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TECHNICAL REPRINT T-237

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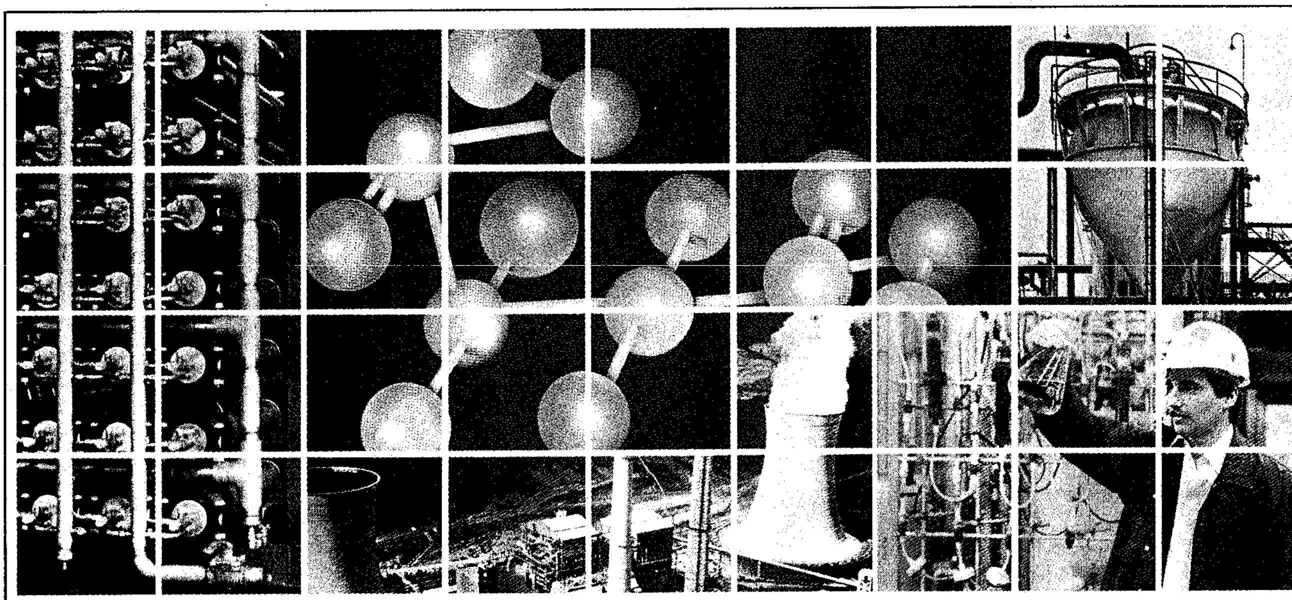

THE GRAVER-ELF/ANVAR COALESCENCE PROCESS FOR THE TREATMENT OF OILY STEAM CONDENSATE:

by
Robert T. O'Connell
Manager, Waste Water Technology

Presented at:
42nd ANNUAL MEETING
INTERNATIONAL WATER CONFERENCE
PITTSBURGH, PENNSYLVANIA

THE GRAVER-ELF/ANVAR COALESCENCE PROCESS FOR THE TREATMENT OF OILY STEAM CONDENSATE:

INTRODUCTION:

The contamination of water by oils is prevalent in many industries. However, oil contamination is indelibly associated with the petroleum refining and petro-chemical industries. It is in these industries that the need for oil/water separation is greatest and where most separation process development has occurred.

The potential for contamination of steam condensate within a refinery is especially great. In a refinery, steam is utilized to convey heat, produce vacuums and supply various process requirements. Steam fed directly to a process unit (i.e., fluid catalytic cracker, deasphalting, etc.) and steam fed to ejectors results in highly contaminated condensate. This condensate is extremely difficult and costly to reclaim and is normally wasted. Steam employed in heat exchangers for process heating should result in a relatively clean, reusable condensate, but it will normally exhibit some oil. Normal concentrations of oil in refinery condensate range between 5 and 20 mg/l. Also, there is a high potential for a leak that can result in hundreds of mg/l of oil in the condensate. If left untreated, the oil would lead to any of the following problems in the boiler:

1. Foaming, under alkaline conditions.
2. Formation of large, tar-like clumps in the drum.
3. Coating on the heat exchange surface.

In order to ensure that the oil is not carried to the boiler, an oil removal step is necessitated.

Historically, precoat type filters have been used to remove oil from petroleum refinery condensate. The utilization of a precoat, plus body feed, can be applied to various media; deep bed granular (predominantly anthracite), or screen (leaf type pressure filter or rotary vacuum filter). The precoat material itself can be alum floc, diatomaceous earth or cellulose fiber. Typical cellulose fiber precoated filter performance is an average effluent oil concentration of 1.0 to 2.0 mg/l (0.5-10 mg/l range) with an average influent of 10-15 mg/l (1.0-100 mg/l range). Frequency of backwash and precoat operations is a function of the oil content. Discharged precoat material, now saturated with oil, must be handled through the plant waste system.

DEVELOPMENT OF THE GRAVER-ELF/ANVAR COALESCER

The process was developed by Elf, which is the Societe Nationale Elf Aquitaine. Elf is a French concern which is primarily involved in the exploration, production, refining and marketing of oil, gas and petrochemicals. ANVAR is a French government sponsored research institute. ANVAR provided a grant to members of the Chemistry Department of Toulouse University, which led to the development of the coalescer. Patents were obtained and assigned to ANVAR. Elf Aquitaine obtained an exclusive license and has carried out the full scale development of the process. The development program eventually led to a pilot trial in the Elf Refinery at Feyzin, France in 1975. In 1976 a full scale unit was installed at the Elf Refinery at Ambes, France.

THE PROCESS

The process uses synthetic ion exchange resin as a coalescing media. To impart true oleophilic properties to the resin, it is treated with a surface active agent. The surface active agent becomes strongly affixed to a multiplicity of the available ion exchange sites. The exact nature of the attachment is unknown, however, the bond is not broken over a pH range from 2 to 12.

In the treatment of oily condensate, the resin is packed tightly between retaining plates in a vertical tank. The oil laden condensate flows upward through the packed resin bed. The dispersed oil droplets are then brought into contact with the resin bead surface, allowing coalescence to take place. An oil film is formed on the exposed resin bead surface. Oil continues to coalesce on the bead surface until a critical thickness is reached. At this point the shearing action of the bulk fluid flow removes the oil film from the bead. The bead is now capable of receiving more oil. With this operation the resin can be thought of as self-regenerating.

The freed oil film will form drops which are carried through the bed by the condensate flow. The oil drops ultimately arrive at the upper resin retaining plate (see Figure No. 1), where they ooze out along with the condensate.

The coalescer operates in a "steady state" condition. The quantity of oil contained in the condensate entering the resin bed is equal to the

Photograph of coalesced oil droplets (10-12 mm) disengaging from a bed of oleophilic resin. Influent contained mechanically dispersed oil (less than 100 micron droplet size), which was introduced into the bottom of the 10 cm diameter column.

Figure 1

quantity exiting the bed. The difference, between the entering and exiting condensate, being the number and size distribution of the oil droplets. The oil entering the coalescer is normally present as a primary or secondary dispersion, with a droplet size ranging from 10 to 130 microns. The oil exiting the resin bed is "free oil," with droplet sizes above 150 micron. These droplets will behave as predicted by Stoke's Law: the rise rate will be a function of droplet diameter, relative density of the two fluids and the viscosity of the bulk fluid.

VESSEL DESIGN CHARACTERISTICS

The coalescer vessel *itself* is designed to incorporate the two distinct steps necessary for oil removal — coalescence and separation (see Figure No. 2). Condensate enters the bottom of the vessel and flows upward toward the resin bed. The resin bed is restrained top and bottom by support plates and resin retaining screens. The design of the upper support is critical because the coalesced oil drops must separate cleanly to avoid redispersion.

After leaving the bed the condensate enters the separation zone. The condensate flow is directed to the upper section through a chimney, which directs the flow of droplets away from the effluent connection. The condensate velocity in the chimney must be controlled to ensure that:

1. Turbulent flow is avoided.
2. Sufficient momentum is imparted to the oil drops to drive the drops upward *after* exiting the chimney.

Upon leaving the chimney the condensate enters the separation section of the vessel. At this point the condensate velocity is reduced and the direction of condensate flow is changed. The separation occurs as the oil droplets continue upward to the vessel crown, while the condensate changes direction and flows downward to the effluent connection.

The oil is allowed to collect in the crown; discharge of the oil is controlled by an automatic liquid level controller. Obviously the oil layer must be discharged before it approaches the separating condensate flow. The oil recovered from the vessel normally contains less than 0.5% water and is easily reclaimed for use. We consider the condensate to be relatively free of suspended solids, however, prefiltration may be necessary. The degree of prefiltration required will depend on the concentration and size range of the suspended particles present in the condensate. Also, the coalescer is provided with a flush water connection above the resin bed. If excessive differential pressure across the bed is experienced, a reverse flush is required. The flush will return the bed to normal operating conditions.

GRAVER
ELF/ANVAR
COALESCER
VESSEL DESIGN

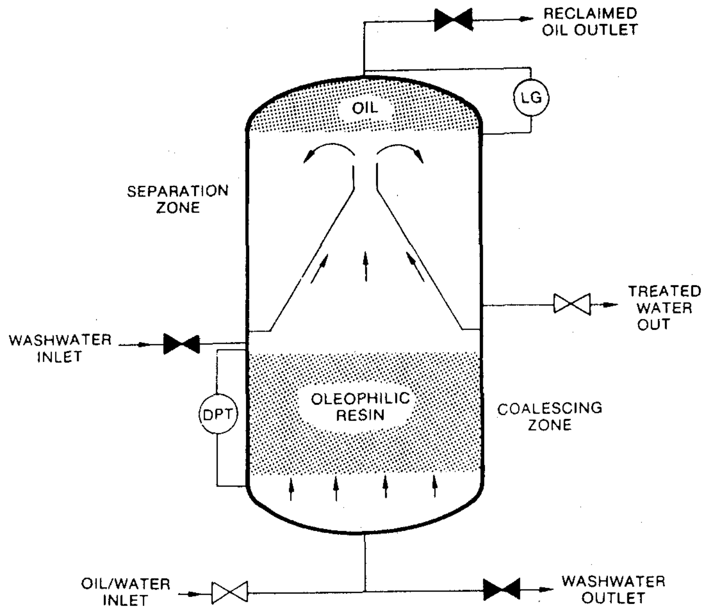

Figure 2

OPERATING CONDITIONS

Temperature limitation on the system is 250°F. This represents the maximum applicable temperature of the resin. The pH operating range in which the resin has been tested, with satisfactory results, is 2 to 12.

The usual design surface loading rate is 4 gpm/ft^2 with a maximum rate of 5. Prolonged operation above these rates may result in redispersion of the oil.

OPERATING EXPERIENCE

Initial development tests were conducted at the Elf Feyzin Refinery, near Lyon, starting in 1974 and included operation on both condensate alone and with hydrocarbons added. After completion of the pilot work, a full scale unit was installed at the Elf Refinery at Ambes, France.

The Ambes Refinery was using two anthracite filters, which were installed in 1948, for condensate deoiling. Alum floc precoat and body feed were used to remove the insoluble oils. Units were usually producing an acceptable effluent (influent 12.6 mg/l average, effluent 1.5 mg/l average). However, occasional bleed through of oil resulted in unacceptable oil levels in the boilers (up to 20 mg/l of oil). Also, there was concern about post-precipitation of aluminum hydroxide after the filters.

In September, 1976, a single coalescer, design flow rate 88 gpm, was installed to replace the anthracite filters. The unit has been operating for over five years with the initial resin charge. Flow range experienced during operation has been 22 to 132 gpm. Operating data is given in Figure No. 3. Average temperature of the condensate is 190°F. Influent oil concentration has averaged 18 mg/l, with a range of 2 mg/l to 180 mg/l. The effluent oil concentration has averaged 0.54 mg/l with a range of 0 to 7.0 mg/l. It is also interesting to note that the average effluent oil concentration has been steadily declining from 1.0 mg/l to 0.32 mg/l over the four year period. Figure No. 4 represents a statistical distribution of data points. The median value (half of the data points are greater than, half are less than) for the influent and effluent oil concentration are 7.0 and 0.25 mg/l, respectively. Also, of the 130 data points collected over a period of four years, only 3 have been greater than 1.0 mg/l. Over a period of 20 months, data from the anthracite filters indicated that 30% (11 of 36) of the data points were greater than 1.0 mg/l. The average oil content in the boiler drums during 1975, while using the anthracite filters, was 4 mg/l. Throughout 1979 only traces of oil have been detected in the boiler drums.

Over the 5 year period the coalescer has been in operation, it has been taken off line only once for a countercurrent wash.

SUMMARY OF RESULTS FROM AMBES DE-OILING PLANT

YEAR/ DEOILER	NO. OF TESTS	PLANT INLET mg/l OIL			PLANT OUTLET mg/l OIL		
		MAX	MIN	AVE	AVE	MAX	MIN
1975 Anthracite Filter	36 (incl. part) 1976	45	3.5	12.6	1.5	9	0.5
1976 Coalescer	Part year 17	121	5	21.5	1.0	7	0
1977 Coalescer	33	64	2.5	10.4	0.62	1.0	0
1978 Coalescer	44	38	3	7	0.37	4.0	0
1979 Coalescer	36	180	2	38	0.32	1.0	0
Coalescer-Total	130	180	2	18	0.54	7	0

Figure 3

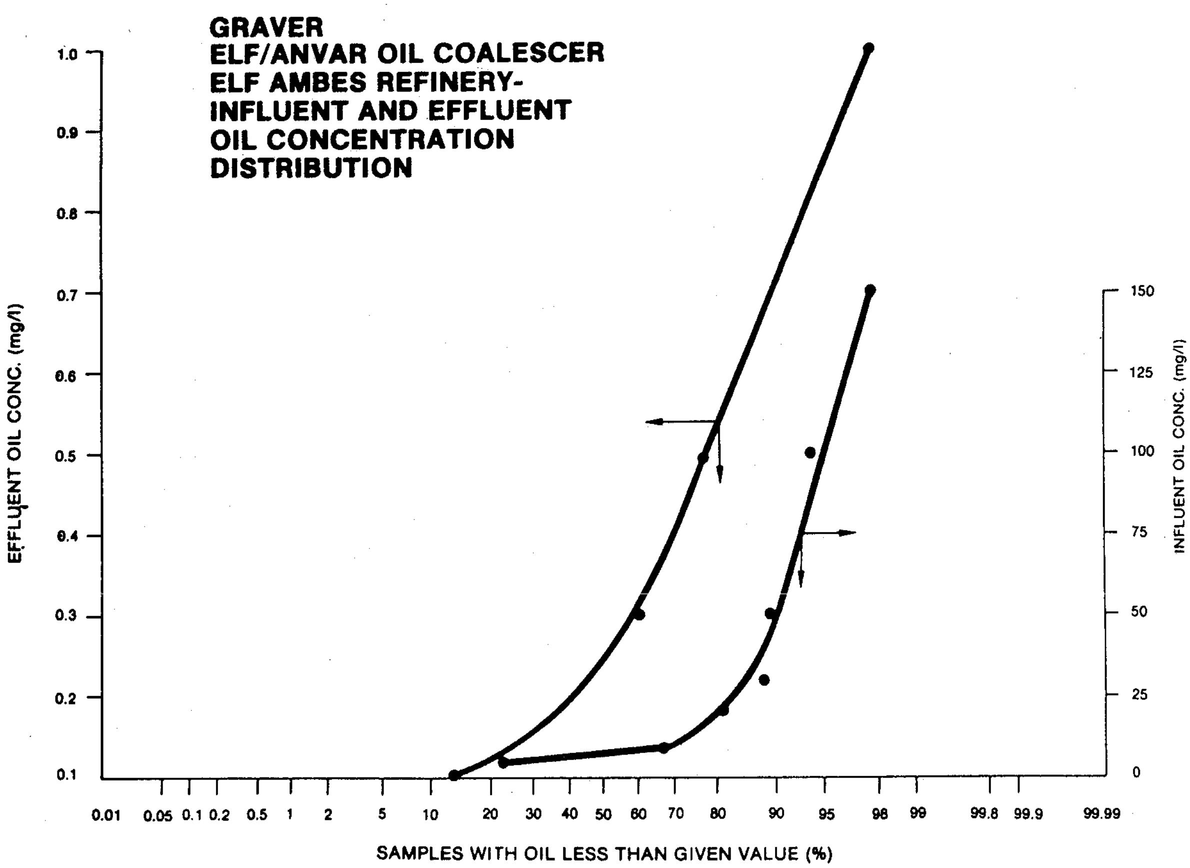

Figure 4

Normal pressure drop across the unit is 4.5 to 6 psid. On one occasion when the pressure drop reached 9 psid, the unit was reverse flushed for 15 minutes. After flushing, the unit was replaced in service within the normal differential pressure range.

EFFECTS OF VARYING TYPES AND CONCENTRATION OF OIL

During the initial development of the process at the Elf Feyzin Refinery the effect of incursions of specific types of oil was studied. This was done to simulate a heat exchanger tube leak or similar occurrence. Various oils were injected into the condensate with resulting concentrations ranging from 400 mg/l to 2000 mg/l. Medium gas oil (450°F/650°F B.P.), No. 2 fuel oil and kerosene were tested. During these trials, coalescer effluent averaged less than 1 mg/l of oil.

Similar testing conducted in the U.S. earlier this year resulted in the data contained in Table I. With influent oil concentrations of up to 800 mg/l, effluent oil concentrations averaged 1.5 mg/l. These data point out the unit's ability to accept high influent oil concentrations, while remaining on line, and producing good quality effluent.

CONCLUSION

The Elf/Anvar coalescer offers several distinct advantages over the conventional treatment of oil refinery steam condensate. These advantages include:

A. Process is continuous, virtually eliminating downtime.

B. Manpower requirements are low, involving sample collecting and gauge monitoring only.

C. Elimination of chemical feeds and therefore backwash disposal.

D. Recovered oil can be easily reprocessed.

E. System can operate at up to 250°F without the risk of silica throw to the boiler.

F. Process is applicable to a wide range of oils at varying concentrations.

Pilot work is now being carried out at U.S. refineries to gain further knowledge about the process. Applications other than condensate for the process include ballast water (a 1200 gpm facility is now operating in Brest, France), oil well field produced water and oily waste waters. Investigations on the application of the coalescer to all of the aforementioned uses are ongoing and will be presented more in future reports.

TABLE 1
OIL INJECTION TESTS

			Elf Coalescer	
Date	Time	Type of Oil Introduced	Inlet mg/l	Outlet mg/l
5/28	15 min.	Light	410.5	0.8
	60 min.	Light	81.2	2.6
	95 min.	Light	14.0	1.8
6/02	10 min.	Heavy	574.9	1.1
	45 min.	Heavy	419.0	0.8
	70 min.	Heavy	215.0	1.8
6/08	10 min.	Heavy	575.4	1.6
	100 min.	Heavy	632.7	1.7
	200 min.	Heavy	166.8	1.5
6/25	15 min.	Heavy	800.0	4.0
	20 min.	Heavy	137.0	0.4
	30 min.	Heavy	55.0	0.8
	40 min.	Heavy	31.3	0.3

Figure 5

Although this paper was presented in October of 1981, it accurately reflects the State-of-the-Art today.

We've come a long way since 1886 when William Graver started his small company in Lima, Ohio to supply process equipment to a fledgling industry. Little did he realize the scope of the businesses that would grow out of his pioneering efforts. The Graver Company, a member of the multi-billion dollar Marmon Group, is one of them. Its four Divisions - Graver Water, Graver Chemical, Unitech and Ecodyne Limited - design and supply the most comprehensive line of water treatment and fluid processing equipment, systems, products and specialized chemicals for the electric utility, chemical, petroleum, pulp and paper, electronics, pharmaceutical, food and metal industries.

GRAVER WATER
Division of The Graver Company
2720 U.S. Highway 22
Union, New Jersey 07083
(201) 964-2400
Telex 13-8215

MARMON
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