Optimization of Photovoltaic (PV) Mounting Structures - Savings on Material and Cost

Overview

Manufacturing today is strongly characterized by strict cost awareness and high-efficiency with regard to time and material. Of course, this also applies to the production of renewable energy products such as PV facilities to generate solar energy. Ground based PV facilities are usually mounted on special structures, which not only carry the PV modules, but are also required to orient the modules for an optimal degree of efficiency when producing electricity. These mounting structures, consisting of a so-called Purlin, a Rafter, and a Pole (and Hat), have to be designed to withstand potentially occurring loads from wind and snow, as well as dead loads. Since the structures are made of steel and, for safety reasons, have to be extremely stable, they are usually rather heavy, hence they might be good candidates for weight and material savings via topology optimization.

Thesan, an Italian company based in Chiusa di San Michele designs, manufactures, and distributes the above described mounting structures for photovoltaic plants. In addition, the company also develops, constructs, and operates renewable energy power plants, including photovoltaic and mini-hydroelectric power plants. Thesan was founded in 2008 and operates as a subsidiary of Savio Spa, a global manufacturer and foremost specialist in hardware for aluminum windows and doors, with factories in Italy, China, and India.

Drawing on the Savio Group's competence in the design of steel and aluminum structures and thanks to a team of over 40 engineers, photovoltaic specialist Thesan is able to satisfy every construction requirement of photovoltaic power plants at all altitude and climatic conditions, using any specific fixation requirements. The company provides the technical expertise and the corresponding experience to follow all phases of the production chain; from project development to construction, management to maintenance of the power plant.

In addition to offering support and advice in the assembly of the mounting structures, Thesan is also active in the design and development of the structures. The company's offers include among other, numerical optimization, simulation tasks, and the consideration of maintenance costs as early as in the design phase.

Challenge

Recently Thesan conducted a project in which the engineers optimized the mounting structure of a medium sized PV field with a power of 5 MW. The field consists of 1700 arrays, each mounted on two poles. Each individual assembled structure has a weight of about 60 kg. The mounted overall structures on the field have a total weight of 204 tons of steel, with material costs of about 170,000 Euro. A weight reduction of only 5 kg per structure would lead to tremendous savings in material and cost. The structure is composed by two main parts, a steel driven pile and an aluminum rafter: weight reduction of the much more costly aluminum parts is crucial. Another significant factor for cost savings is transportation, since PV fields are often built in remote areas with poor infrastructure. Lighter structures not only mean less material costs in production, they also have the advantage that transportation efforts and costs can be lowered to a great extent. Since safety is crucial for Thesan's mounting structures, the new, lighter weight structures still have to be able to carry all occurring loads from natural causes such as wind or snow and the dead load of the structure. Hence, Thesan has to ensure perfect quality, consistent stability and the requested stiffness of the structures.

All images courtesy of Savio S.p.A.

"By using optimization with HyperWorks OptiStruct we could reduce the weight of the rafter structure by more than 13 percent in its most costly parts and about 10 percent in the steel parts. As for the construction of a PV field many of these components are required, the savings add up to a considerable amount of material. With optimization we could not only reduce the manufacturing and material costs, we also improved our logistics, since now less material has to be transported when a new PV field is built. All in all, we can say that the optimization with HyperWorks clearly contributed to our strategic measures to increase our competitiveness."

Roberto Vadori, R&D Technical Officer
Savio S.p.A.

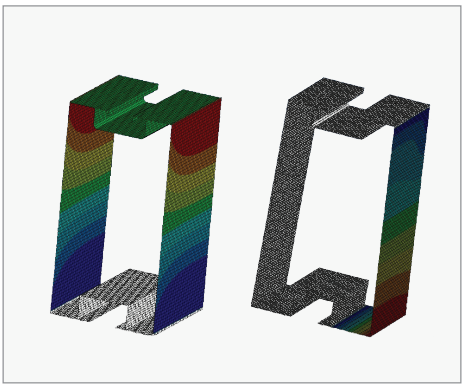
Solution

To reduce the weight of the overall structure, while still ensuring stiffness and safety, the engineers first looked for a component that would offer the highest potential for weight savings via structural optimization. With the goal to remove unneeded material from the structure, the team investigated various options. As a result, they identified the profile of a mounting part (rafter), which is used to connect the solar panels to the support poles.

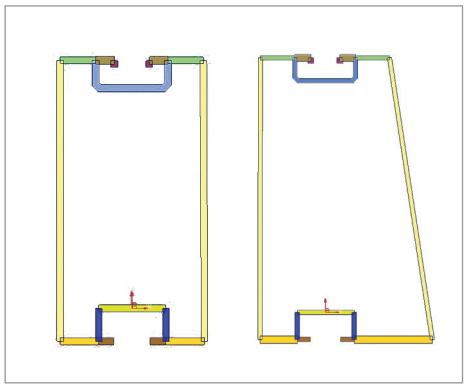
To optimize the rafter component, the engineers at Thesan used OptiStruct®, the optimization tool and FE-solver included in Altair's HyperWorks® suite. They started by creating a design space and then added boundary conditions and loads such as those coming from snow, wind, and dead loads. By varying the wall thicknesses and the overall shape of the profile, they were able to minimize weight while keeping stresses and displacements within an acceptable level. The optimization results proposed a new profile design, with a decreased upper, lateral, and lower wall thickness and an overall increased height as well as an increased lower section. The resulting new design was then verified with FE analysis to assure its stiffness and safety at possible angles and occurring loads.

As a result, the Thesan team fully achieved its targets. Compared to the original profile, which had a weight of 2.06 kg/m, the weight of the new design has been reduced by 13.5 percent, coming to a total weight of 1.78 kg/m, all while keeping the stiffness of the structure as high as it was with the old design: a net saving of more than 15 tons of aluminum.

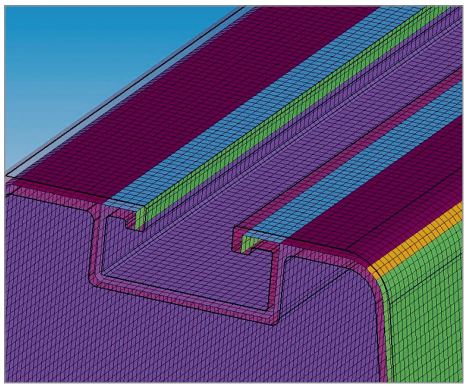
A similar strategy was then applied to reduce thickness and optimize the shape of the steel structure, leading to a light but nonetheless reliable and safe structure.



With the goal to design a stiffer and lighter section the team investigated various shape and thickness combinations.



Cross-section of the mounting structure before (l) and after (r) optimization and redesign.



The meshed model serves for detailed analyses of the structure.

Benefits

The optimized profile for the rafter component offers two major benefits to Thesan. With the new design they are able to save a lot of material, which means that the production itself is much more cost efficient. In addition, the lighter overall construction requires less transportation effort, which is especially important for PV fields that are mounted in remote areas with poor infrastructure.
HyperWorks OptiStruct helped Thesan to:

- Reduce material usage in the production
- Reduce manufacturing costs
- Reduce transportation costs
- Improve competitiveness of Thesan in a contested market

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