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DELIVERABLE

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1. Executive Summary

This deliverable describes the work done within Task 8.2 "Pilot I - OMV Pilot (Austria)". Based on the D 8.1, the Hydroptics Sensing Platform ("Prototype") was transported to the assigned test side at OMV premises. After passing all test concerning HSSE topics, the Prototype was connected to the process stream at the OMV Water Treatment Plant selected in T.8.1

The Prototype was piloted between CW42 and CW48 2023 providing uninterrupted data acquisition over several hours per day, even after a substantial change in the composition of the monitored process stream.

2. Table of Contents

1. Executive Summary 2
2. Table of Contents 3
3. Introduction 4
4. T8.2: Pilot I – OMV Pilot (Austria) 4
4.1. Prototype Implementation at OMV Test site 4
4.2. Sampling points 5
4.3. System Optimization 5
5. Results 6
6. Conclusions 11

3. Introduction

WP8 "Hydroptics sensor validation in real industry settings & Process optimization" experienced both a major setback as well as a severe time delay due to the termination and liquidation of the project partner QRT. QRT would have been responsible for the assembly of all sensor systems in a fit for industry usage (with obvious regards on HSSE concerns) setup. Hindered by the legal fallout of QRT's termination, the prototype had to be reconstructed by TUW and SAL. This led to the decision to split the Prototype into two modules, one tasked to cope with the liquid handling (separation of oil and water for both modules) and the oil in water analysis (including oil extraction, Module A, TUW), the other one (Module B, SAL) dealing with the particle measurement of the designated process streams. Meanwhile, and after the successful testing of the two modules at TUW & SAL premises, OMV was busy to tackle all HSSE concerns regarding piloting a prototype with no conformity declarations on electrical and occupational safety within a facility of the oil and gas industry. In a joint effort, the authorization for testing the prototype at OMV premises was given in CW 42. Field Testing started immediately afterwards.

4. T8.2: Pilot I – OMV Pilot (Austria)

4.1. Prototype Implementation at OMV Test site

On October 17th, Module A was successfully connected to the process stream of OMW water treatment plant (OMV WTP) in Schönkirchen as selected in D8.1 (Figure 1).

Figure 1: Hydroptics Oil in water module connected to the process stream of OMV WTP

The module was measuring two times for 4 hours without any electrical issues or liquid leakages on this day. During the whole pilot phase, reference samples were taken and analysed at OMV TECH Center & Lab to enable assessing the accuracy of the prototype at a later point in time.

Module B arrived on October 23rd, 2023, at OMV premises and was connected to Module A (and thus to the OMV process stream) on the same day. No electrical issues or liquid leakages could be observed during operational time (Figure 2).

Figure 2: Modules A & B connected and measuring OMV WTP process stream

4.2. Sampling points

Due to the continuous sampling and monitoring program implemented for facility surveillance, the WTP Schönkirchen is equipped with a multitude of sampling points. These are located before and after the three water treatment stages and in most cases laid out for manual sampling. After laboratory testing of the prototype, only the last two stages (see Table 1) were considered as suitable field-testing connection points. Connecting the prototype upstream would have heavily increased the risk of losing test time due to prolonged (manual) cleaning operations caused by heavy oil content.

Table 1: Sampling point overview for WTP Schönkirchen

Sampling Point	Flow rate [m³/h]	Pressure [barg]	Temperature [°C]	Oil content OiW [ppm]	Solids TSS > 3 µm [mg/kg]
After DGF/before NSF			36	~ 40	1.4
WTP Outlet	~ 800	10	36	~ 6	~ 0.3

4.3. System Optimization

A substantial change in the composition of the analyzed process stream led to a severe performance deterioration of the oil water separation step in Module A. The (beforehand) operation time of hours was reduced to 30 minutes as the built-in centrifugal separator ceased to function properly (separation of oil and water did not work) . This led to blockage of the downstream installed membrane separator. The testing had to be suspended and the membrane had to be replaced by a new one.

The problem was sucessfully circumvented by adjustments of flow- and revolution rate in the centrifugal separator bringing up the the operational time to hours again.

Beforehand performed laboratory testing with field samples from the OMV test site showed that the Hyper Spectral Imaging (HSI) component built in Module B showed, the integration time needed to achieve an acceptable SNR is too long (~50 ms) and thus not applicable for the imaging of moving particles. Increasing the illumination would decrease the integration time but would heat up the flow cell even more, which has a detrimental effect on the performance of the employed ultrasonic particle trap. Therefore, the HSI system was not operated during the field test at OMV premises.

5. Results

The field test at OMV premises showed that both prototype Modules, A and B, can be connected (standalone or in series) to the selected OMV process stream(s) without causing any HSSE incident (leakages, fires), neither impairing nor altering the analysed OMV process itself.

Module A (Oil in Water measurement) clearly showed different responses when connected to sampling points (see 4.2) with varying oil in water contents, which is a first-hand success demonstrating the system's sensitivity to distinguish different oil in water concentrations (Figure 3). The alignment of concentrations with value from reference measurements is then – as known from other online analysers – a matter of data postprocessing and calibration efforts.

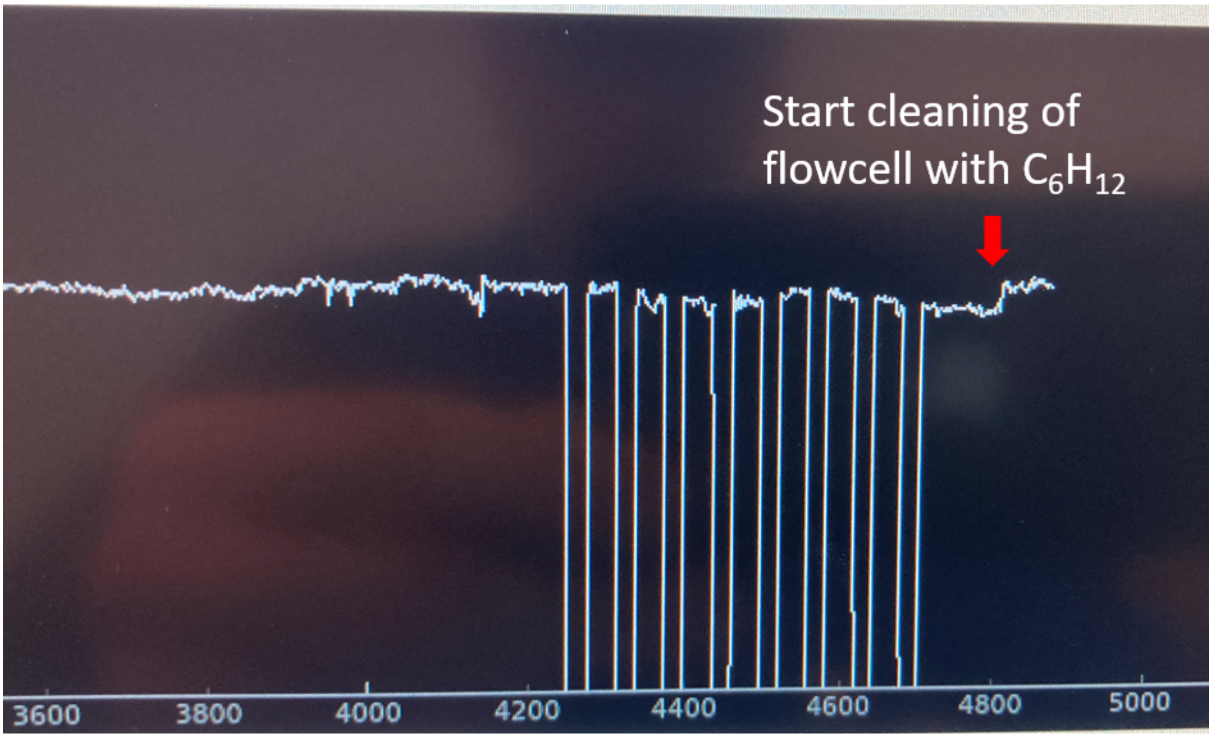

Figure 3: Internal Data logger of Module A during a measurement at OMV premises.

Module B (particle measurement) confirmed OMV analytics on particles (Total Suspended Solids, TSS): The solids in the analysed OMV process stream(s) are usually small (5 microns and smaller) and the amount is usually low (Figure 4). Nevertheless, the heterogeneity in size and composition (resulting in varying sonic contrast) rendered the ultrasonic particle "trap" (for bringing particles into the focus of the imaging system) ineffective, despite the promising laboratory tests (with model particles).

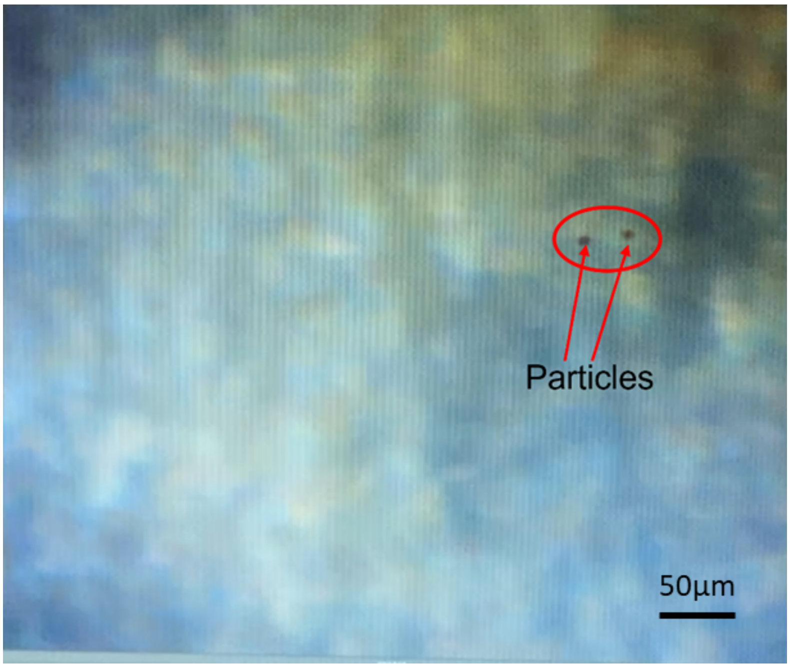

Figure 4: Particles in OMV process stream in the Flow cell of Module B.

Hence, it was not possible to image particles in the volume of the flow cell. Despite evaluating a wide range of frequency and power setting of the ultrasound manipulation and various flow speeds, the focusing and guiding of particles via the ultrasound particle manipulation was only slightly noticeable but not pronounced enough to guide the particles into the focal plane of the imaging systems. However, the system can detect particles, air bubbles and droplets on the surface of the optical window. This makes it possible to judge the size of present particles, as well as the presence of oil droplets or cyclohexane. The imaging situation in the flow cell is challenging for WLI due to the low optical contrast. The low optical contrast is caused by the light reflected from the bottom of the aluminium flow channel. However, this is beneficial for dark particles which would not be visible on a dark background. This finding was confirmed by evaluating different coatings. Despite the well-visible colours of the model particles in the laboratory tests, the particles in the field test appeared all dark without colour. This may be due either to the small size of the particles, or the fact that they are all dark in appearance and that the assumption that colour can be used to infer about the particle material is not true. However, field test data show that oil droplets have a brown colour compared to transparent cyclohexane droplets. Example images from particles, oil droplets and air bubbles on the optical window are shown in Figs. 5-7.

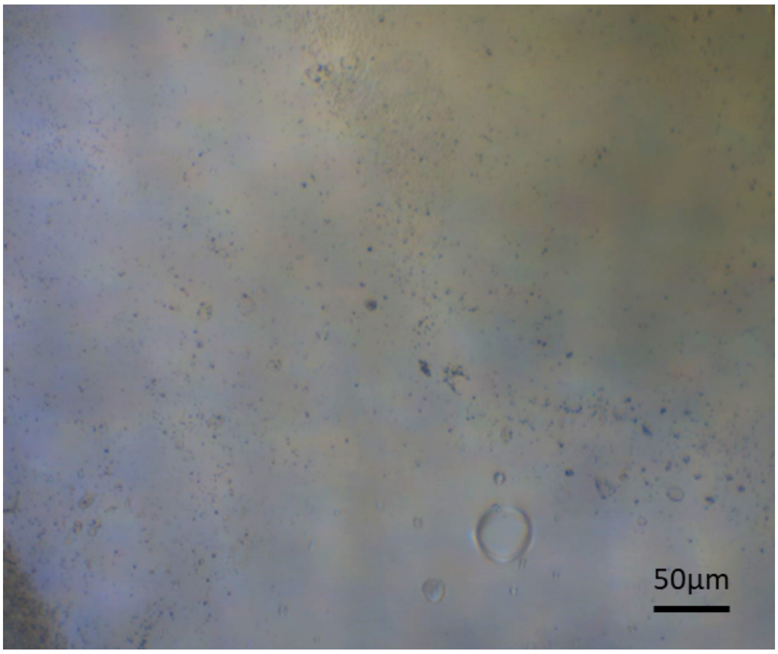

Figure 5: Particles, air bubbles and oil droplets on the optical window.

If cyclohexane was still present in the process water and the ultrasound manipulation was active, the cyclohexane droplets were pushed to the measurement window and covered the whole window.

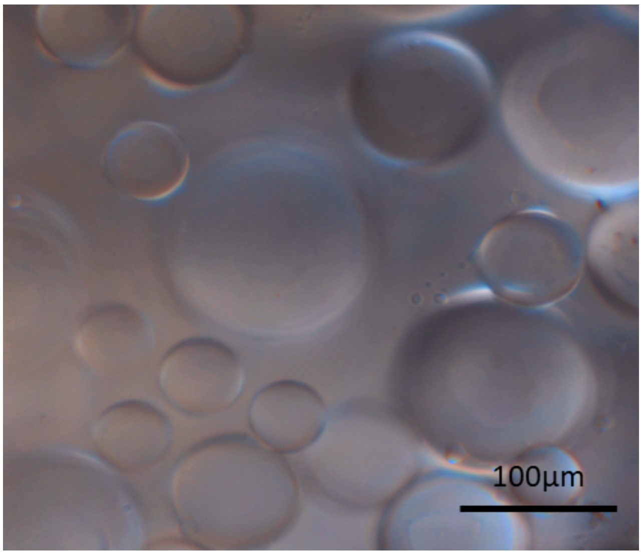

Figure 6: Cyclohexane droplets on the optical window with active ultrasound manipulation.

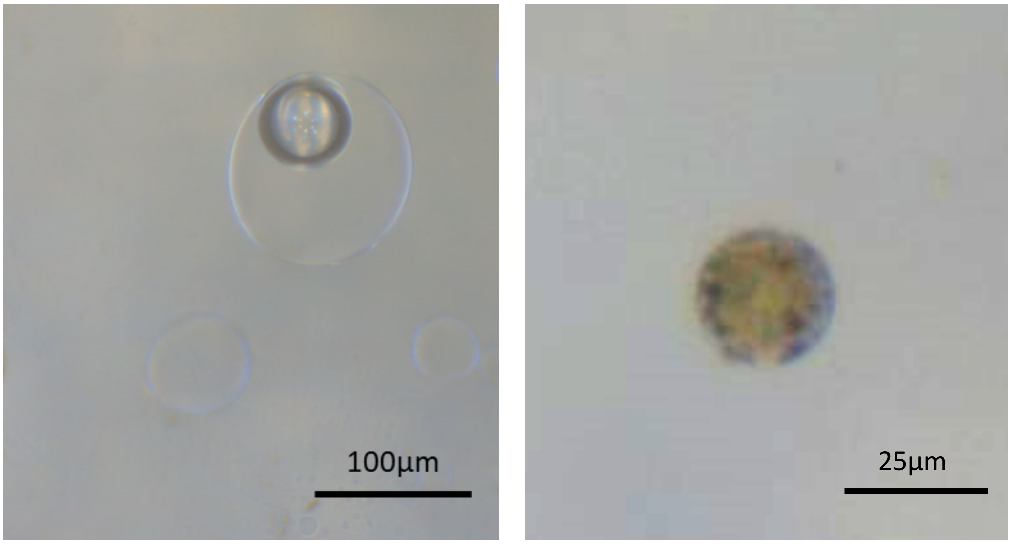

Figure 7: Cyclohexane droplets with air bubble inside (left). Oil droplets with particles inside (right)

On the other hand, the built-in Fluorescence Imaging (FLI) device provided size distribution data (Figs. 8 and 9) on the oil droplets in OMV process stream(s), which is important when dealing with oil/water separation optimization. As for the solid particles, the ultrasound manipulation showed some guiding effect for the oil droplets but was not able to keep the oil droplets in the focus of the imaging system. This is due to the size distribution of the oil droplets. How much an oil droplet is affected by the force applied by the ultrasound manipulation depends on the size of the droplet, its acoustic contrast, the flow speed, and the settings of the ultrasound manipulation (frequency, power). If there is a broad range of oil droplet sizes, then medium-sized droplets will be guided, large droplets will not be affected, and small droplets will get trapped. The situation gets even more complex if different particles and droplets with different acoustic contrasts and size distributions are present at the same time in the process water stream. Hence, an analysis of the size distribution of oil droplets was only possible for oil droplets lying on the optical window of the flow cell.

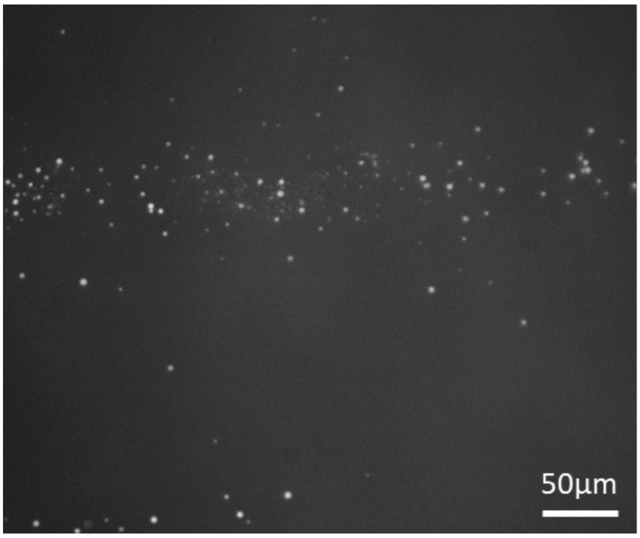

Figure 8: Fluorescence images of oil droplets in OMV process on the optical window of the flow cell.

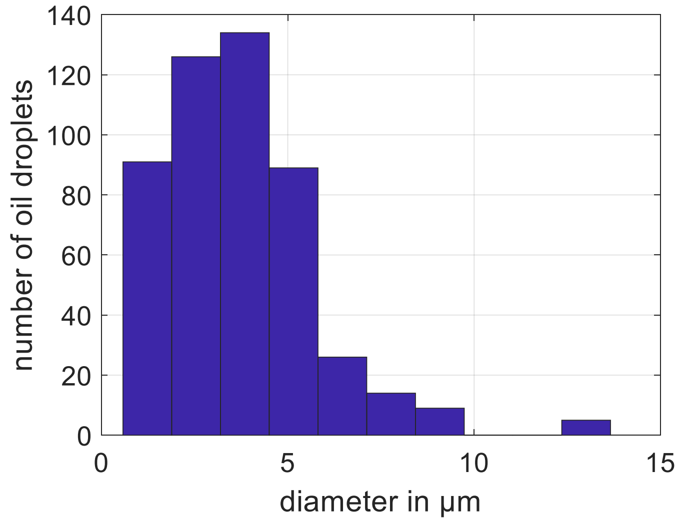

Figure 9: Histogram of size distribution of oil droplets in OMV process derived from fluorescence images.

6. Conclusions

The Hydroptics Sensing Platform Field test (Task 8.2) at OMV premises successfully demonstrated the functionality of the prototype (even after partial reconstruction) and the measurement principles of the built-in sensing device in an industrial environment.

It also showed – again – the importance of piloting prototype-state online analyser under field conditions for both sides, the technology provider, as well as the interested party, as even the most intensive laboratory testing (even with field samples provided) is no real substitution for onsite testing.

This includes not only environmental and process conditions, which cannot be recreated in the laboratory, but also HSSE topics that are not (due to its inherent nature) applicable for laboratory surroundings.