CERAMIC MATRIX COMPOSITES (CMCS) AT GE: FROM INCEPTION TO COMMERCIALIZATION

Krishan L Luthra, GE Research (Retd.), Schenectady, NY, USA
Krishanlluthra@gmail.com
James S. Vartuli , GE Research, Schenectady, NY, USA

Ceramists had been dreaming of using ceramics in gas turbines/aircraft engines since the nineteen sixties. There was a DoD report around 2002, which questioned whether it would ever happen by a thought-provoking title, “Will pigs fly before ceramics do?” In 2016, it became a reality when GE introduced CMCs as shrouds in aircraft engines for narrow-body planes Airbus 320 Neo and Boeing 737 MAX. CMCs would be used very extensively, practically every hot stage component except for rotating components, in GE 9X for large body Boeing 777X entry into service in 2025. Rotating components will also be viable in not too-distant future.

Earlier efforts at GE were focused on sintered SIC and melt-infiltrated SiC-Si ceramics in nineteen sixties thru early eighties. However, because of their inherent brittleness, these ceramics didn’t succeed in commercialization. These efforts led to the development of ceramic matrix composites, which started with particle and whisker reinforced composites and ultimately settled on SiC fiber reinforced SiC-Si matrix composites made by silicon infiltration. These composites are replacing nickel-based superalloys, which were extensively developed for 50-60 years, with an average capability improvement of about 50 F every decade. For comparison, the CMCs currently in use provide an additional capability of 300-400 F over state-of-the art nickel-based superalloys.

The development of a revolutionary technology like CMCs was an enormous, challenging effort, requiring inter-disciplinary efforts in materials science, ceramics, mechanics and mechanical engineering. Design and commercialization of CMCs is equally challenging, if not more so, requiring training and development of a new discipline. GE has successfully developed the entire supply chain starting from fiber to fiber-coatings, making preforms of the desired shape, silicon melt infiltration, machining and grinding of components, application of Environmental Barrier Coatings (EBCs) to the testing of materials and components in relevant environments. Consequently, GE has spent over one-and-half billion dollars in development and commercialization of CMCs. This talk will focus on the development history and commercialization of CMCs, including the current infrastructure as well as some of the challenges faced during the long history. Also included will be some discussion of the next generation of CMCs, which can potentially provide an additional capability of up to 300 F as well as the use of CMCs for rotating components.