Cost-effective lightweighting routes for an automotive door panel

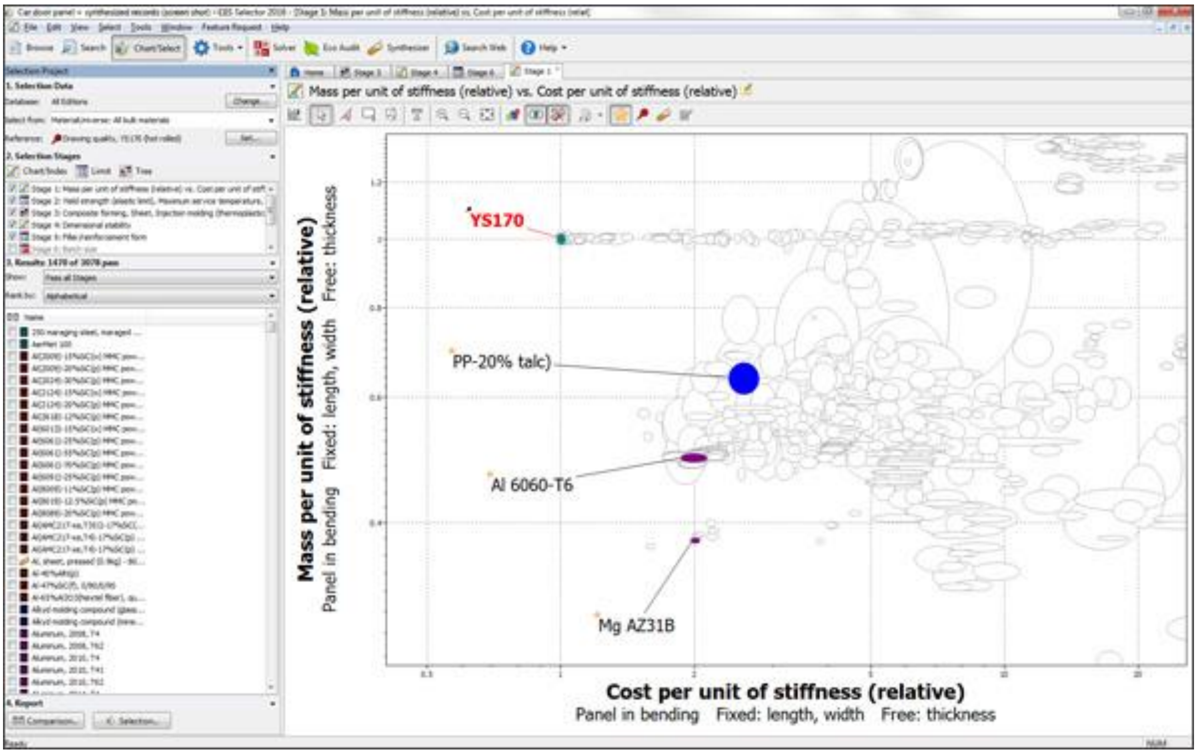
Image from David Villarreal Fernández under Creative Commons license https://creativecommons.org/licenses/by-sa/2.0/legalcode

The current focus on reducing environmental impact and lightweighting is forcing many companies to consider new materials. Identifying cost-effective alternatives can be difficult, as most cost models require detailed information about the component, which isn't available in the early stages of design.

In this case study, Granta has investigated the impact of material choice on part cost for lightweighting an automotive exterior door panel. Inspired by the plastic panels in the Smart ForTwo car, we studied the suitability of this class of material as a replacement for steel.

In the CES Selector software, we began by filtering metals and plastics against some of the key requirements for the panel (e.g., strength, maximum service temperature, the need for dimensional stability at different operating temperatures, good resistance to salt water). We then plotted materials that pass these constraints on a materials property chart. Expressed simply, the engineering application here is a panel in bending limited by stiffness (we do not want the panel to deflect too far). Within the graphical user interface of CES Selector, we can quickly select this scenario and generate the graph below, which shows the trade-off between mass and cost. The chart is created using data from the MaterialUniverse data set, which includes engineering, environmental, and economic (including relative price) data for nearly 4,000 types of engineering material. On the chart, we have marked a steel typically used for automotive door panels (YS170), the talc filled polypropylene (used in the by Smart car), and two other alternatives—aluminum and magnesium alloys.

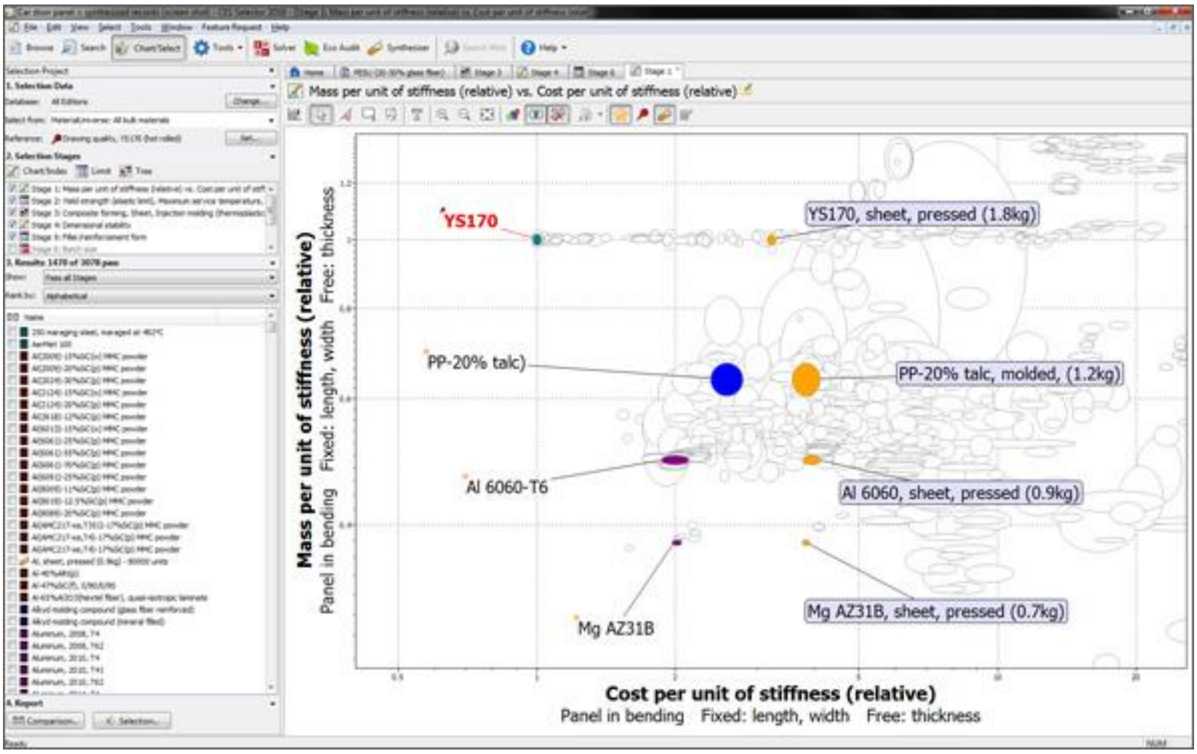
GRANTA
MATERIAL INTELLIGENCE



The chart shows that the polypropylene could lead to a weight saving of 35% relative to the steel, but at substantially higher (2.5 times) cost. *However*, this cost is based on just the material prices and does not account for processing costs. We can account for processing using the Part Cost Estimator model in CES Selector.

To do this, we specified the processing parameters for the each of the materials we are considering. For example, we specified that the steel is rolled into a sheet, which will be purchased "off-the-shelf" and press-formed into the final component, producing 20% manufacturing waste, which will be sold back to the supplier (we assigned a value for selling any manufacturing scrap back to a supplier, and also part mass and length). For the PP material, we assumed that the material was shaped in a single injection-molding process using custom tooling and we specified processing routes for the other two materials.

The Part Cost Estimator enables us to analyze these material and processing options at different batch sizes. The updated version of the mass-cost chart below has plotted estimated properties for the material/process scenarios specified for our four materials at a batch size of 80,000. Now we see that the 35% weight saving provided by PP is achieved with just a 20% increase in part cost. We also see that the lightweight alloys might result in a similar cost increase, but at even lower mass.



Without needing to gather any detailed information about the part or potential materials and processes, a designer would now have the information needed to consider trade-offs and to identify the likeliest routes for more in-depth study.

In the case of the Smart car, we can see how this level of increase in cost could be regarded as a reasonable trade-off for the benefits of the PP in lightweighting and aesthetics.