How Tecumseh use systematic materials selection to reduce costs while enhancing quality and reliability

A CASE STUDY

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Tecumseh have been committed to innovation and product quality for the air conditioning and refrigeration market for more than 75 years. Their reputation has been built on good design and material expertise. In an increasingly competitive global market, they wanted to ensure that their material selection processes were rigorous and reproducible, and use these processes to produce high quality products at an optimal price, whilst also considering environmental factors.

Tecumseh recently adopted CES Selector™, taking advantage of extensive materials property data, advanced graphical analysis, and specialist tools to support materials selection and substitution decisions. This has ensured that their materials experts can make the best use of their materials understanding and share it within the group. This case study looks at two applications, demonstrating how just a few weeks' work using CES Selector has led to three-fold reduction in production time for one component, and generated millions of euros of cost savings from making the right materials decisions.

Extensive plastics data and comparison tables support redesign

Engineers from Tecumseh were looking to reduce the weight of an electrical box cover, while ensuring it continued to meet UL fire-resistance legislation. Changes in regulations had led them to use a different plastic but they had problems with the solutions that suppliers offered. After several months and design iterations, where all new suggestions came at a higher price, the team gained access to CES Selector and were able to apply it as part of a rationalized decision making process. With CES Selector, they were able to constrain the material properties and quickly, objectivity, and exhaustively search a wide range of supplier datasheets. Constraints included finding a material with the right impact testing, Charpy test value, flammability, and thermal insulation (CEI). Searching within the ~88,000 datasheets (from 870 suppliers) available in the IDES Plastics database yielded 29 families of polymers which met all the criteria including ABS + PC, PC, PPO + PS, and ABS "Polylac".

To compare the physical, mechanical, and other properties of these materials, both against the current material (PP H) and against each other, they used CES Selector's comparison table (*pictured*). The engineers quickly identified Noryl (PPO + PS) as the ideal solution because it not only meets the legislative and weight requirements, but has significant advantages in terms of the cost/density ratio of the material.

Being able to quickly search and compare supplier data in this way meant engineers could make informed choices based on their expert appreciation of the material requirements. The development cycle, having chosen the right material, was then simple and efficient. The business case was strengthened by bulk-sourcing this material, and using it across a wide range of products.

	ADDILENE H 490 M20 F (ADDIPLAST)	POLYLAC PA-765 (CHI MEI CORPORATION)	LEXAN® 920 Resin (SABIC Innovative Plastics Europe)	CYCOLOY® C2800 Resin (SABIC Innovative Plastics Europe)	NORYL® LS175 Resin (SABIC Innovative Plastics Europe)
Availability					
Europe	✓	✓	✓	✓	✓
Processing Method					
Injection Molding		✓	✓	✓	✓
Physical					
Density (ISO 1183) (g/cm^3)	1.34	1.19	1.2	1.17	1.12
Mechanical					
Tensile Stress at Break (ISO 527-2) (MPa)	28	34	60	40	68.6
Impact					
Charpy Notched Impact Strength (23°C) (ISO 179) (kJ/m^2)	2	20	60	30	26
Flammability					
Flame Rating - UL (HB/V) (1.5mm) (UL 94)	V-0	V-0	V-0	V-0	V-0
UL 746					
RTI Imp (UL 746) (K)		353	393	333	338
Links					
MaterialUniverse	0	1	1	1	0
Full Datasheet	view	view	view	view	view

Material:	PP H	ABS	PC	ABS+PC	PPO+PS
Cost (€/kg):	2.5	2.2-2.4	3.61-3.9	3.17-3.4	1.8-2.8

Using graphical selection methods to replace a metal with plastic

The materials experts at Tecumseh have used CES Selector for much more than simply ranking materials and comparing their properties. They revisited previous material choices to look for cost reduction strategies, while aware that the customer perceptions of quality mattered as much as performance. The engineers understand that, for any given engineering problem, material performance usually depends on combinations of two or more of these properties. The mathematical expression of these combinations are known as *performance indices*. Finding a material with a high value of the index maximizes the performance of the component.

Engineers at Tecumseh made good use of performance indices when they set out to reduce both the cost and weight of a ventilation unit (pictured, right). The fan mounting bracket (the topmost component) had previously been of metal construction. While plastics are often discounted due to lower rigidity, the materials experts were aware that switching to a lighter thermoforming plastic could significantly reduce the manufacturing time (by avoiding the multi-stage processing required for the metal), and thus the cost. They were happy to redesign the component if it would lead to the predicted threefold reduction in production time.
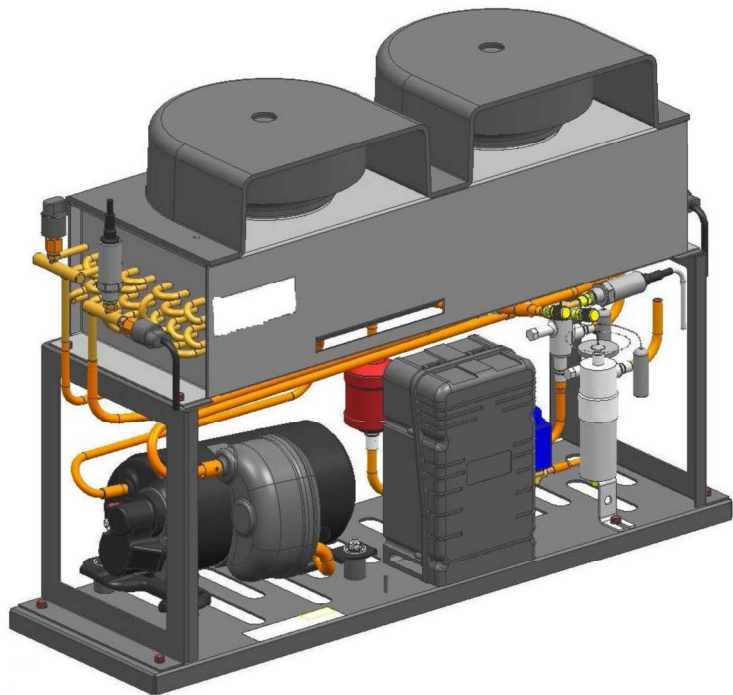
This led to a systematic search for a cheap, light, rigid, plastic with high flexural strength. When searching for the right materials, the engineers considered material properties (such as density, price, and thermal and mechanical behavior) and also the methods of fabrication and assembly. The new

component would have to match the performance of the metal bracket, but could be slightly thicker: the maximum wall thickness was ~5mm. It must also be possible to fabricate it with recessing at both ends.

To support a systematic and reproducible search for a suitable replacement material, the engineers use the powerful graphical interfaces in CES Selector. The objective for selection was to minimize weight whilst ensuring vibration from the fan did not cause the plastic to break. Having made the decisions to use a thermoforming plastic, additional constraints were set to limit thickness, deformation, frequency range, and price.

Granta's MaterialUniverse™ data module represents the entire 'universe' of engineering materials, providing a complete set of material properties with every record. This is important to allow an exhaustive search—engineers can be confident that materials are included or excluded on the basis of their performance, not whether data exists. Each record also contains links to supplier datasheets, making it easy to go from a generic material to a commercially available product.
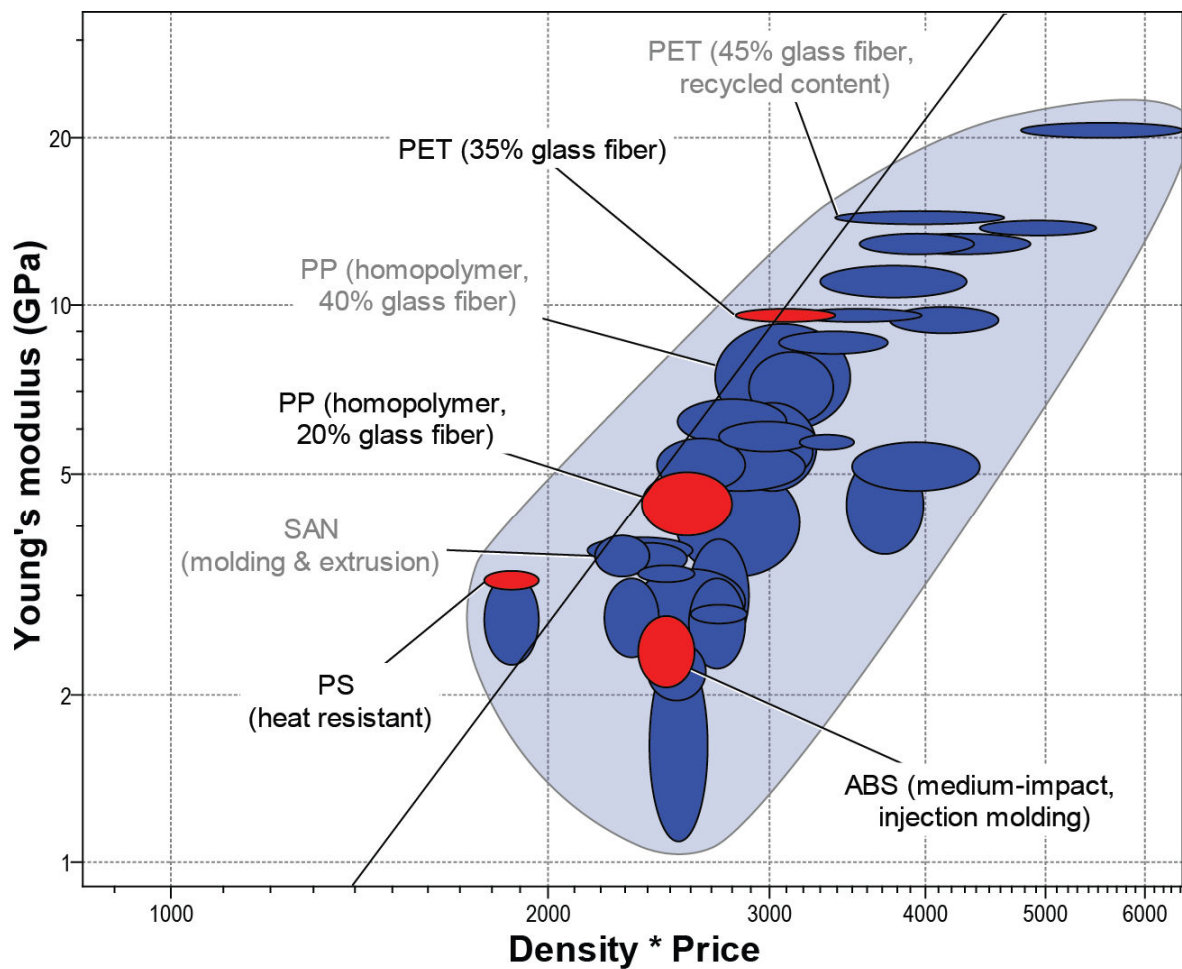
Of the initial >650 generic polymers available in MaterialUniverse, 61 met the criteria, including families such as ABS / PBT / PET / PMMA / POM / PP / PS / SAN and SMA. To find those who best met the objective of minimized weight and vibration, the appropriate performance index[1] must be maximized. Plotting this graphically (pictured, the line represents points with the same value of

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[1] See, for example, "Materials Selection in Mechanical Design" (4th edition) by M.F. Ashby, Butterworth Heinemann, 2011. Some of the key concepts are also described here: www.grantadesign.com/products/ces/ashby.htm

performance index) using CES Selector, a shortlist of materials was quickly identified (marked red), including PS, PP-H (20%GF), ASB, and PET(35%GF).

To reduce overall vibration, calculations were also performed based on mass and rotational frequencies, accounting for the resonant modes of the fan. Having first carried out the rational selection, engineering could concentrate these more advanced simulations on just a few likely candidate materials.

CAE modeling was used to study vibrational modes. Among the four preferred polymers, ABS and PS were shown to have vibrational modes close to those of the fan, which would lead to resonance. PP-H (20% GF) and PET (35% GF), on the other hand, meet the criteria. With PET (35% GF) significantly cheaper, the optimal material was easily identified.

Having identified the optimal material with this combination of CES Selector and CAE modeling, the links from records describing families of plastics in the MaterialUniverse to datasheets detailing actual supplier grades helped Tecumseh source the final material. The raw material is slightly more expensive that the original steel, but given the reduced fabrication complexity (and even having made appropriate design modifications to account for the slightly thicker plastic), the overall cost of the product was reduced by 0.5€ per part.

By using CES Selector to enable this systematic selection process, it took materials engineers at Tecumseh just a few weeks to research and model a suitable replacement part. The result is a cheaper, lighter product, made from easy-to-source materials. When making more than 2 million of these units per year, this soon leads to significant cost savings.

Conclusions

Tecumseh found that using this rational selection methodology allowed them to reduce their development time, fix problems quickly, reduce cost, and react rapidly to changes in legislations. In particular, they often encountered issues with suppliers discontinuing a material, and offering more expensive alternatives. Now they have put the material choices back in the hands of those who really understand both the materials and their applications – the engineers. Linking generic materials to reference data that includes specific suppliers helps them find potential suppliers and alternative materials.

While the two examples here have highlighted the role of CES Selector in material replacement studies, the engineers at Tecumseh are also using this approach from the 'first stages of product design'. This means they are making the right choices early-on, before significant costs have been committed to prototyping and testing. The software is also being used to validate the environmental impact of the new material chosen.

It is the cost reduction that is most outstanding. For high turn-over products, like the ventilation unit described above, making small savings in production time and material costs, quickly show results. A few week's work led to saving of 0.5€ per product which has already saved 2 million €.