Delivering the potential of thermoplastic composites

» Whilst many have been discussing and championing the benefits of thermoplastic composites (TPCs) as the next breakthrough, high-volume, lightweighting technology for more than a decade, their market penetration has not yet met these expectations. Why has this adoption of TPCs been slower than expected, and who is best placed to accelerate it?

The TPC market has been forecast to grow to nearly US$42 billion by 2022[1], with leading material market players, including Celanese, BASF, Solvay, Lanxess, DSM, PolyOne and RTP, offering a massive range of resin options and product formats, for a wide range of applications.

The list of benefits of TPCs certainly makes a compelling case for their consideration as a material replacement in both metallic and thermoset composite parts and assemblies. Massive processing speed gains vs. thermoset composites, plus recyclability and toughness make a very strong argument for engineers.

Raw material and intermediate cost comparisons are complex, given the large price variances between commodity TP resins, (e.g., polyamide, polypropylene) and the higher performing engineered matrices (polyarlketones, such as PEEK, PEKK and PAEK) as well as varying stages of maturity in the TPC intermediate supply chain. Therefore, some of the clearer cost advantages of TPCs relate to the option to re-design previously metallic parts to simplify later steps in manufacturing or assembly.

So, what is holding them back? Taking a top-level view, the principal barriers to increased use of thermoplastics include a less widely accepted set of design data and less familiarity with material properties and the overall technology compared to that of their thermoset cousins. In some high-performance TPC applications, we do not yet have raw materials that are fully stable and consistent enough to maintain tolerances and match void content percentages seen with thermosets. Thermoplastics typically need melt temperatures of 160-300˚C and high pressures to impregnate reinforcement fibers or injection mold parts. The complex and often expensive tooling and machinery required is very different from that for conventional thermoset composite molding.

In our opinion, over the past 20 years, the investment in technology development has favored thermosets. But this is now being reassessed as the aerostructure and automotive markets look to thermoplastics to reduce cycle times and produce more readily recyclable composite parts out of the autoclave. We have hypothesized that the still-nascent TPC industry could overcome these barriers and realize its forecast potential with the help of two different industry sectors, coming at the problem from two very different approaches.

Approach #1: TPCs bring industrial scale to composites. The first sector is dominated by large industrial chemical solutions providers, those with thermoplastic capability that typically operate on a scale at least an order of magnitude greater than their counterparts in thermoset composites that supply thermosets to the composites industry. We see these chemical heavyweights, with their deep-rooted resin and polymer expertise, and the maturity of the thermoplastic materials sector, as being both well placed and motivated to drive the transformation of the TPC sector.

To large players, such as Celanese and Solvay, the attraction of composites is the opportunity to improve margins and capitalize on large-volume applications, such as metal replacement in automotive. Development of new composite materials and applications also provides scope to further differentiate their product offering.

The thermoplastics transformation approach we expect to see deployed in this case would involve targeted product cost reduction via the integration of large-scale manufacturing technologies, further consolidation of the supply chain by bringing compounding and composite material production in-house, and the leveraging of existing strong relationships with OEMs. Significant M&A activity also would occur. We've already seen evidence of this trend in recent transactions: Solvay acquired Cytec, expanded its product portfolio and a boosted its activities in the aerospace and automotive markets. Celanese also added additional compounding capacity and materials technology to the portfolio with its 2017 purchases of compounders Omni Plastics and Nilit Plastics.

Approach #2: Extending the reach of composites with TPCs. The thermoset composites molding sector presents a more fragmented structure than that for industrial TPCs, with numerous smaller specialists and less integration than is seen in the TPC sector as a whole. With an impressive growth rate (5-year CAGR estimated at 6-7%[2]) forecast to continue as lightweighting technologies become more established, margins are also higher for these applications that remain smaller in scale than their thermoplastic counterparts.

A differentiator between those who market thermoplastics and thermosets is that the latter have more experience with fiber reinforcement and use more complex, multi-component resin systems.

For suppliers of thermoset composites, the draw to expand into TPCs is the opportunity for step-change increases in volume and the potential to enter markets where thermoset composites are less well-established because their cycle times are too slow, costs are too high or recyclability is a prerequisite. Consider, for example, Teijin and TenCate. Both have a strong textile heritage, have certainly picked up the pace of TPC development and shown key aspects of our previously noted TPC approaches in their recent actions.

TenCate's range of thermoplastic products now almost mirrors its thermoset offering in scope: UD tapes and prepregs, reinforced laminates and bulk molding compounds are available with a range of mainly higher performance thermoplastic matrices. It's this focus on material performance in small- to medium-sized series, with examples such as aerospace leading edges, floors, brackets and cover plates, that we expect to see from this approach. TenCate also has formalized its industry and research collaboration,

supplementing internal competencies and development with partnerships, such as its Tier 1 membership in the Thermoplastic Composites Research Center (TPRC) and other European consortiums and clusters, such as Thermoplastic Affordable Primary Aircraft Structure (TAPAS) and European Thermoplastic Automotive Composites consortium (eTAC)[3].

Teijin has developed TPC materials reinforced with its own carbon fibers and offers high-rate processing techniques for sub-60 second automotive parts. It also has added part production capacity and expertise, with its acquisition of molder Continental Structural Plastics, and has launched a recycled carbon fiber-reinforced thermoplastic material in Europe[4]. These downstream movements and transactions provide momentum to kick-start use of Teijin's new materials at component level.

Ultimately, we predict that aspects of both approaches will be evident over the next five-year period, with a solid understanding of the entire value chain being the key to success in this complex tapestry. The largest thermoplastics players are well placed, and evidently very keen to deploy their developmental and financial firepower now. Recent thermoplastic automotive projects, such as the Bentley *Bentayga* and Audi *Q7* SUV underbody engine shields, fuel tank and center tunnel covers, produced with trademarked LANXESS Tepex TPCs, are examples of thermoplastic technology leaders' involvement in truly industrial-scale composite applications that would be hard to match with thermoset composites. Therefore, we see the chemical materials giants as most likely to be able to execute in the largest scale applications.

Composites manufacturing specialists that focus on high-performance TP materials and employ downstream acquisition strategies to facilitate rapid adoption of their technology and promote their knowledge are especially suited to growth in more niche applications, such as aerospace or medical. We also expect to see M&A activity here because these technology leaders are attractive targets for major thermoplastics players that wish to integrate thermoset and thermoplastic composite expertise into their operations. CW

REFERENCES

[1] MarketsandMarkets.com.
[2] Future Materials Group.
[3] Sara Black, *CompositesWorld* (2015).
[4] Teijin press releases (2017).

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