MET TECHNOLOGY: INNOVATIVE MICROWAVE-INDUCED SEPARATION FOR OIL-WATER MIXTURES IN THE WASTE DISPOSAL SECTOR

SRH Team: Prof. Dr. Ulrike Gayh & M.Sc. Vilmaurora Castillo-Moie
GiveTech Team: Dr. T. Seyrich & A. Blätte

INTRODUCTION

Oily wastewater originates from metalworking processes [1] and crude oil extraction, transportation, and processing [2]. Its treatment is crucial to prevent environmental damage, as untreated wastewater increases organic load, reduces sunlight in water bodies, and disrupts aquatic ecosystems.

Chemical methods for emulsion splitting are widely used for quick separation and effective emulsifier matching. However, they have drawbacks such as producing by-products, causing secondary pollution, and incurring high costs[3]. In recent years, there has been a notable increase in the utilization of microwave technology, largely due to its efficacy in accelerating chemical reactions[4]. In 2008, the European Patent Office designated a Patent to the MET (Microwave Induced Emulsion Separation) technology, also known as the MET device. The results of various studies provided valuable initial findings, including a separation rate of up to 90% of the oil in the water. The project's objective is to assess the separation performance and energy efficiency of the MET process through comparative tests on a small-scale experiment.

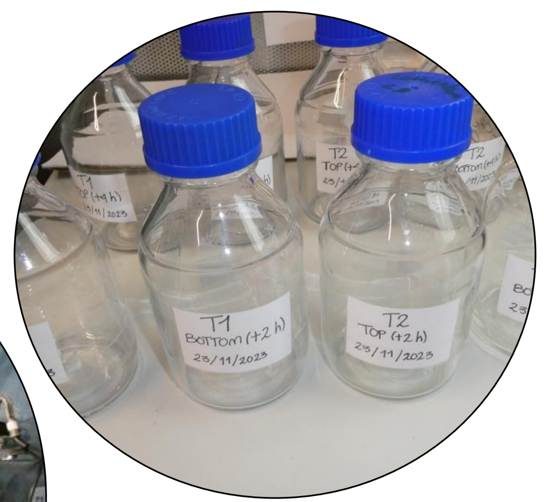
EXPERIMENTAL SETUP

The emulsion material utilized in this study was procured from a waste disposal company in Mannheim. The research involved an examination of emulsions containing approximately 5% mineral oil and emulsions containing a greater than 50% mineral oil concentration. Two 200-liter stainless steel tanks were filled to a volume of 80% of their total capacity, which corresponds to 160 liters.

Subsequently, a heating element was introduced into each tank. Each heating unit was connected to the temperature controller to maintain the emulsion at a temperature of 60°C. Each sample was comprised of 2 bottles, taken from the upper and lower sections of the tank. Two MET treatments were conducted in Tank 1 at a designated time throughout the course of each experiment. The physico-chemical analysis, including measurements of pH, temperature, conductivity, salinity, and total dissolved solids (TDS), was conducted using a Voltcraft multimeter (modelKBM 700) with a range of electrodes.

A series of statistical tests were employed to ascertain the impact of the MET treatment. Specifically, the Mann-Whitney U-tests were employed, as these do not assume a normal distribution of the samples (excluded according to the Kolmogorov-Smirnov test with a significance level of $p < 0.05$).

The heating, stirring, and MET devices were connected to an energy meter to measure the energy consumption.



MET Technology

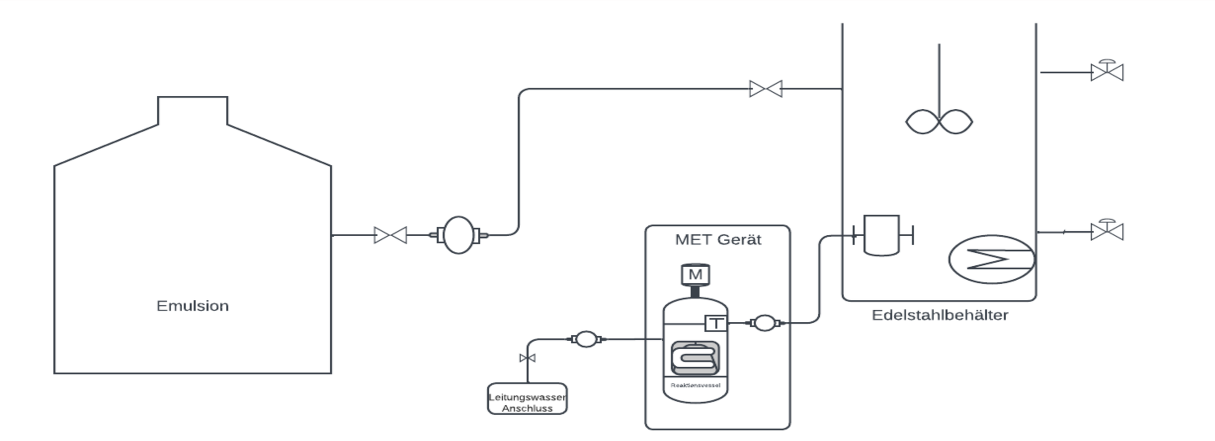


Figure 1. Flow chart of the emulsion treatment with the MET device.

Figure 1 depicts the general MET treatment process. However, the process within the MET device occurs as follows: When the MET device is activated, the internal glass container is filled with water. The generation of microwaves by the magnetron is triggered by the sensors as soon as a sufficient water level is detected, resulting in a heating reaction within the glass container. During the thermal reaction in the glass container, the treated water vapor ascends and flows through a metal lance that has been inserted into the container with the emulsion to be treated.

RESULTS AND DISCUSSION

In all four experiments, the parameters reflected typical emulsion phase separation, with oil droplets coalescing into a distinct phase. The salt content remained mostly in the aqueous phase due to its high solubility in water, resulting in lower conductivity in the oil phase compared to the aqueous phase. Regarding the water content, significant statistical differences were identified in 3 of the 4 tests with 95% certainty between the tank treated with the MET device and the control tank. *Figure 2* illustrates the behavior of the top samples from the experimental trial #1.

The calculation of the energy requirement for a single MET treatment resulted in a value of 9.44 kWh. In comparison, various emulsion treatment devices from other suppliers indicate an average energy consumption of approximately 50 kWh/m³. However, it should be noted that the costs of a MET treatment are lower compared to the other emulsion splitting processes due to the non-use of chemicals.

Figure 2: Water content of the upper samples from experimental trial #1

CONCLUSIONS AND RECOMMENDATIONS

The MET treatments showed a significant improvement in emulsion separation, proving it to be an effective addition to existing technologies. MET technology offers an economical and sustainable option for emulsion separation. Further optimization is recommended, including acquiring specialized equipment, improving heating methods, increasing sample size, using duplicate determinations, and extending experiment duration.

WWW.DEMOCRATIA-AQUA.ORG

REFERENCES

(1). Isenburg, T. (2008). Sparen mit Vakuumverdampfern: Prozesswasser-Aufbereitung. JOT Journal für Oberflächentechnik, 48, 62-68.
(2). Gidarakos, E. K. (1989). Entsorgung von Öl-in-Wasser-Emulsionen durch Elektrokoagulation. Chemie Ingenieur Technik, 61(6), 443-448
(3). Kovaleva, L., Zinnatullin, R., Musin, A., Gabdrafikov, A., Sultanguzhin, R., & Kireev, V. (2021). Influence of radio-frequency and microwave electromagnetic treatment on water-in-oil emulsion separation. Colloids and Surfaces A: Physicochemical and Engineering Aspects, 614
(4). Fortuny, M., Oliveira, C., Melo, R., Nele, M., Coutinho, R., & Santos , A. (2007). Effect of salinity, temperature, water content and pH on the microwave demulsification of crude oil of emulsion. Energy & Fuels, 21(3), 1358-1364.

Funded by the DAAD from funds of the Federal Foreign Office:
DAAD Deutscher Akademischer Austauschdienst German Academic Exchange Service
Federal Foreign Office