An expert system approach to manufacturing preforms for infiltration-processing of ceramic and metal matrix composites

R. Pitchumani, P. A. Schwenk, A. K. Kordon, V. M. Karbhari, B. R. Rossing* and F. D. Claar*

Center for Composite Materials, University of Delaware, Newark, Delaware 19716-3144, USA

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The application of artificial intelligence techniques to composites manufacturing has been initiated in recent years. While much of the research efforts have concentrated on organic-matrix composites for which there is wealth of information available, parallel developments in the area of ceramic- and metal-matrix composites have been scant. Our research is aimed at developing a comprehensive knowledge-based expert system for the manufacture of ceramic- and metal-matrix composites. We present here the first phase of the knowledge base development, wherein the problem domain is that of manufacturing preforms which are subsequently infiltrated with the matrix material to form composites. The knowledge base spans the production tasks of materials selection, process selection and process design, and encompasses the experience of seasoned designers as well as theoretical models based on first principles. The dual resources available in the knowledge base provides a robust problem-solving tool in the face of routine problems and new situations alike. The development of the knowledge base and a generic framework supporting the ongoing enhancements towards the ultimate goal of the research are described.

Keywords: Ceramic matrix composites; metal matrix composites; preforms; knowledge-based systems

1. Introduction

Knowledge-based expert systems are intelligent computer programs that capture the knowledge of a particular domain and mimic the problem-solving process of human experts to arrive at competent solutions. Following their earlier successes in the fields of medical diagnosis [1], and speech and image analysis, knowledge-based systems have rapidly found applications in the manufacturing domain [2]. The design and execution of a manufacturing process, in general, comprises several tasks, each involving numerous, highly interdependent decisions pertaining to the manufacture of a product. Motivated by the fact that decisions are often guided by 'rules of thumb' many rule-based 'intelligent' systems have been developed for various individual production tasks ranging from design and diagnosis to monitoring and control [3–5].

Apart from representing a very practical application of artificial intelligence techniques, knowledge-based manufacturing systems also provide practising engineers with a comprehensive problem-solving and decision-making paradigm in the face of challenging real-world problems. Such a tool is of immense practical use in making critical decisions more proficiently, consistently, and with confidence. In addition, they provide useful consultations and suggestions to marketing/managerial personnel in examining the needs of the customer vis-à-vis the manufacturing resources of the company, as well as for strategic planning.

A production process normally involves the broad tasks of materials selection, process selection, process design,