



Abrasive machining of advanced aerospace alloys and composites

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ARTICLE INFO

Keywords:
Abrasion
Grinding
Material removal

ABSTRACT

The aerospace industry has experienced significant growth over the past decade and it is estimated that nearly 30,000 new commercial passenger aircraft will be required by 2030 to meet rising global demand. Abrasive machining is a key material removal process utilised in the production of aerospace components. Current industrial practice and perspectives relating to grinding in the aerospace sector are presented including general workpiece surface integrity standards/requirements, fluid delivery systems, wheel preparation options and machine tool design/configurations. Corresponding academic research on the machinability of aerospace alloys and composites are critically reviewed together with recent developments involving novel/innovative grinding processes.

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1. Introduction

The worldwide market for civil aircraft is rising in line with increasing global population and affluence. Growth in new airplane deliveries is expected to be at an average of 3.6% per annum up to 2030 [114]. This naturally translates to a greater demand for gas turbine engines, which places significant strains on current as well as future supply chain and production capacity.

Commercial pressures for continuous improvement in aeroengine performance and fuel efficiency have driven the development of materials with increasing temperature limits at affordable cost [85]. This is evident from the evolution of materials composition in engines, with the trend moving towards alloys with higher temperature capability (from steels to nickel and titanium alloys) and materials with lower density (aluminium to carbon fibre composites). Although not fully mature, ceramic and metal matrix composites (CMC and MMC) are showing evidence of replacing some of the high temperature alloys that dominated engines towards the end of the 20th century. The constantly changing state of aeroengine materials technology is another factor that will considerably stretch the limits/capability of established manufacturing processes and therefore further emphasises the critical need to develop more advanced and robust production techniques.

Despite the rapid development and increasing acceptance of non-conventional machining processes for the manufacture of

turbomachinery parts [123], grinding is still one of the primary operations in the finish machining of critical gas turbine engine components. This is due to the strict requirement for achieving tight dimensional tolerances of $<10\ \mu\text{m}$ and superior surface finish with roughness in the order of $<0.5\ \mu\text{m Ra}$ together with acceptable workpiece quality/integrity.

The keynote will discuss the latest developments in academic research together with current state-of-the-art relating to abrasive machinability of key aerospace alloys and composite materials, fluid delivery and wheel preparation strategies, machine tool technologies and innovative process configurations, as well as example case studies and perspectives from practitioners in the aeroengine manufacturing sector. The paper complements a sister keynote to be presented in STC-C relating to the 'High performance cutting of advanced aerospace materials' as well as the keynote delivered last year (2014) in STC-E [123].

2. Workpiece surface/sub-surface integrity requirements

Aeroengine discs are categorised as critical components and are therefore subject to highly stringent dimensional accuracy, surface integrity and fatigue requirements. It is well documented that the functional performance of parts subject to machining processes is strongly affected by the resulting material surface/subsurface integrity conditions [111]. Publications detailing investigations relating to the influence of material removal processes on workpiece residual stresses initially appeared in the 1950s. However, Field and Kahles [66] were the first to define the concept of surface integrity and propose associated methodologies

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