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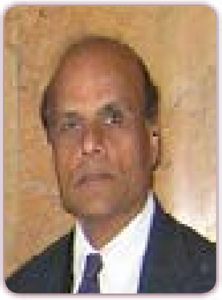

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Innovations in design, materials and manufacturing of turbine blades for jet-engines

Turbo-engines are used in land-based power generators as well as in aircraft. The modern turbo-engine is the product of decades of innovations in design, materials and manufacturing; and the innovations are continuing, in the never-ending quest for lighter and more efficient turbo-engines. Among the five essential parts of a turbo-engine namely the air-intake, compressor, combustion chamber, turbine and exhaust the blades of the high-pressure turbine are subjected to very high centrifugal loads and very high temperatures. Historically, the early jet engines developed in Germany and England utilized stainless steels for the turbine blades and they had a temperature limit of about 500^{0}C. Nickel-based superalloys were developed around the Second World War. Several generations of these superalloys were the result of material innovations. Several manufacturing innovations extended the operating temperature of the superalloys: notably, directional solidification to induce elongated grains, single-crystal solidification and directional solidification of eutectic superalloys to align the fibrous reinforcements. The ever-increasing demands for lighter and more efficient turbo-engines, due to rising fuel prices, air-traffic volume and environmental concerns, have continuously raised the turbine inlet temperature. Design innovations such as intricate cooling passages in the blades allow them to operate at temperatures well in excess of the melting point of the superalloys themselves. Ceramic coatings on the superalloy blades represent the next material innovation. Innovations in manufacturing are enabling the additive manufacturing of superalloy blades, reducing the time needed to move from the design phase to the testing phase. With the superalloy blades reaching their limit, conventional limitations of brittleness and low reliability of monolithic ceramics are sought to be overcome by innovations such as self-healing ceramics and transformation-toughened ceramics. Ceramic matrix composites are showing promise to push the turbine inlet temperature beyond the current limits. This presentation will summarize some of these innovations.

Biography

Ramamurthy Prabhakaran, joined at Old Dominion University in 1979 and working as an Eminent Professor of Mechanical and Aerospace Engineering, has been at the Old Dominion University since 1987. He obtained his PhD in Mechanical Engineering at Illinois Institute of Technology in 1970. He worked as a graduate Research Assistant, IIT, Chicago from 1967-1970; Research Associate, IIT, Chicago from 1971-1972; and worked as Assistant Professor in Indian Institute of Technology, Kanpur, India; promoted to full Professor in 1980; Associate Professor, Old Dominion University, Norfolk, from 1979-1985; Professor, Old Dominion University from 1985-1987.

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