Industrial Water in the Automotive Industry

Public report

Project within FFI Sustainable Production
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Content

1. Summary

This project aims to support the automotive metal manufacturing industry in enhancing sustainability and environmental performance by reducing the consumption of freshwater, chemicals, and energy. To achieve this, tailored water treatment processes and analytical methods were developed to ensure appropriate water quality for reuse and recirculation in various production processes. In collaboration with chemical and equipment suppliers and research institutions, the project seeks to establish a scalable and replicable framework for water-efficient manufacturing.

The project was structured around three distinct business cases, each addressing specific needs identified by different OEMs:

1. **Volvo Trucks and Volvo Construction Equipment (VCE):** Focused on optimizing water treatment technologies to increase water recirculation and reuse. Trials with evaporators and membranes demonstrated up to 95% water reuse at VCE and successful reuse in cooling towers at Volvo Skövde. Ozone treatment and acoustic sensors were also tested, contributing to improved bacterial control and predictive process modelling.

2. **Scania:** Investigated methods to extend the lifetime of heat treatment process baths, which are typically replaced every four weeks due to bacterial contamination. UV and ozone treatments were evaluated, alongside in-line and impedance sensors for monitoring fluid quality and microbial activity. While lab results showed effective bacterial reduction, on-site results were less conclusive, indicating the need for further investigation.

3. **Aurobay:** Examined the reuse of cutting fluids in washing processes and their impact on process stability. Data on water quality and process parameters was integrated into a data management platform to support predictive modelling. Mapping of water flows for the current state was provided to understand hot-spots for water use. Characterisation factors for environmental impacts of water use are included to evaluate the system and potential scenarios. The platform's development should include data acquisition, storage, statistical analysis, and visualization, with the goal of enhancing process monitoring and early detection of deviations.

Across all cases, the project pursued key objectives including specification of water quality requirements, development of in-line sensors, biological growth detection methods, and environmental and cost assessments. The outcomes contribute to reduced freshwater usage, improved process efficiency, and enhanced sustainability in metalworking operations.

2. Sammanfattning på svenska

Projektets syfte är att stödja metallbearbetning inom fordonsindustrin i arbetet med att öka hållbarheten och uppnå miljömål genom att minska förbrukningen av färskvatten,

kemikalier och energi. För att uppnå detta krävs skräddarsydda vattenbehandlingsprocesser samt analysmetoder som säkerställer att vattenkvaliteten är anpassad till respektive process där vattnet ska återcirkuleras eller återanvändas. I samarbete med kemikalie- och utrustningsleverantörer samt forskningsinstitut syftar projektet till att etablera en skalbar och reproducerbar modell för vatteneffektiv användning, vilket bidrar till minskad miljöpåverkan, förbättrad driftseffektivitet och långsiktig resursanvändning inom fordons- och metallindustrin.

Projektet delades upp i tre business case, var och en med fokus på olika behov identifierade av respektive OEM:

1. **Volvo Lastvagnar och Volvo Construction Equipment (VCE):** Fokus låg på att optimera vattenbehandlingstekniker för ökad återcirkulation och återanvändning av vatten. Tester med indunstare och membran visade upp till 95% återanvändning av vatten hos VCE, samt möjligheten att återanvända behandlat vatten i kylsystemet vid Volvo Skövde. Ozonbehandling och akustiska sensorer testades också, vilket bidrog till förbättrad bakteriekontroll och prediktiv processmodellering.

2. **Scania:** Undersökte metoder för att förlänga livslängden på processbad inom värmebehandling, som idag byts ut var fjärde vecka på grund av bakteriekontaminering. UV- och ozonbehandlingar utvärderades, tillsammans med in-line-sensorer och impedanssensorer för övervakning av vätskekvalitet och mikrobiell aktivitet. Laboratorietester visade god bakteriereduktion, men resultaten från tester på plats var mindre entydiga, vilket kräver vidare undersökning.

3. **Aurobay:** Fokuserade på återanvändning av skärvätskor i tvättprocesser och dess påverkan på process stabilitet över tid. Data om vattenkvalitet och processparametrar integrerades i en dataplattform för att stödja modellering och kvalitetsprognoser. Kartläggning av vattenflöden för nuvarande hantering gjordes för identifiering av hot-spots. Karakteriseringsfaktorer för beräkning av miljöpåverkan laggats till för evaluering av nuläge och scenarier. Plattformens utveckling omfattade datainsamling, lagring, statistisk analys och visualisering, med målet att förbättra övervakning och tidig identifiering av avvikelser.

Gemensamt för alla business case var att projektet strävade efter att specificera vattenkvalitetskrav, utveckla sensorer för in-line-analys, etablera metoder för biologisk tillväxtkontroll samt genomföra tekniska, miljömässiga och ekonomiska analyser. Resultaten bidrar till minskad färskvattenförbrukning, förbättrad processeffektivitet och ökad hållbarhet inom metallbearbetning.

3. Background

The metal manufacturing industry is the third largest consumer of fresh water in Sweden, accounting for approximately 325 million cubic meters in 2015—around 15% of the country's total industrial water usage. Water plays a critical role in various manufacturing processes such as machining, washing, and heat treatment, particularly in the production of engine components for the automotive sector. These processes rely heavily on water as

a constituent in process fluids, for bath replenishment due to evaporation, and for bath replacement when contamination occurs from biological growth, particles, chemical drag-in, or poor water quality.

The project is built through insights from the previous Industrial Water project (Vinnova DNo. 2019-00954), conducted by a consortium including Scania, Volvo CE, Volvo AB, IVL, Chalmers, and RISE. That initiative mapped water usage and treatment in metal machining processes, identified water quality parameters affecting fluid performance and bath longevity, and explored available and emerging sensor technologies for monitoring these parameters. While some solutions are commercially available, others require adaptation or further development to meet specific industrial needs.

This project is dedicated to the development of solutions aimed at minimizing tap water consumption through the reuse of process water within the metal manufacturing industry, thereby enabling intelligent water recycling. Moreover, improved control over water quality enhances the efficiency of process baths and associated metalworking operations. This leads to increased productivity by reducing bath contamination and minimizing production interruptions caused by bath replacement. These solutions are expected to reduce the environmental impact of metalworking processes by lowering chemical usage, mitigating workplace exposure risks, and decreasing energy and waste generation ultimately contributing to more sustainable manufacturing practices.

4. Purpose, research questions and method

Purpose

The purpose of the project is to support the metal manufacturing in the automotive industry in their efforts to increase sustainability and environmental goals through the decrease the consumption of fresh water, chemicals and energy. To achieve this, tailored water treatment processes need to be put in place as well as analysis methods to supply the processes with the appropriate water quality in correspondence with the process where it will be recirculated or reused. With assistance of chemical and equipment suppliers in collaboration with research institutions the project aims to establish a scalable and replicable framework for water-efficient manufacturing, contributing to reduced environmental impact, improved operational efficiency, and long-term resource sustainability in the automotive and metalworking sectors.

Research Questions

The project investigates key challenges in water optimization in the metal manufacturing processes. Central research questions include the identification and evaluation of treatment processes capable of achieving the required quality standards for water reuse and recirculation.

Effects of recirculation on process fluids and bath lifetime: How does recirculation of cutting and washing fluids influence critical performance metrics, product quality and

bath failure modes (e.g., microbial spoilage, foaming, loss of lubricity, cooling curve), and which recirculation strategies optimize bath lifetime while preserving process performance? LCC and LCA for different water and chemical treatment solutions?

Treatment technologies for reuse & recirculation: Which individual treatment processes or hybrid treatment trains (physical/chemical, biological, membrane-based) can consistently produce process water from metal-manufacturing streams that meet defined reuse quality criteria (e.g., BOD, oil index, nitrification-inhibiting compounds, TDS/conductivity)? How does an increased amount of ester-based products replacing mineral-oil based chemicals impact the treatment technologies?

Impacts of UV and ozone treatment: What are the effects of UV and ozone on microbial control, removal of organic contaminants and on the functional properties of process fluids (e.g., surfactant performance, lubricity, cooling curve), and what dose/contact-time windows achieve disinfection without degrading fluid functionality?

Inline measurement and real-time control: How can inline sensors and control strategies provide reliable, actionable real-time data for automated dosing, filtration control and predictive maintenance to reduce freshwater and chemical consumption while ensuring traceability and process stability?

Method

The project was divided into three different business cases, each one attending different priorities or needs set up by the different OEMs. One business case focused on water treatment technologies and processes for increased water recirculation or reuse in another section of the production site. The second case focused on the reuse of cutting fluids in the washing process and analyzing its effect in a short-medium term. Finally, the third business case aimed at prolonging the lifetime of the process baths for the heat treatment process. In all three business cases different sensors were tested for measuring water quality and process fluids parameters. Additionally, water treatment processes for separation of process fluids from water or bacterial control and decontamination were tested.

5. Objective

The primary objective of this project is to develop innovative solutions for smart water recirculation and reduced water usage within the automotive industry, while simultaneously minimizing the consumption of chemicals in process fluids and reducing industrial waste.

During the project the following objectives were pursued:
- Specification of the water quality necessary for the different processes and process fluids
- Establish limits or boundaries for the quality parameters of water
- Understand the impact of water quality in process efficiency
- Water treatment technologies capable of providing the required quality

- Development of sensors for in-line analysis and monitoring of water quality parameters
- Methodologies of biological (bacteria, fungi, mould) growth detection and prevention
- Technical, environmental, and cost analysis of different water and fluid treatment methods
- Development and implementation of a water management plan
- Environmental and cost assessment of water life cycle and process life cycle

6. Results and deliverables

The business case conducted at Volvo Trucks (Volvo Lastvagnar) and Volvo Construction Equipment (VCE) centred on the recirculation and reuse of water from the treatment facility, achieved through the selection and optimization of appropriate treatment processes. In response to increasingly stringent municipal regulations regarding effluent discharge, the project also aimed to identify and evaluate processes capable of ensuring compliance with water quality standards.

Experimental trials were carried out using various equipment—including evaporators, polishers, and membranes—at the OEMs' facilities, at IVL's bed test site, and at the premises of the equipment suppliers. Key water quality parameters such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), nitrification inhibition, and oil index were monitored and measured to assess the effectiveness of the treatment processes.

The results demonstrated a significant improvement in water reuse, with VCE achieving up to a 95% increase in water recirculation. At the Volvo site in Skövde, the tests confirmed the feasibility of reusing treated water in the cooling tower system. Furthermore, the trials contributed to enhanced decontamination of water effluents, particularly in the treatment of bio-based process fluids and glycol compounds. Additionally, ozone treatment was evaluated at both OEMs for its effectiveness in bacterial decontamination and reduction of nitrification inhibitors, yielding promising results. An acoustic sensor was also tested at VCE to monitor process fluid concentration and water quality parameters. The data collected from these measurements were integrated into a predictive model to support simulation and forecasting of process performance. The results archived from evaluating the impact of an increased amount of ester-based products suggests that while the evaporators over all had better performance with ester based products there was higher effluent concentrations after UF and RO. There were however not measurable differences in fouling or treatability with the membrane technologies during the tests but to fully evaluate this further long term pilot operation is needed.

These outcomes align with the overarching goals of the project, contributing to reduced freshwater consumption and enhanced sustainability and productivity in metalworking operations.

The business case at Scania focused on the heat treatment process, specifically investigating methods to extend the lifetime of the process baths. These baths currently require replacement every four weeks due to bacterial contamination, resulting in both environmental and economic drawbacks. To address this issue, two water treatment technologies, ultraviolet (UV) irradiation and ozone treatment, were evaluated.

The effectiveness of these treatments was assessed at both laboratory scale, at the facilities of the technology providers, and in situ at one of the induction hardening lines at Scania's Södertälje plant. To enhance process control, an in-line sensor was installed by the chemical supplier. This sensor enabled continuous monitoring of key parameters such as process fluid concentration, temperature, and pH. Given that water evaporation during operation can alter fluid concentration, the sensor plays a critical role in maintaining consistent process conditions. Concurrently, bacterial concentrations were monitored using an impedance sensor at RISE, providing additional insights into microbial activity during the tests.

The potential degradation of the quenching fluid due to UV and ozone treatments was examined across various treatment concentrations. No significant degradation of the fluid was observed.

While laboratory tests, treating the process fluid, demonstrated effective bacterial decontamination with both treatment methods, the results from on-site testing at Scania were less conclusive. Although bacterial growth was reduced in influent, contamination persisted in the process baths. Further investigation is required to better understand the origin of the bacterial contamination and to identify the need for renewal of the process bath. A suitable and sustainable control strategy need to continue to monitor pH, temperature and include proper cleaning of equipment. The project clearly demonstrated the potential of ozone and UV-treatment directly in the process bath without impact on the cooling curves. The next step would be a full-scale implementation. The holistic evaluation showed little impact on water consumption in the specific case since water consumption is mainly due to evaporation and drag-out losses. The benefits of the prolonged process bath lifetime are rather associated with reduced chemical consumption and reduced need for transportation and destruction of process fluids. Demineralised water was also evaluated in the process and could be a part of the solution along with prolonged lifetime of process baths as evaporation increases mineral concentrations in the baths that could see increased impact with prolonged bath life. It should also be mentioned that even if results are inconclusive from the full-scale test operation at Scania, some process baths were operated for eight weeks instead of four weeks demonstrating that much can be done.

Additionally, further testing of the impedance sensor is necessary to differentiate the signal generated by the process fluids from that of the bacterial presence.

The business case conducted at Aurobay focused on the reuse of cutting fluids within washing processes, with the objective of evaluating the medium- to long-term effects on process stability. The study involved the analysis of water quality, process parameters, and fluid concentrations across various production lines. This data was assessed for integration into a data management platform designed to support process modelling and quality prediction.

The foundational aspects of the data management platform were examined, including data acquisition, storage architecture, statistical analysis, and visualization techniques, with the aim of enabling predictive capabilities. Continued development of this platform is expected to enhance process monitoring and facilitate early detection of deviations, thereby contributing to improved operational efficiency and reliability.

The project contributes to the overarching FFI objectives by:
- Promoting collaboration between the different parties involved in the metal manufacturing processes in the automotive industry: Swedish OEMs (Volvo AB, Volvo CE, Powertrain Engineering Sweden, Scania), chemical suppliers, equipment manufacturers, sensor developers, and research institutions thereby promoting cross-industrial cooperation and increasing the capacity for research and innovation in the value chain.
- Involvement of SMEs, and international chemical suppliers. (SMEs involved: Wallenius Water, Vilokan, Mercatus, Rubertsson).
- Collaboration between chemical suppliers and OEMs for process efficiency.

The project specifically contributes to the sub-program challenge Resource efficiency in production for reduced environmental impact and increased competitiveness by:
- Reducing the carbon footprint and water footprint by minimizing freshwater consumption and creating a closed loop of water usage by recirculation.
- Improving the competitivity of the automotive industry by increasing their sustainability, process efficiency and productivity
- Increasing the metal manufacturing process efficiency
- Achieving a more robust and productive manufacturing of metal-related automotive components
- Decreasing the industry´s environmental impact by decreasing chemical consumption, energy, and generation of waste by extending the lifetime of process baths and recovering of process fluids.

7. Dissemination and publications

7.1 Dissemination

During the project, different dissemination activities were performed to discuss and inform the progress and results. The project was presented in two sessions of the Center for Process Fluid (Processvätskacentrum) whose members include automotive end-users, chemical and equipment suppliers as well as research organizations like Chalmers, KTH and RISE. Furthermore, the project results were presented in the Manufacturing R&D Cluster Conference in Gothenburg in May 2025.

How are the project results planned to be used and disseminated?	Mark with X	Comment
Increase knowledge in the field	X	A better understanding of the treatment processes and their effect in the water recirculation. Knowledge of the water quality parameters, process fluids treatment and efficiency
Be passed on to other advanced technological development projects	X	Even with the results obtained in the project, there are still areas for improvement and innovation for an increase optimization of water recirculation towards a zero waste and close loop production
Be passed on to product development projects		The initial tests and evaluation of inline sensors give valuable information regarding the control and monitoring of the metal manufacturing processes. This will continue to be developed in future projects
Introduced on the market		
Used in investigations / regulatory / licensing / political decisions	X	The increasing use of biobased process fluids raises questions regarding specifications contaminants concentration in water effluents which can be addressed for a more environmental and sustainable production.

7.2 Publications

No publications were produced during the project since the findings and results are considered confidential and belong to the participating companies.

8. Conclusions and future research

The project results show that increased recirculation can be obtained in the automotive industry. The treatment needed depends on the purpose of reuse and if a certain overflow is discharged to municipal wastewater treatment plants. High pH and high ammonium/amine concentrations are an example of parameters that show maybe slightly increased process properties but causes problems in municipal wastewater treatment plants. BOD, oil index and denitrification inhibition were also identified as problematic parameters for discharge. While ozone showed good reduction of nitrification inhibition it is recommended to evaluate it in pilot scale on discharged water. To further target BOD and oil index, it could be combined with a biological active filter.
Evaporation followed by ultrafiltration and reverse osmosis and UV showed good results for recirculating water from both metal working fluids and from the painting. On site pilot operation also demonstrated a system with ultrafiltration and reverse osmosis replacing the train as good enough for process fluid recirculation with the evaporator treating concentrates showing overall reduced CAPEX and OPEX while improving environmental performance. A clear difference was noted from studying the treatability

of spent metal working fluids mainly based on mineral oil versus those based on esters. Further research is, however, needed to better understand the impact on fouling and how operational parameters and equipment can be used to mitigate the difference.

Ozone was demonstrated and implemented for reuse of water in combination with evaporation of water from painting.

A pilot study to evaluate treatment of PAG containing wastewater was conducted and performed successfully. Good concentration factor was reached but special attention is needed in selection of technology and how to process the liquid. Overall, the results are expected to reduce waste streams and increased treatability for reuse applications. In Skövde glycol containing wastewater on the other hand showed little impact on treatability, suggesting the evaporation processes are more sensitive to glycol containing wastewater.

An innovative acoustic sensor system was implemented at a washing machine in Skövde where there had been a history of deviations in concentrations. The instability in concentration and the inability to measure concentration with available sensors resulted in increased labour for frequent manual sampling and analysis along with increased consumption of water and chemicals.

A measurement system for collecting vibration data was installed and operated 24/7 for 7 months with only one major interruption. A model was developed to predict the current production state and was used to extract vibration data when the washing machine was running. A multi-variate analysis and calibration was performed on spectra and laboratory data (Concentration, pH, Chlorine, oP, Rust). The most promising parameter for developing a prediction model was Concentration. However, the model was based on a small number of laboratory samples (132). Exact timestamps for the collection of the laboratory samples would reduce uncertainties when aligning laboratory and spectral data timestamps. The models need to be validated on a separate test set to determine how well they will perform in practice, this data was collected but could not be evaluated within the project timeframe.

The heat treatment fluids in general and the system at Scania specifically shows that further work with process monitoring and systems cleaning can likely prolong bath life to a certain degree. Both ozone and UV show disinfection capacity without affecting cooling curve. The next step is demonstrating in-situ disinfection of process liquid. Deionized water could help with salt build up and Petroseal sensor for continuous process control along with automatic top up of water. Further research would benefit from continuous, in-situ, measurements of the impedance sensor. More data points are necessary to differentiate the signal generated by the process fluids from that of the bacterial presence. Time between sampling and measurement along with temperature differences could influence results therefore on-site measurements would be necessary.

Aurobay's business case explored the reuse of cutting fluids in washing processes by analyzing water quality, process parameters, and fluid concentrations. This data was evaluated for integration into a data management platform aimed at supporting process modeling and quality prediction. Key components such as data collection, storage, statistical analysis, and visualization were assessed to enable predictive capabilities.

Ongoing development of the platform is expected to improve process monitoring, allow early detection of anomalies, and enhance operational efficiency and reliability.

The overall outcome of the project contributes to the sub-program challenge Resource efficiency in production for reduced environmental impact and increased competitiveness in some cases by development and integration during the project. For some solutions the process is outlined but verification remains.

This work depended on close collaboration between chemical and equipment suppliers in collaboration with research institutions.

9. Participating parties and contact persons

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