PRESS RELEASE
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Precision in battery recycling: RHINOCEROS project's Disassembly Process Plan leaves no room for errors

Researchers at the Faculty of Engineering and Science within the University of Agder have developed a digital simulator along with an algorithm that automatically generates the Disassembly Process Plan [DPP] for batteries. The DPP optimises battery disassembly, reducing process duration and supporting sustainability in battery recycling.

Within the RHINOCEROS EU-funded project, the research group at University of Agder [UiA] is responsible for developing an automated system for characterising battery state, discharging batteries via the grid and dismantling them for reuse or recycling. Their ultimate goal is to reduce the operational duration and to improve resource utilisation. Over the past two years, the researchers have developed an innovative Disassembly Process Plan [DPP] for batteries. This technological development automates the selection of the most suitable machines and toolkits for each disassembly operation, significantly reducing the total process duration. The DPP is a key component of the RHINOCEROS project, which aims to develop and demonstrate advanced technologies that will enable battery recycling and repurposing.

Addressing the safety questions raised by lithium-ion battery recycling

With the rise of electric vehicles, managing the upcoming wave of e-waste, particularly LiBs, poses significant challenges. LiBs are inflammable and require careful handling, making bulk shredding impractical due to contamination risks. Separating components before shredding yields higher purity levels and allows various parts to be reused. However, dismantling batteries is dangerous, often involving manual labour to remove casings and separate internal components. The RHINOCEROS project aims to automate this process with a smart sorting and dismantling robot, thus enabling the recovery of all materials present in LiBs: metals, graphite, fluorinated compounds, electrolytes, polymers and active materials.

Technical innovations with impact on real-world applications

The DPP integrates a digital simulator and an algorithm trained to autonomously generate the disassembly sequence plan (DSP). This technological breakthrough promises to optimise the disassembly process, making it more efficient and cost-effective. Moreover, the simulator provides a safe and controlled environment for testing and refining the algorithm, ensuring its reliability before real-world implementation.

The DPP's computational framework models tool-changing operations and associated costs, optimising robotic movements and tool selection. From a technical point of view, the digital simulator, built on a foundation of Python and NumPy, efficiently tracks job progress, machine availability, tool states and temporal dependencies. Researchers applied various Reinforcement Learning (RL) algorithms using datasets similar to the battery disassembling problem, bringing the simulator closer to real use case scenarios.

In reality, this framework has been built with a multi-purpose approach, potentially benefitting various stakeholders in industries that prioritise efficiency and sustainability – EV battery recyclers, automation integrators, robotic system developers and academic institutions – by providing a well-defined problem structure for testing new

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algorithms and heuristics. Moreover, industrial research labs can leverage the DPP to develop tailored applications, evaluate alternative product designs and simulate disassembly strategies, reducing development costs and accelerating innovation cycles in recycling technologies.

Future plans for the DPP foresee its integration into a comprehensive digital twin of the manufacturing environment, which will operate with configurable tool capabilities and interdependent job sequences. Thorough testing in a simulated environment will precede its demonstration in a real-world setup.

Representatives of University of Agder underlined: *"Reaching this milestone demonstrates the impact of intelligent Disassembly Process Planning in real-world applications. By optimising disassembly sequences and tool usage, our system significantly reduces operational costs and completion time. This is especially valuable in EV battery recycling, where efficiency and resource optimisation are critical to sustainable practices."*

The project coordinator, Álvaro Manjón Fernández from TECNALIA, emphasised one more time the importance of being able to simulate dismantling operations to ensure the efficiency of the battery recycling process: *"The development of this model for the robotic dismantling of LIBs from EOL BEVs has a great potential, as it uses simulations and real-world datasets to create highly accurate scenarios. This enables precise process optimisation, improves material recovery, and creates an impact supporting the development of more efficient and sustainable recycling technologies that can be applied at both scientific and industrial scale level."*

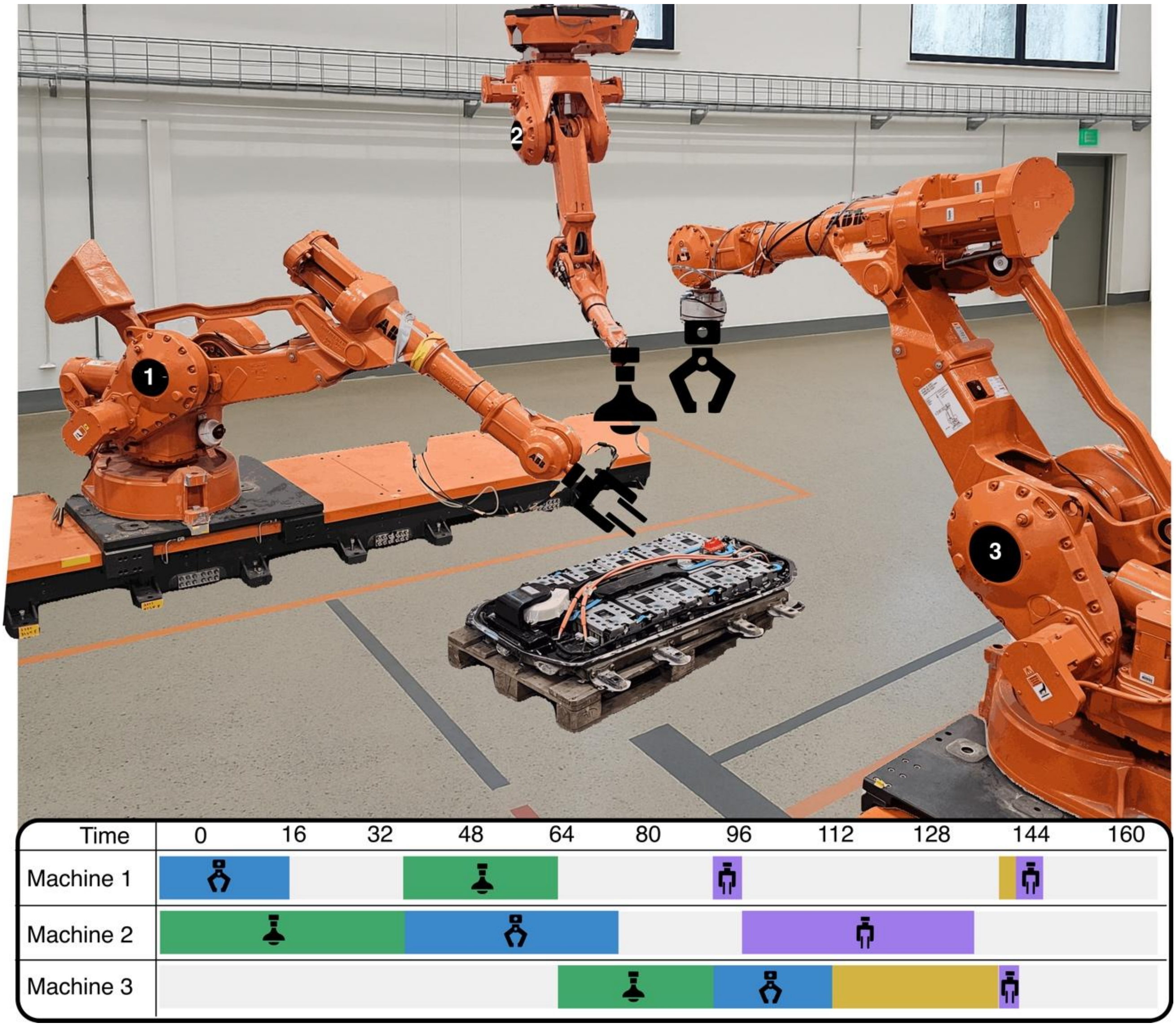

Figure 1. Battery dismantling operations ©UiA

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About the RHINOCEROS project

The RHINOCEROS project – short for "Batteries reuse and direct production of high-performance cathodic and anodic materials and other raw materials from batteries recycling using low-cost and environmentally friendly technologies", will demonstrate a smart sorting and dismantling robot that will enable the automation of a battery repurposing production line. When direct reuse and repurposing of batteries is not feasible, the project will investigate innovative recycling routes aiming at the recovery of all materials present in LIBs: metals, graphite, fluorinated compounds, electrolytes, polymers and active materials.

About University of Agder

The University of Agder (UiA) is an academic institution that provides a combination of excellent educational and research opportunities within a pleasant and open environment. Regionally anchored in southern Norway, which is famous for its astonishing natural surroundings, UiA offers a wide range of studies across its faculties. The university has two campuses, one in Kristiansand and one in Grimstad. UiA is an open and inclusive university characterised by a strong culture of collaboration and a global outlook. Co-creation of future knowledge is their common vision. The University of Agder aims at further developing education and research at a high international level.

The Faculty of Engineering and Science cooperates extensively both on research and education with high-profile international technology companies in the region. Most of the Bachelor's and Master's theses are written in cooperation with local industry and the public sector. The University of Agder is a pioneer in mechatronics with the only Master's and PhD programme in this field in Norway. The Energy Materials Research Group has developed hydrogen, fuel cell and an application-oriented Battery Engineering education, in close proximity and collaboration with major battery players in the south of Norway and internationally. It offers Bachelor's, Master's and PhD training in these areas.

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Consortium members

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