Final report

1. Project details

Project title	SEM-BC
File no.	64019-0105
Name of the funding scheme	
Project managing company / institution	ENABL A/S
CVR number (central business register)	DK-40 87 34 06
Project partners	Mouritsen A/S
Submission date	02 February 2022

2. Summary

Danish version:

ENABL og Mouritsen er teknologi virksomheder, som sammen vil udvikle en semi-automatisk applikation til maling af vinger til vindmøller. ENABL står for alt fra den konkrete overførsel af malingen til vingen med værktøjet og alt, der kommer før værktøjet. Og Mouritsen håndterer alt omkring selve malingen. Dette projekt vil medvirke til at reducere driftsomkostningerne, reducere forbruget af maling og elektricitet, reducere investeringen til udsugning, reducere forbruget af værktøjer samt forbedre arbejdsmiljøet for medarbejdere i vingeproduktionsindustrien. Ved brug af SEM-BC og rullemalingsteknik i stedet for sprøjtemaling vil omkostningerne ved maling af vinger til vindmøller blive reduceret betydeligt og bidrage til reduktion af Levelized Cost of Energy (LCoE). SEM-BC vil være anvendelig på alle vingedesigns, gøre malingsprocessen mere standardiseret/ensartet, og SEM-BC er fleksibel (nemt at demontere og montere), så den er brugbar til fleksibel produktion og kan f.eks. flyttes til anden produktionslinje eller anden fabrik. SEM-BC vil reducere lønomkostningerne med 50%[1] og gøre det muligt at reducere malingsforbruget med mindst 15%[2] på grund af en mere præcis lagtykkelse på hver vinge. SEM-BC vil gøre vingeproducenterne i stand til at øge fleksibiliteten og optimere produktionslayoutet, da det ikke længere vil være nødvendigt at have samme antal lifte til medarbejderne, og der vil være brug for mindre ventilationskapacitet. Den nuværende udvikling i vindmølleindustrien betyder i, at vingerne bliver større hvilket medfører, at eksisterende malekabiner bliver udfordret.

English version:

[1] The amount is based on known labor needed to finalize a wind blade.

[2] Based on assessment by Mouritsen

ENABL and Mouritsen are technology companies, and they will together develop a semi-automatic application for painting blades for wind turbines. ENABL handles everything from toll that performs the actual transfer of the paint and everything before the tool while Mouritsen handles the physical paint itself. This project will help reduce operating costs, reduce the consumption of paint and electricity, reduce investment in extraction, reduce the consumption of tools and improve the working environment for employees in the blade manufacturing industry. By using SEM-BC and using roller painting technique instead of spray painting, the cost of painting blades for wind turbines will be significantly reduced and contribute to the reduction of Levelized Cost of Energy (LCoE). SEM-BC will be applicable to all wing designs, make the painting process more standardized / uniform and SEM-BC is flexible (easy to disassemble and assemble), so it is usable for flexible production and can e.g., easily be moved to another production line or factory. SEM-BC will reduce labor costs by 50% and make it possible to reduce paint consumption by at least 15% due to a more precise layer thickness on each wing. SEM-BC will enable the wind blade manufacturers to increase flexibility and optimize the production layout, as it would no longer be necessary to have the same number of lifts for employees as well as less ventilation capacity is needed. The current development in the wind turbine industry causes the blade to grow, which means that existing painting cabins are being challenged.

3. Project objectives

The objective of the blade painting machine is to make the blade production cheaper, safer and more flexible.

The primary objectives have been to develop a technology that can:

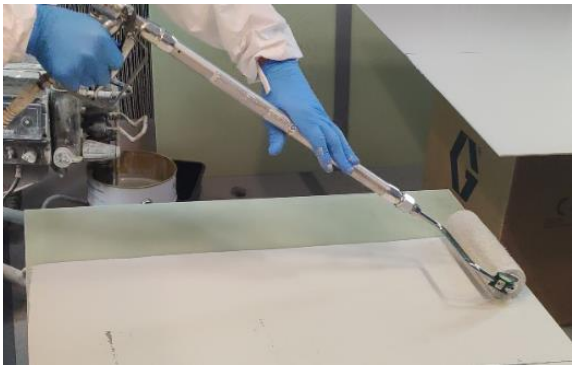
- Provide a safer work environment by removing extensive manual working processes in bad ergonomic positions.
- Provide a safer work environment by eliminating spray contamination
- Reduce paint consumption used in the process with at least 15%.
- Reduce labor costs by 50% compared to traditional roller paint methods
- Deliver a quality in the painting process with a high degree of repeatability and reliability compared to a manual painting process.

Secondary objectives have been to further develop ENABL's existing machine to an extend so roller painting could be achieved on the customers blades.

- The existing technology (roller painting) has been introduced into a challenging and automated solution which has not yet been achieved on a scale as big as wind turbine blades.

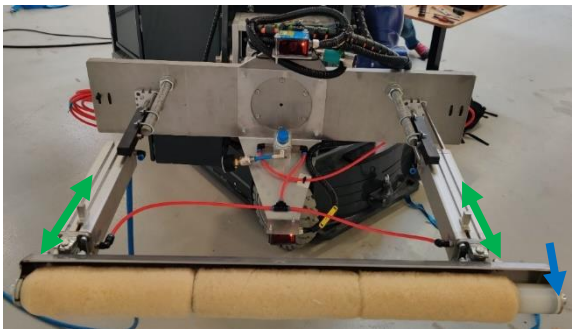
4. Project implementation

Roller painting of wind turbine blades takes place today, using the traditionally paint roller process, where the paint is applied to the roller in a roller bucket and then from roller to blade. This is a 100% manual operation, it's both tedious and tiresome for the personal and an economic disadvantage as it requires many people to paint the blade.



Experiments on fiberglass boards shows that using a pressure-fed paint roller, the desired amount of paint can be transferred from roller to board and applied in the correct layer thickness.

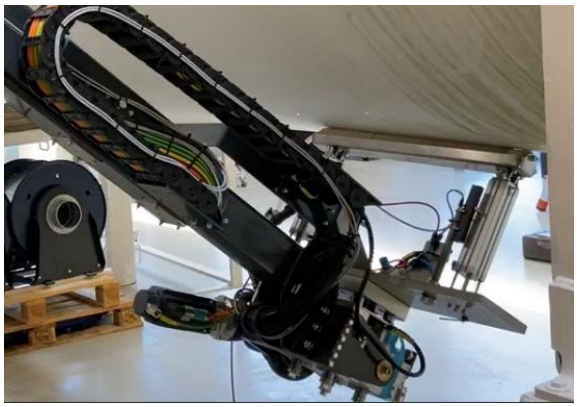
This technique was chosen as the paint supply principle for this project.



The idea is to pressure feed the paint roller from the inside. This is done by applying paint (blue arrow) at the end of the distribution pipe on which the paint rollers are mounted.

The paint roller must be a spring actuated to keep the paint roller against the blade at a specific pressure, at the same time the springs absorb uneven movement. (Green arrows)

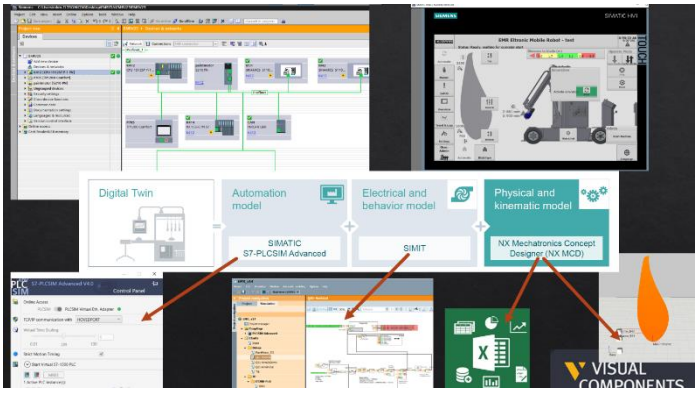
Paint roller must have simple separation, for easy cleaning.



During multiple tests it was found critical to maintain a low and concistent pressure against the surface of the blade.

The software together with hydraulic system on the machine had major updates to keep the presure against the blade to a minimum as well as maintaining the contact between the roller and the wind turbine blade.

The EMR quickly developed in a direction where the desire to verify the software was needed to ensure that the issues on performance, we were struggling with were not caused by software but by hardware.



Then it became necessary to build a small version of the EMR as a Digital Twin and. SIMIT, Visual Components, Excel, and other programs were aligned to interact in a virtual world. Then it became possible to test the software without disturbance from the physical world.

5. Project results

The prototype project indicates that a commercial version of product can meet the initial objectives of reducing labor costs and amount of paint used in the process.

However further development is needed to reach a commercial version.

The targeted market is Wind Turbine Blade Manufacturing. Within this market there are two customer groups; OEM's and Independent Blade Manufactures.

The added value for the users are; Reduced cost of manufacturing and improved working environment.

So far, the EMR is still a work in progress before it can become a product for the industry. But for now, it is certainly going to be a product after further development by
ENABL. Primarily the mechanical design needs further development to comply with the desire in the wind turbine industry.

6. Utilization of project results

The results will be utilized by the targeted group of the project. Global Blade Manufactures can use this technology to reduce the cost of Wind Turbine Blade Manufacturing, which ultimately lowers LCOE of the wind industry.

In addition to the EUDP funds ENABL and its partner haveadditionally invested in this technology.

As part of the project ENABL has engaged in discussions with potential customers, that has shown great interest in the technology and its ultimate benefits. In addition, the funding of the project has ensured a development of European competencies of automated manufacturing processes in the wind industry.

The project has not yet resulted in turnover, but technology show great potential to solve pains at the targeted customers.

The alternatives of painting wind turbine blades are predominantly manual labor-intensive processes. This project aims to solve the process semi-automatic in which no other supplier is known to offer in the market.

The sales barriers are capital expenditure and the lack of track-record in this new technology.

However, the business case of deploying this technology to solve the painting process of wind turbine blade manufacturing is found to reduce the total cost of a wind turbine blade, which ultimately reduces the LCOE and supports the European energy policy objectives.

7. Project conclusion and perspective

The overall conclusion of the project is that its technical feasible to reach commercial version that can reduce labor costs and improve work environment of wind turbine blade manufacturing.

A vast improvement in performance has been achieved and enabled the ability to reach blades with the precision needed. However, the working height must be increased to meet recent blade sizes. Furthermore, the end effector on the EMR must be further developed as the final transfer of the paint onto the blade still has some issues that must be investigated before it can be utilized in the market with an acceptableprecision and reliability..

Primary concerns are the overlapping lanes when painting automaticly and the risk of gathering paint on part of the paint tool which eventually might be left on the blade causing a big clump of paint left behind. Furthermore, the tools capability to evenly distribute paint on its physical size as pressure onto the blade is derived from two pistons could cause an uneven force distribution if the tool is too large. However, if the tool is too small, the time it would take to paint a blade with an EMR would become too long. The layer thickness transferred to the blade was uniform however further development in the 3-component paint, primary mixing, must be thoroughly investigated.

The next steps are to focus on the actual paint technology and increase the repeatability and reliability to transfer paint from the EMR-tool to the blade. Furthermore, the mechanical construction of the EMR must be finalized as currently it is not ready for the market. Primary concerns are again repeatability and reliability.

This project could hopefully enlighten future projects into understanding the critical parts in the technology and get a potential jumpstart. We experience it possible to further develop this technology to a matureness where it becomes a vastly spread technology seen in the wind power industry. Thus, replacing previous tedious, physical rough and more expensive traditionally man-powered operation.

Furthermore, improvement of quality, reduction of production cost and contributing towards a healthier planet is essentially what the EMR and the SEM-BC paint-tool would be able to provide.

8. Appendices

https://www.undp.org/sustainable-development-goals

https://www.enabl-wind.com

Standardization discussion: “2020-10-02 Teknologisk institut besøg vedr. EMR 02.docx”

Standardization discussion: “Teknologisk Institut valg af standarder_01.pptx”