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How a small lab wants to rescue the offshore wind power industry

European offshore wind-turbine manufacturers are struggling to keep their heads above water in a highly competitive international market. A small Danish lab is hoping to come to their rescue by following in the footsteps of the shipbuilding industry: by relying on highly productive laser hybrid welding.

When it comes to prophesying what will happen in the energy industry, there's one thing experts agree on: offshore wind power has a definite role to play in the broad macroeconomic future. What's more, that role is set to become increasingly important, as demand for clean energy is growing. On the face of it, that seems like good news for wind-turbine manufacturers. So why is there such a tangible feeling of uncertainty along Europe's coastlines? Essentially, the wind-turbine sector is facing the same dilemma as many other industries: its products are unquestionably superior in technical terms, but the prices are simply too high for many customers. The problem lies in the manufacturing costs. Assembling a wind turbine remains a predominantly manual, time-consuming job – and specialized welders command very high hourly wages. That's why the industry is desperately searching for automated methods.

Investments in automation can pay off

The problem is that wind-turbine components are enormous, have complex geometries and are made using materials whose thickness in millimeters starts in mid-range, double-digit territory. Faced with that kind of challenge, even automated systems end up being too complex and costly. European wind-power companies have so far balked at making such huge investments. But all that might soon change: a small company in the Danish town of Munkebo is hoping to allay manufacturers' fears by showing them how investments in automation can pay off in the long term. The Lindø Welding Technology (LWT) institute is a subsidiary of Force Technology, a technology consulting company. A project manager at LWT, Steen Erik Nielsen is responsible for innovative welding technologies. He doesn't regard either himself or his colleagues as researchers: "We leave it to other people to tackle the basics," he says. "Our goal is to deliver tangible results to manufacturers." In the case of wind turbines, his approach is modeled on a very specific example: shipbuilding.

Laser hybrid welding already saved the shipbuilding industry

Around 15 years ago, European shipyards were in the same situation as wind-turbine manufacturers find themselves in today: they were stuck using expensive, manual manufacturing methods, and global competitors were breathing down their necks. One by one, the European shipyards fell by the wayside; the last remaining shipbuilders frantically searched for something that could save them. They changed their mindset, welcomed the laser into their production halls - and have managed to stay afloat. " Laser hybrid welding played a crucial role in achieving that," says Nielsen. "We were able to show that it works and fits the bill of cost-effective automation. That helped us get it certified as an application method, and now laser hybrid welding is in widespread use throughout the shipbuilding industry." The idea now is that laser hybrid welding could also save the European wind-turbine industry. Over the past five years, Nielsen and his colleagues have completed four projects funded by the Danish government that focused on various parts of the manufacturing process. "As far as laser power goes, we have plenty of resources to draw on," says Nielsen with a smile. LWT's cutting-edge 32-kilowatt laser system delivers enough power for materials of just about any thickness. In addition, it can produce welds up to 25 millimeters deep in a single pass. Two 200-micrometer fibers connect two 16-kilowatt TRUMPF disk lasers to a laser welding head, which is positioned on a robot arm together with the arc-welding system. "With this set-up we can demonstrate the hybrid process very realistically," says Nielsen. "The absence of technological limitations means we can focus entirely on process design."

Now two defenders of the European wind turbine industry are hoping to repeat that feat: project manager Steen Erik Nielsen and technician Jørgen Thomsen from Force Technology/LWT. Photo: Kasper Fladmose

Technician Jorgen Thomson from Force Technology wants to rescue the offshore wind enery industry through laser hybrid welding. Photo: Kasper Fladmose

Welds up to 25 millimeters deep: Force Technology /LWT engineers use a 32-kilowatt laser to demonstrate laser hybrid welding processes for the maritime and the offshore wind turbine industries. Photo: Kasper Fladmose

The nodes are a crucial part of the underwater lattice structure that supports a wind turbine. It takes several days to make one of these by hand - but the method developed by Force Technology / LWT gets the job done in just a few hours. Illustration: Gernot Walter

Die zwei Kämpfer für die Windkraftindustrie in Europa, wollen den Trick wiederholen: Projektmanager Steen Erik Nielsen und Techniker Jørgen Thomsen von Force Technology/LWT. Foto: Kasper Fladmose

Only two instead of ten welding passes necessary

One of the biggest issues was butt joints. These are an important element in the construction of wind-turbine towers, which are typically composed of multiple rings. The rings are made from rolled sheet steel and are welded together horizontally with a butt joint. The individual elements themselves are also joined using butt joints; the material is somewhere between 40 and 70 millimeters thick. "Turbine makers have traditionally used submerged arc welding to do that," says Nielsen. "But to be sure the seam is tough enough, you need around ten welding passes. The laser hybrid welding process we've developed gets it done in just two!" In LWT's method, the machining head travels over the weld once on either side of the metal sheet, producing a high-quality weld seam with no distortion. "That speeds up processing fivefold, and in some cases even tenfold," says Nielsen enthusiastically. For a variety of reasons, some users prefer to weld on only one side of the sheet. "And we have a solution for them, too: root welding." The Danes first execute the root pass with gas metal arcwelding. Then they finish off the seam with one pass of the hybrid welding system. "Regardless which approach the manufacturer chooses: they still benefit from the time savings the laser offers," says Nielsen.

If we convince one wind-turbine manufacturer, everyone else will then follow suit.

Steen Erik Nielsen, Project Manager Innovation in Welding Technology

Jacket on the seabed

When it comes to making wind turbines, particular attention has to be paid to the components that will end up underwater. The wind turbine rests on a lattice structure known as a jacket, whose individual parts are extremely costly to produce - particularly the nodes. These are the components that interconnect the various tubes at the intersections of the lattice structure. It takes a welder between 30 and 50 passes to finish each part. "What would you say if I told you that, with our method, you need just a fraction of those passes?" says Nielsen. A modern node consists of three to five individual parts, basically two to four smaller tubes that connect to a larger one. LWT examined every joint and began drawing up a plan for an automated process. "Although there are some minor variations in welding depth and joint geometry at each of the joints, our experiments quickly revealed that the root welding method would work well in this case, too," Nielsen explains. Gas metal arc welding is used for the first root pass on the inside, and then all it takes is a single pass of laser hybrid welding on the outside - and the node is finished.

Excellent results - but what now?

"Now the construction process for welding the full node takes just a few hours," says Nielsen happily. "With conventional methods, it would take somebody several days to do that!" So, does that mean that wind turbines made using laser hybrid welding will be sprouting up everywhere the next few years? Nielsen very much hopes so. The task of getting the method certified is almost finished, he says. "Now we just need someone bold enough to put it into practice," he says. "I imagine that we will convince at least one manufacturer to take the plunge – everyone else will then follow suit."

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