

Newsletter 12

Putting wind turbine gearbox remanufacturing to the test

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Feasibility and impact validated with Flender

LUT, working with Flender Finland, Ikerlan, DBL, CSEM, NCI and EWF, has compared the results of the demonstration work in Tasks 4.2–4.5 with the validation framework agreed at the start of the project.

The picture is encouraging. Repair and upgrade methods for journal bearings and flange connections reached a 90% failure prevention rate and a 90% lower carbon footprint than new components, alongside a raw material saving potential of 85%. Simulation tools for induction hardening and gear fatigue predicted real test behaviour well.

Just as valuable were the lessons. Rebuilding gear teeth by laser cladding has not yet reached the strength needed for approval, which shows where further process development is needed. Together, the results give Europe's circular manufacturing agenda tested evidence, not just promise.

Task 4.6 tests wind turbine remanufacturing technologies against the project's impact targets and Europe's circularity goals

Wind turbines keep growing, and so do the cost and risk of repairing their drivetrains. Maintenance and repair account for roughly a fifth to a quarter of the levelised cost of wind energy, and until now reuse of gearbox components has mostly meant regrinding minor surface wear. Demo case 3 of R3-MYDAS asks a more ambitious question: can failed gearbox components be repaired, upgraded and returned to service with the reliability that this demanding industry requires?

Task 4.6, led by LUT, provides the answer. It draws together the outputs of the flange connection, gear, journal bearing and stray-current work (Tasks 4.2–4.5) and measures them against the validation framework set up in Task 4.1. That framework, built from interviews, workshops and the project's own targets, links each objective to key performance indicators with a baseline, data and method. Flender Finland owns the use case, Ikerlan supports the gear work, DBL contributes the human factors view, CSEM the digital cross-dimension, and NCI and EWF help turn the findings into transferable, standardisation-ready knowledge.

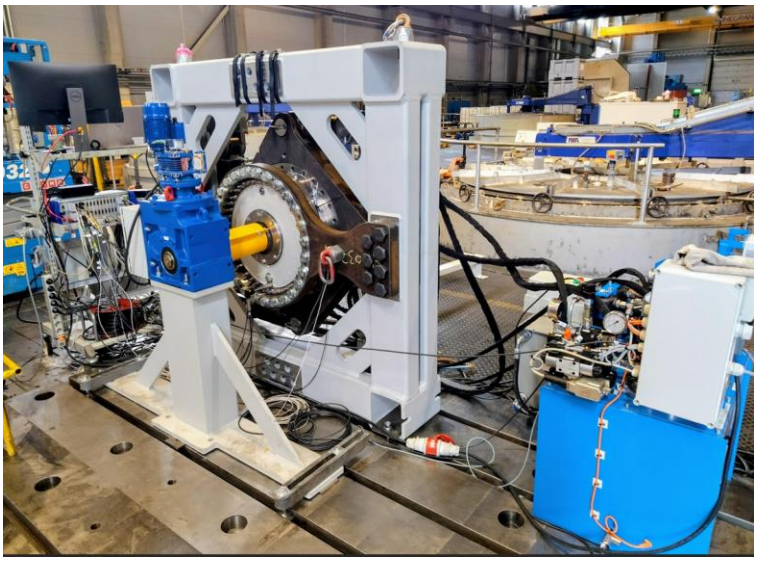
What the validation confirmed

Journal bearings and flange connections. The repair and upgrade methods reached a 90% failure prevention rate and cut the carbon footprint by 90% compared with a new component. Reference tests to failure, including the demanding single blade installation condition, gave a solid dataset for validating simulation models, and methods to improve robustness against asperity contact were found. The flange work also produced the specification for a dedicated tester that can reproduce localised fretting over the long term.

Materials and cost. Reuse and remanufacturing offer a raw material saving potential of 85%. Because wind components are strongly raw-material driven, the approved repair methods produced parts that

came out significantly cheaper than new ones. Traceability and documentation can match those of new production.

Simulation as an enabler. Ikerlan and Flender Finland developed tools to simulate induction hardening and to predict tooth root and tooth flank fatigue. Simulated hardness and residual stress maps were consistent, and fatigue life predictions were more accurate than those of a commercial standard-based tool used for comparison. Induction-hardened gears showed root strength 5–20% below case-carburised ones, which is acceptable in most applications. Induction hardening also lowers the carbon footprint and can deliver the same design lifetime as a new component, with a lower safety margin against infinite life. One of the prediction tools has already been registered as software, and another is in registration. Together with the validated bearing, flange and drivetrain models, they feed into a whole-gearbox simulation framework.



What we learned along the way

The most important lesson came from the part that did not work as hoped. Gear teeth rebuilt with laser-cladded material and then machined, and induction hardened reached only about half of the expected root bending strength. Cracking of the base material during cladding and porosity in the deposited material proved critical: either one can undermine fatigue strength. Both can be turned into critical-to-quality parameters for production, but more process development is needed before this route can be approved. The carbon and cost gains reported above do not yet apply to rebuilt gear teeth.

A second lesson is cultural as much as technical. Wind turbine drivetrains are designed around a zero-defect principle, and remanufactured parts must meet it too. That makes simulation and engineering validation before approval mandatory, and it makes proof of mechanical properties the main bottleneck for scaling up a supply chain for remanufactured components. Process quality control matters just as much: small variations in serial processes translate directly into variations in strength. Finally, technical release is not market acceptance. Early volumes will be modest until customers gain confidence in remanufactured parts.

Connecting to European ambitions

These results speak directly to the Made in Europe partnership's strategic research agenda. They contribute to its circular products objective, in particular de-manufacturing and remanufacturing technologies and ultra-efficient low-carbon manufacturing, and to its objective of zero-defect manufacturing and virtual life-cycle engineering. Among the key enablers, the demo case advances additive and surface-tailoring processes, simulation and digital twins, standards, and a skilled workforce.

The timing is relevant. The European Commission has put circularity at the centre of the Clean Industrial Deal, is preparing a Circular Economy Act, and has set out ecodesign rules, including digital product passports, that favour repair and remanufacturing. The Council has pointed to a remanufacturing market that could grow from around EUR 31 billion to EUR 100 billion by 2030, with some 500,000 new jobs. Credible, tested evidence on what remanufactured energy components can and cannot deliver is exactly what industry and policymakers need to turn those ambitions into practice. The R3-MYDAS targets for reuse, raw material savings, lead time and failure prevention give that evidence a measurable shape.

Next steps

The full validation will be reported in deliverable D4.5 at the end of 2026, and the project-level evaluation of impact will be shared with stakeholders through the dissemination work. Beyond the project, Flender Finland and partners are planning new test configurations, next-generation journal bearings, and long-term testing of the stray-current demonstrator built at LUT, and are looking for funding to carry them out.

For more information, contact the R3-MYDAS team at LUT University.