Treatment of waste coolant from emulsified industrial effluent using hydrochloric acid

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Abstract

Oil and grease content is a common occurrence in the industrial effluents. Presence of oil & grease in the effluent increase the pollution load and is also an indicator of numerous other organics in the effluent. Excess oil and grease content affects the biological effluent treatment and hence, must be separated from the effluent in the primary treatment stage itself. Free oil is easy to separate and can be easily removed by physical oil & grease separators but emulsified oil is difficult to remove unless the emulsion bond is broken. This study explores the option of removal of oil and grease by acid cracking. With reference to the study conducted, use of hydrochloric acid for emulsion bond breaking results in COD by 46.4%, BOD by 41.4% and Oil & Grease by 39.4%

Keywords: Acid cracking, emulsified oil, free oil, oil & grease removal

1. Introduction

In the industry, the effluent contains high amount of oil and grease as coolant is used in high quantities for machining purposes. This oil comprises of free, dispersed and emulsified oil particles. Out of which, the free oil is separated easily using physical treatment like oil & grease skimming through vertical belt skimmers. The emulsified oil is difficult to remove by physical means due to the oil-water emulsion bond.

For this project, the study was performed on an isolated source tank where waste coolant is brought and stored for treatment.

These coolants are heterogeneous waste containing water soluble oil derived from fatty acids, both synthetic and natural. Coolant basically comprises of a proprietary emulsion concentrate out of which 90% by volume is water while rest of mixture comprises of oil, triethanalomine, anti-foaming agents, rust inhibitors, fungicides and bactericides.

The coolant is pumped on the metal part that is being machined on a lathe. The coolants purpose is to swish away metal turnings as the tool cuts the metal part, prevent the temperature of the part from rising and provides lubrication. The coolant is recirculated into the system and discarded once it's contaminated with metals and oil. The discarded coolant is then collected and brought to the collection tank which is connected to the effluent treatment plant.

To treat this waste coolant, the emulsion bond between oil and water needs to be broken. If not broken, the pollution strength of the effluent will not be reduced and it will put load on the further treatment system.

Various mechanisms available for emulsified oil removal in the market were reviewed to identify treatment mechanism for the analysis:

a) Dissolved air floatation (Richard G. Luthy et al. 1978)
b) Heating
c) Chemical treatment
d) Acid cracking

The following study is done focussing on the acid cracking method for splitting the emulsified oil and its subsequent pollutant removal efficiency.

Characteristics of the effluent selected for the study are as follows:

Table 1: General characteristics of selected effluent

Parameter	Average characteristics (in mg/l except pH)
pH	5-7
TDS	20000-25000
TSS	10000-20000
COD	50000-150000
BOD	12000-20000
Oil & Grease	2000-5000
Chloride	1000-2000

4.4.2 Methodology

In the process of acid cracking, a strong acid was used to break the oil-water emulsion bond and hence, free the oil from the solution. Both sulphuric and hydrochloric acid are used for acid cracking but hydrochloric acid is considered to give better results as per research papers referred for the aforementioned purpose. Hence, the study has been conducted using hydrochloric acid.

a) Effluent Sampling

Grab samples were collected from the coolant collection tank for analysis. The tank contained waste coolant which was used for machining purpose.
Three samples were tested in total to understand average efficiency of pollutant removal using acid cracking.

b) Chemicals used: Hydrochloric acid

c) Acid cracking process

- Waste coolant effluent was used for the analysis where it was aerated in the coolant tank homogenize the contents.
- 'Before treatment' sample was collected in a 1 lit beaker and parameter analysis was conducted on this sample.
- Another sample was collected in 1 lit beaker and the beaker was kept still till that time the free oil from the coolant started floating on top of it.
- Oil layer in the beaker was measured.
- Initial pH of the sample was checked.
- 33% Hydrochloric acid was added to the waste coolant effluent sample until the pH reached 2.
- The acid was allowed to mix with the sample.
- The sample was then kept still for 10 mins and the oil layer was re-measured.
- Oil layer was skimmed off from the sample.
- Parameter analysis was conducted for treated sample and was compared with before treatment sample results.

Fig 1: oil layer separation before treatment (Left) and after treatment (Right)

Fig 2: oil recovery after treatment from one litre of sample

2. Results and discussion

1. Effect of pH on the oil and grease removal

The oil emulsion bond is split when acid is added. This means the oil and grease removal efficiency is inversely proportional to the pH. Lower pH helps in high oil and grease removal from the waste coolant effluent sample.

2. Efficiency of oil & grease removal by hydrochloric acid

Hydrochloric acid is used for lowering the pH to a desirable extent to enable breaking of the emulsion bond. This can be visualized by measuring the oil layer before and after treatment. After acid addition, a thick layer of oil (around 6 mm) separates from the sample. The analysis shows an average reduction of 39.4% in the oil and grease content.

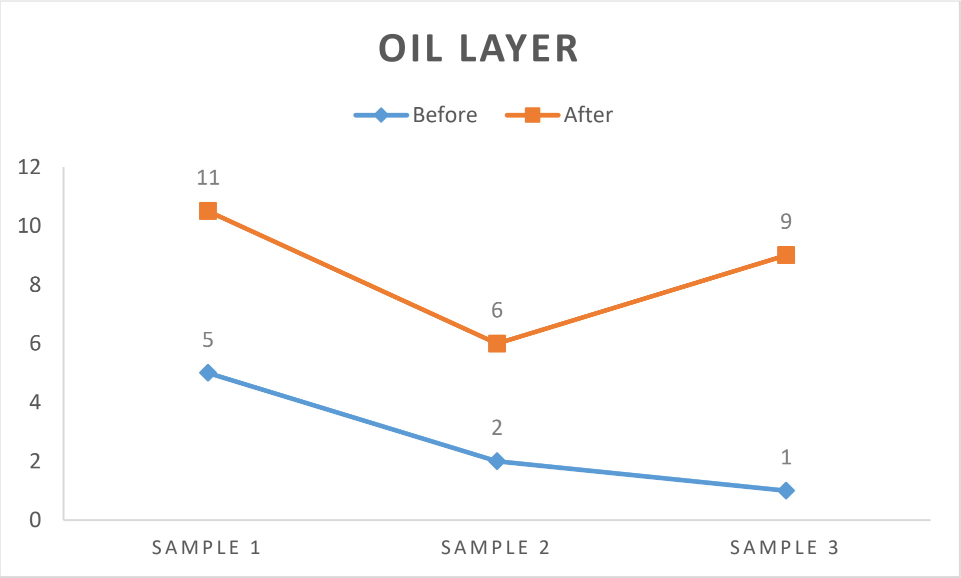

Fig 3: Free oil separation after dosing of hydrochloric acid

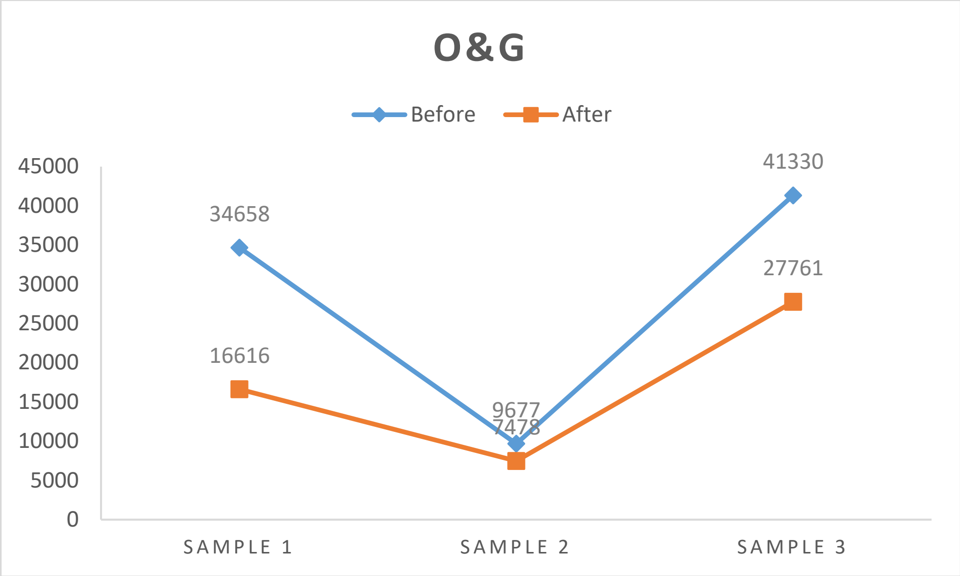

Fig 4: Removal of oil & grease using hydrochloric acid from waste coolant effluent sample

3. Efficiency of organic content removal by hydrochloric acid

As the acid breaks the emulsion bond, the free oil is separated from the sample. Once the free oil is skimmed off, the organic load of the sample reduces too. Hence, resulting in an average COD reduction of 46.4 % and average BOD reduction of 41.4 % .This also results in reduction of TSS content of the sample by 32.9 %.

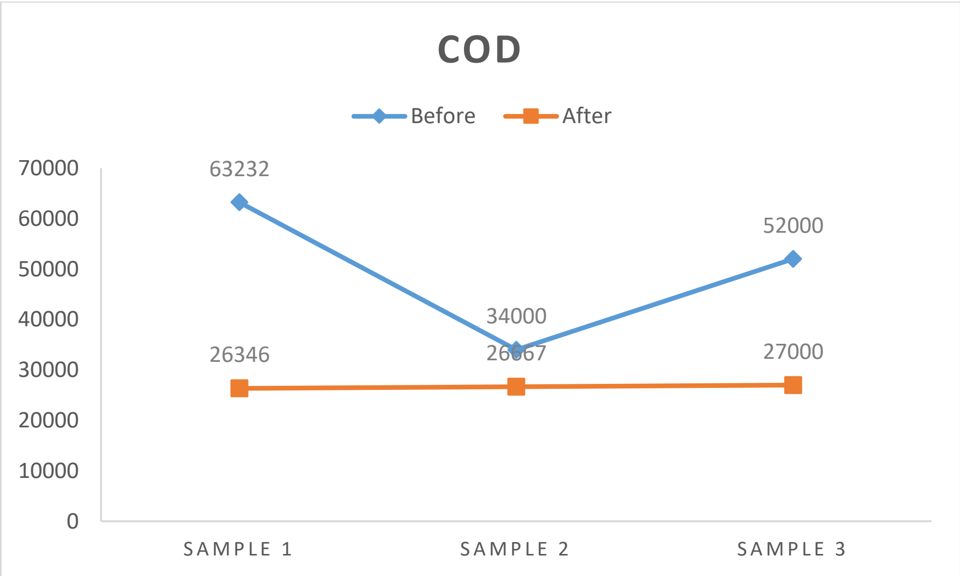

Fig 5: Removal of COD using hydrochloric acid from waste coolant effluent sample

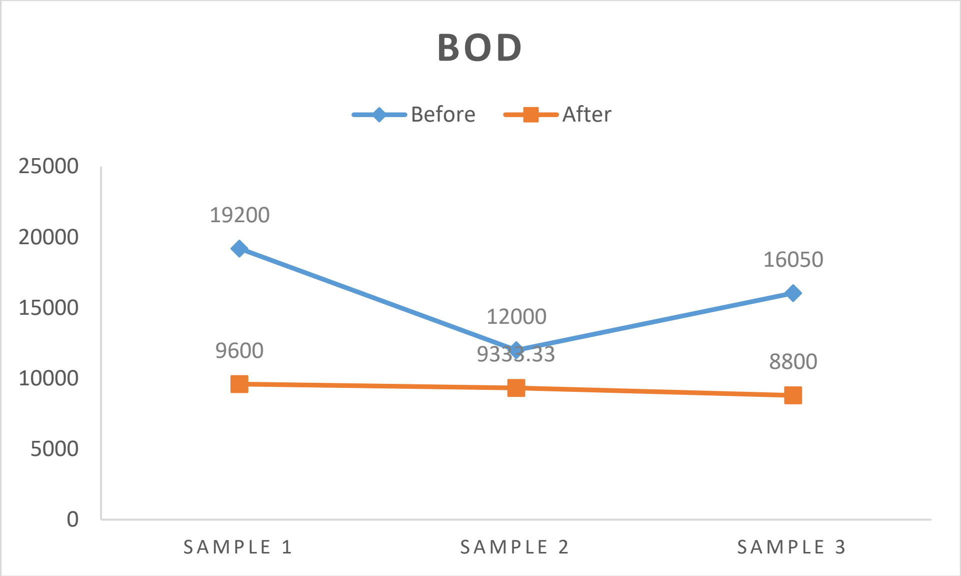

Fig 6: Removal of BOD using hydrochloric acid from waste coolant effluent sample

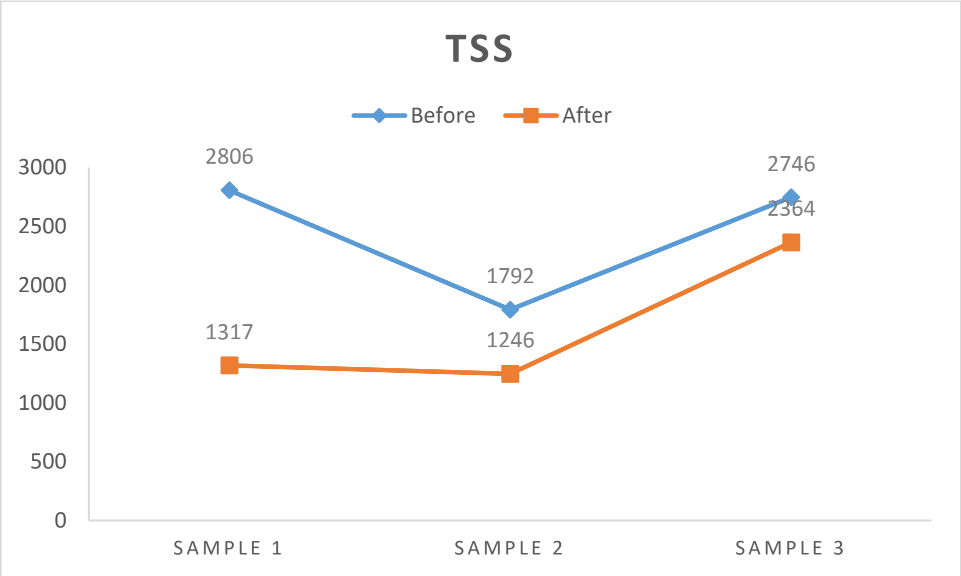

Fig 7: Removal of TSS using hydrochloric acid from waste coolant effluent sample

4. Efficiency of chloride removal

Since the acid used for the experimentation is hydrochloric acid, during the reaction, it adds to the chloride content of the sample. This results in negative efficiency of 80% in the chloride levels of the sample.

5. Efficiency of TDS removal

Along with chlorides, the hydrochloric acid added to the sample for splitting of the emulsion bond, increases TDS content of the sample. This results in negative efficiency of 69.2% in the total dissolved solids levels of the sample.

Overall result of acid-cracking trials:

Table 2: Analysis results for acid cracking

HCL Acid dosing in Waste Coolant Tank - Analysis results								
Sr. No.	Parameters	Units	Activity	Sample 1	Sample 2	Sample 3	Average	Increase / Decrease (After - Before)
1	Oil Layer Separation	mm	Before	5.00	2	1	2.67	6
			After	10.50	6	9	8.50	
2	PH	NA	Before	9.2	8.7	8.4	9	NA
			After	2.5	1.5	1.5	2	
3	TDS	mg/l	Before	3309	5226	5070	4535	10190
			After	9074	19531	15570	14725	
4	TSS	mg/l	Before	2806	1792	2746	2411	-806
			After	1317	1246	2364	1770	
5	COD	mg/l	Before	63232	34000	52000	49744	-23073
			After	26346	26666.67	27000	26671	
6	BOD	mg/l	Before	19200	12000	16050	15750	-6506
			After	9600	9333.33	8800	9244	
7	Oil & Grease	mg/l	Before	34658	9677	41330	28555	-11270
			After	16616	7478	27761	17285	
8	Chloride	mg/l	Before	1039	1066.48	1291.51	1132	4773
			After	4998	6726.64	5992.82	5906	
9	Sulphate	mg/l	Before	547	113.78	465.63	375	268
			After	100	65.1	1766.4	644	
10	Phosphate	mg/l	Before	265	869.04	1514.7	883	263
			After	498	2539.8	400.86	1146	

*negative sign indicates decrease in pollutant concentration

To implement acid cracking treatment at the plant level, a tap was installed on the coolant storage tank to facilitate oil and grease removal.

Figure 8: Acid Addition at the coolant storage tank

Figure 9: Tap fit to the tank for O&G removal

4. **Conclusion**

Major conclusion of this study is that hydrochloric acid definitely helps in cracking of the emulsion bond at pH 2. This helps in reduction of the pollutant concentration by lowering the oil & grease, COD, BOD and TSS values. But on the contrary it also increases the TDS and chloride content of the treated water. In countries like India where we have regulatory norms for treated effluent discharge, acid cracking can be followed by conventional biological treatment to bring BOD and COD under prescribed limits and later deploy tertiary treatment to bring the TDS and chloride under prescribed limit.

5. References

George R. Alther, Industrial treatment *"How to remove emulsified oil from waste water with organoclays", WATER Engineering & Management (2001)*

*MLS Welz, N Baloyi and DA Deglon, "Oil removal from industrial wastewater using flotation in a mechanically agitated flotation cell", Department of Chem*ical Engineering, University of Cape Town, Rondebosch 7701, Cape Town, South Africa, ISSN 0378-4738 = Water SA Vol. 33 (2007)

Scott Kidd and John S Bowers, *"Treatment of mixed waste coolant", HAZMACON,* UCRL-JC-118902 (1995)

Richard G. Luthy, Robert E. *Selleck, Terry R. Galloway, "Removal of emulsified oil with organic coagulants and dissolved air flotation", Jouhsal Watehp Ollutioxco Strol Federation,* Washington, D. C. 20016 (1978)