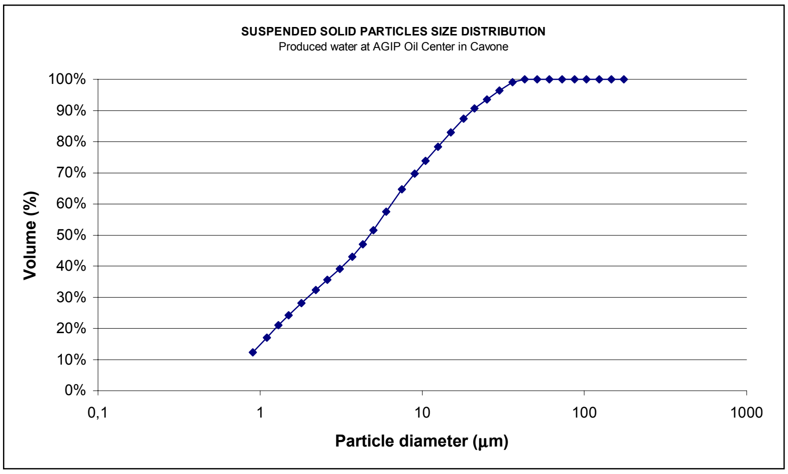

Figure 6 *– Suspended solid size distribution before SPR.*

INLET PARAMETERS	
	VALUE (mg/l)
pH	6.03
Settable matter	< 0.3
Suspended Solids	300
COD	200
BOD_5	25
Mineral oils	120
Salinity expressed as KCl	5
Aromatic-aliphatic solvents	< 0.05

OUTLET PARAMETERS				
	First sample		Second sample	
	VALUE (mg/l)	Separation efficiency	VALUE (mg/l)	Separation efficiency
Suspended Solids	4,4	98,53%	2,5	99,17%
Mineral oils	0,08	99,93%	0,06	99,95%

Table 1 *– Separation results for a field case at AGIP – Cavone.*

SEPARATION RESULTS OF AN SPR SYSTEM			
	Inlet (mg/l)	Outlet (mg/l)	Separation efficiency
Dissolved aromatic components	7,35	< 0,5	> 93,20%
Suspended Solids	300	2,5	99,17%

Table 2 *–Separation results of an SPR system.*