Robert Bosch India Use Simufact Additive to Digitally **Lightweight a Fixture Tool and Save 70% in Mass**

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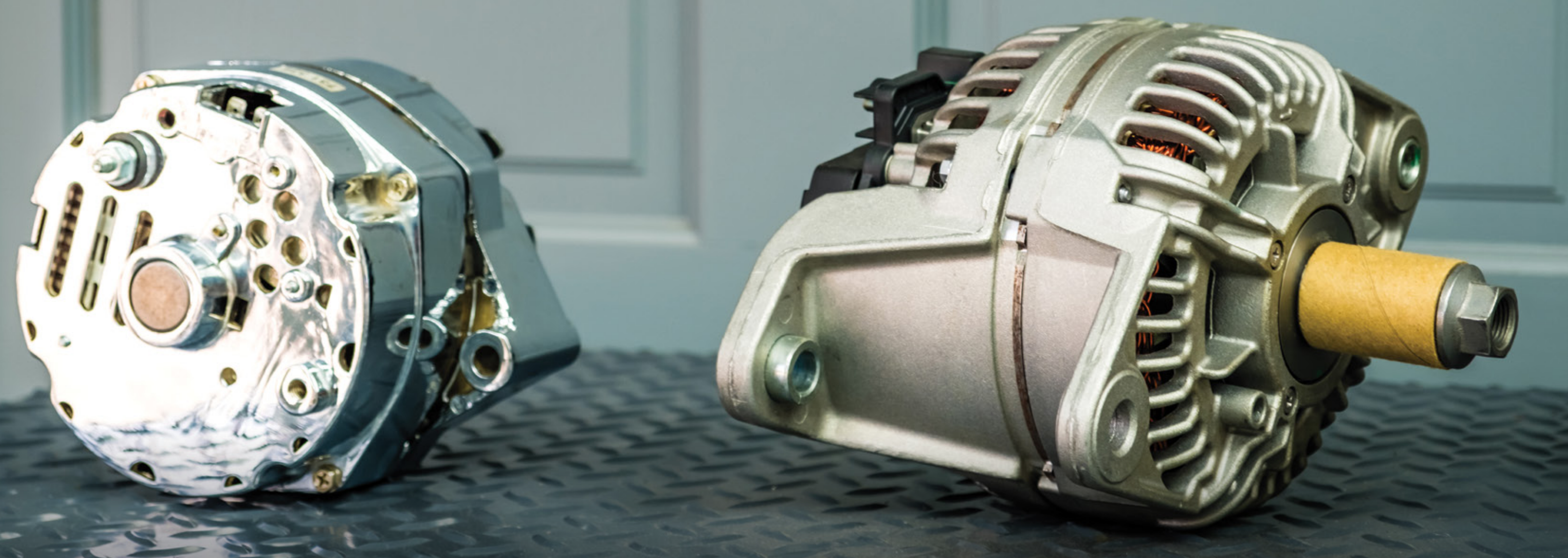
In making the rotor parts of motors, Bosch employs an IRIS fixture tool (figure 1). Each year typically 200 units of this IRIS tool needs to be produced for assembling various types of motors. Until recently, the IRIS tool used to be manufactured by a conventional casting process as two parts. To save tooling costs and time, the idea was put forward to produce the fixture tool by additive manufacturing in a single part with the goal of removing as much weight as possible without compromising the part's mechanical strength.

Bosch engineers decided to employ the Simufact Additive product from MSC Software to model the additive manufacturing (AM) metal build process and subsequent post-processing steps to help eliminate design errors before expensive AM was committed to. Simufact Additive is very powerful at predicting the magnitude and distribution of residual stresses in an additive manufacturing situation taking into account variables such as process type, build rate, build sequence, amount of constraints, etc. Highly localized heating and cooling during the AM process typically produces non-uniform thermal expansion and contraction in the part, which results in a complicated distribution of residual



stresses in the heat affected zones and unexpected distortion across the entire structure. Moreover, these residual stresses may promote fractures and fatigue in the AM part, and induce unpredictable buckling during the service of the printed part. Hence, it is vital to predict the behavior of the AM process and to optimize the design/manufacturing parameters before committing to 3D printing. Simufact Additive is able to predict the influence of several components in the AM build space, determine the best build orientation by performing sensitivity studies, reduce the number of physical iterations and yield high design productivity benefits because it leads to a reduction of total time for AM.

A first Simufact Additive prediction (Case 1) for the part being considered for replacement without precompensation of the part (Figure 2) identified severe manufacturing issues due to high local temperatures in the 3D printed part, final part distortions with tolerances exceeding 3.5 mm, and final part effective stresses exceeding 1,260 MPa if this part was additively manufactured.

Using Topology Optimization methods, Bosch engineers iterated to a Simufact Additive prediction (Case 2) where they were able to integrate the formerly two-part fixture into just one part and to result in a reduction of the component's overall weight by 70% (figure 3). In Case 2, Simufact Additive delivered a shape deviation in distortion reduction of 70% to 1.067 mm after 1 pre-compensation run by ensuring a more uniform metal particle melting temperature of 1399°C throughout the simulation process in order to avoid thermal-stress issues. Effective metal maximum

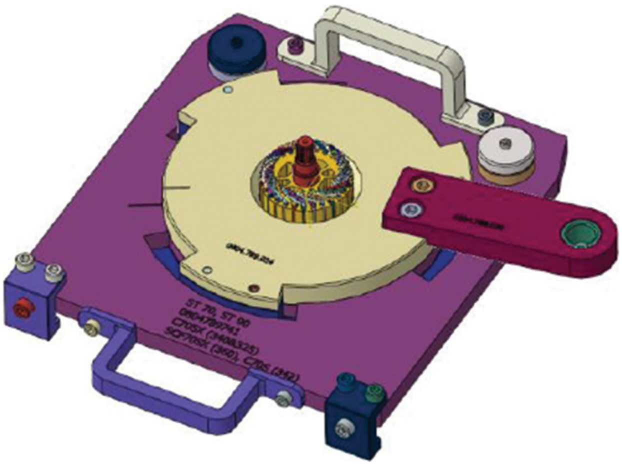


Figure 1: Traditionally manufactured cast metal IRIS tool (cream and maroon parts) inside its assembly

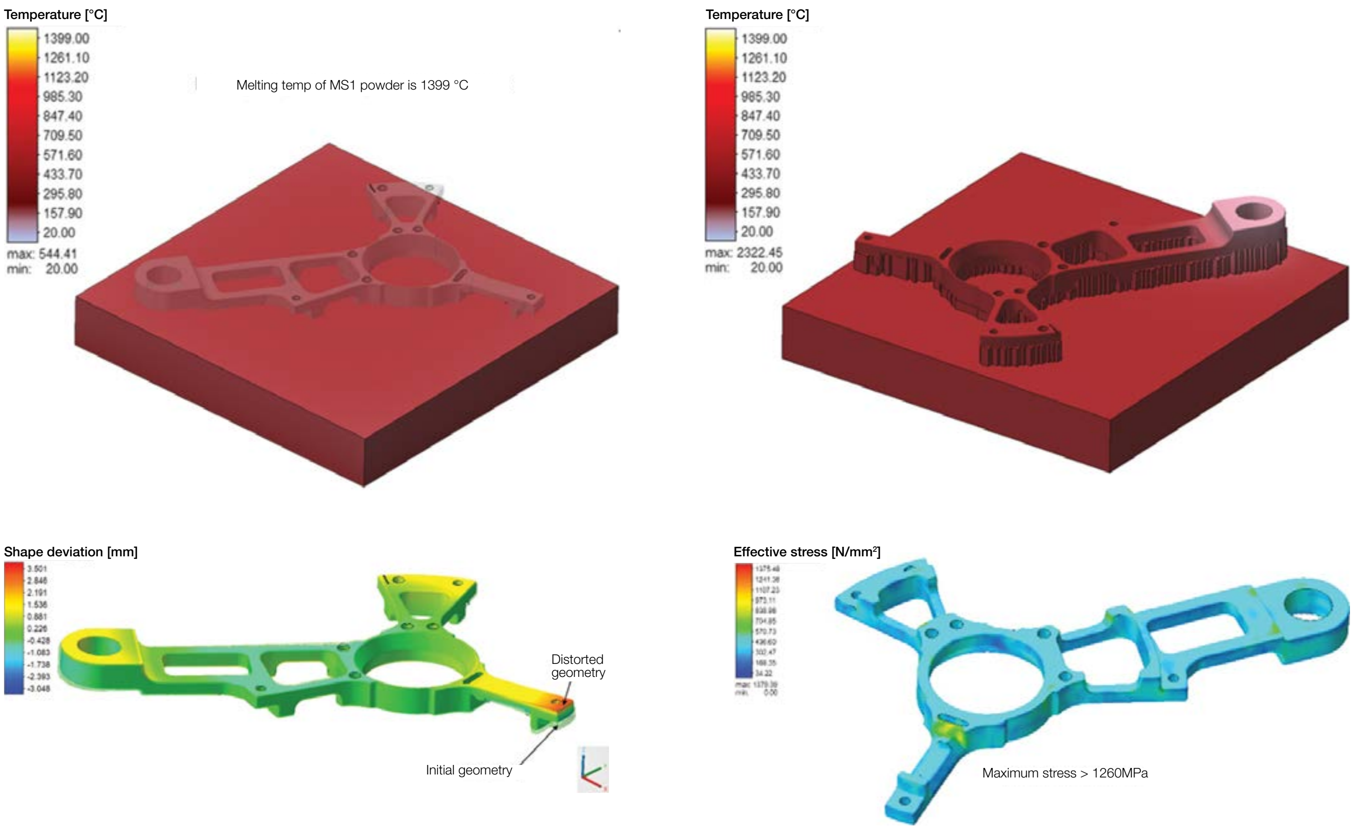


Figure 2: Additively Manufactured IRIS Fixture Tool prediction that has not been topology optimized showing non-uniform melting temperatures of 1399°C, part distortions of up to 3.5 mm and final part effective stresses exceeding 1,260 MPa (Case 1)

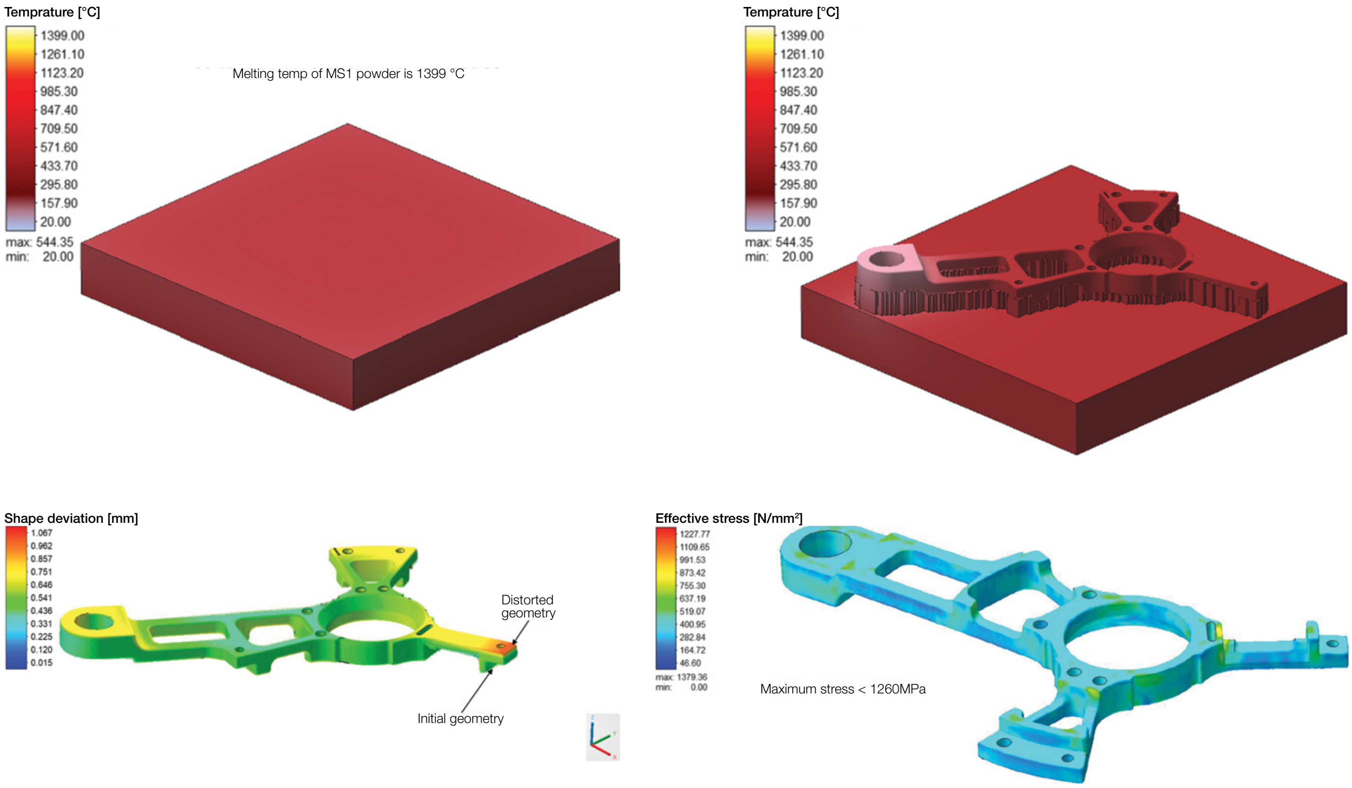


Figure 3: Additively Manufactured IRIS Fixture Tool prediction that was been topology optimized showing constant melting temperatures of 1399°C, part distortions of up to 1.07 mm and final part effective stresses less than 1,260 MPa (Case 2)

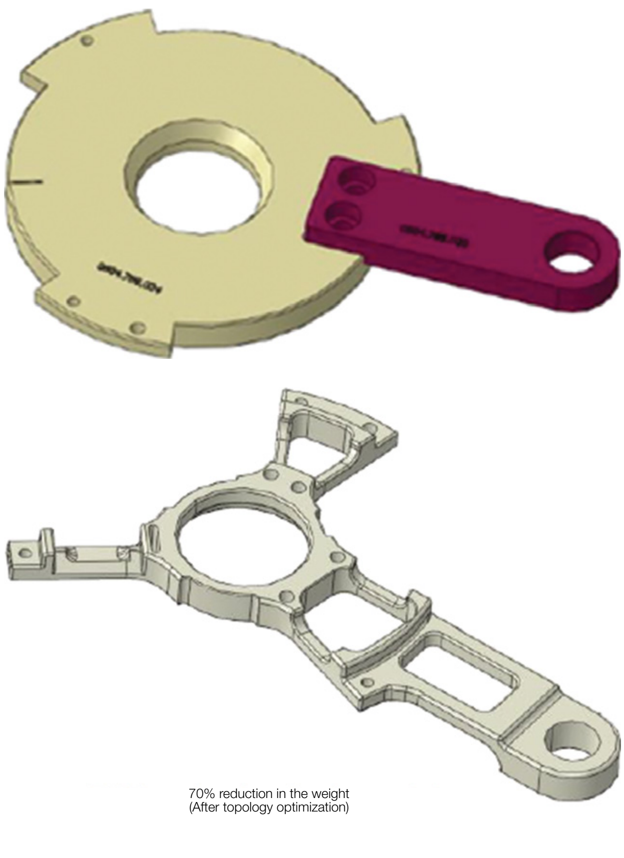


Figure 4: IRIS Fixture Tool from a traditional cast part (top) and fully topology optimized AM part (bottom)

stresses in the AM part were kept below the yield strength limit of 1260 MPa. For the optimization of this AM build process, they used the Simufact Additive pre-compensation method which aimed at a part geometry within acceptable distortion tolerances. In addition, Simufact Additive optimization methods for the build process (e.g. support structure optimization) and post-processing (e.g. cutting strategies, support removal strategies) were also used to improve this manufacturing process.

By applying topology optimization methods to Simufact Additive predictions, Bosch engineers were able in this study to re-design the IRIS tool parts with the objective of developing a lighter single part with adequate stiffness, lower material usage and thus AM power consumption, and ultimately yielding a process cost saving (as well as a mass reduction) – see Figure 3.

Summary

Bosch India used Simufact Additive to replace costly low-volume tool production (casting) by tool-less additive manufacturing for a motor IRIS fixture tool. By re-design and topology optimization, Bosch engineers managed to integrate the functionality of what was once two cast parts into a single AM metallic part with similar mechanical characteristics while at the same time reducing the part's weight by 70%. AM process simulation with Simufact Additive therefore helped Bosch engineers to overcome additive manufacturing issues (distortion, residual stresses) and to establish a new manufacturing process "first time right".