Abradable Capped Metallic Foams for Aero-Engine Sealing Clearance Control

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The aim of this project is to investigate the wear mechanics of a conventional abradable material (Metco320), used for compressor sealing, backed by an open cell metallic foam substrate, determining whether the use of the foam enhances abradability performance. Testing is performed on a scaled down high-speed rig to create engine like conditions, to understand how the capped foam deforms and compacts. The compaction mechanism and energy transfer behaviour is found to explain the fundamentals of how these substrates perform. This study then goes on to compare the effects of incursion rate and foam pore size on the behaviour observed.

Keywords: Tribology, Wear, Foams, Deformation, Compaction

1. Introduction

Abradable materials are commonly used as sealing technologies for aero-engines, these exist between the rotational and static components to allow for good clearance control and performance [1]. Current sealing materials, even under optimum conditions, can vary in performance due to inconsistencies within the material microstructure, resulting in material adhering to the blade and grooving of the liner. Resin filled metallic foams have been shown to actuate a more desirable wear mechanism, as they compact with low forces, resulting in a concentric seal path with minimal blade wear [2]. Given the temperature limitations of resins, this study seeks to investigate whether similar improvements in abradability performance can be achieved by over-spraying a conventional abradable material onto a metallic foam substrate.

2. Methodology

2.1 Rig Setup

Testing is conducted using a scaled down rig at the University of Sheffield, described extensively in [3]. The rig includes a disc mounted to a spindle, upon which a test blade is inserted and rotated to a given tip speed. An abradable substrate is then attached to a stage and raised vertically into the rotating disc, until the desired incursion depth is reached. A dynamometer is located below the sample and measures the forces in the normal and tangential directions with respect to the blade. In addition to this setup, a high speed imaging system is implemented. This enables a visual representation of the material behaviour giving insight into the compaction/deformation mechanisms seen in the substrate, due to the forces from the blade strike.

2.2 Results

Through a series of repeated tests, comparisons are made to characterise the suitability of foams as a liner substrate and their impact on liner abradability. Firstly, results show that pore size has a significant influence on the wear behaviour observed, and secondly that the incursion rate is a major factor that determines what mechanisms are actuated during the rub process. Fig. 1 shows a series of images to show compaction of the substrate through a single pass of the blade, captured at 10,000 frames per second.

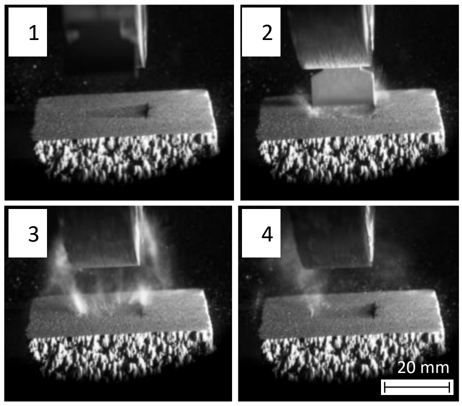

Figure 1. Images series showing compaction after a strike of the blade

3. Discussion

Two main points of discussion include pore size of the base layer metallic foam in addition to the incursion rate at which tests are conducted. For faster incursion rates it is typically seen that the energy input into the system is greater so more compaction and deformation occurs. From Fig. 1 it can clearly be identified that compaction occurs since no underlying ligaments are revealed as the incursion progresses, even though the overall incursion is deeper than the blade cap, with the debris seen observed as a result of where the compacted layer breaks away either side of the blade path.

4. References

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