Chapter 1

PROCESSING WITH AROMATIC POLYMER COMPOSITES

J. B. CATTANACH and F. N. COGSWELL

ICI plc, Petrochemicals and Plastics Division, Wilton, UK

SUMMARY

Continuous fibre reinforced thermoplastics have only become commercially available in the form of preimpregnated tape since 1982. Most of the excitement associated with this new class of materials has been the combination of toughness and environmental resistance which makes them good candidates for high performance structural composite applications. However, by their very nature, thermoplastics offer new scope for high rate, efficient fabrication technology, the development of which may be seen as a key step in enabling high performance fibre reinforced plastics to become a mass production industry. In this chapter we outline the processing strategies which are currently being researched and provide background information on the associated sciences of rheology, heat transfer and morphology on which those strategies depend.

1.1. INTRODUCTION

Continuous collimated high strength carbon fibre preimpregnated with polyether etherketone (PEEK), a thermoplastic resin, is available from ICI under the generic title Aromatic Polymer Composite\(^1\) which is usually abbreviated to the letters APC. This is the first commercial member of a new class of high performance composite materials based on thermoplastic resin systems, whose preparation and properties have been discussed by McMahon in Volume 4 of this series of

\(^1\)
The general characteristics of such composite materials have been reviewed and a more specific mechanical property profile for APC can now be compiled from a range of independent published accounts.

Thermosetting resins, and in particular epoxies, have, during the last decade, provided the major source of matrix materials for high performance structural composites based on continuous fibre reinforcement. Those resins have demonstrated a good balance of properties combined with convenient processing technology: the high performance of components made from such resins has generated a new design philosophy and a potential demand for an appropriate mass production process. As with any new high performance material the design philosophy has pushed the material to its limits and identified certain property constraints—shelf-life, water sensitivity and brittleness—which appear to be inherent in that family. Looking forward to the next generation of materials thermoplastics resins offer an attractive balance of properties to extend the use of composite materials.

The advantages offered by thermoplastic resins fall into four groups. The rigorous chemistry of linear chain polymerisation gives composite materials indefinite shelf-life from which the user obtains enhanced quality assurance. Toughness of the resin phase can translate into improved damage tolerance in the product, and crystallinity of the resin phase gives potential for excellent environmental resistance. Together toughness and crystallinity offer the product designer increased freedom to construct the best product. Finally, the thermoplastic characteristic of the resin permits: rapid processing, the ability to reclaim scrap via injection moulding, and new strategies to repair damaged structures. These advantages may be viewed as decisive factors in determining the future growth of the fibre reinforced plastics industry. That growth will be a partnership between the different classes of resin system, thermoset and thermoplastic each doing what it does best.

The recognition of the potential advantages offered by thermoplastic systems has led to the introduction of a number of preimpregnated tape products from a variety of sources including:

- Aromatic Polymer Composites (APC) from ICI
- Ryton composites from Phillips Petroleum
- Torlon composites from Amoco