INVESTIGATING APPLICATION OF HONEYCOMB ABRADABLE LINING IN AERO-ENGINE TURBINE STAGE

B. Zhang [a*], M. Marshall [b]
*bzhang10@sheffield.ac.uk
[a] Department of Mechanical Engineering, University of Sheffield,
S35, 3 Solly St, Sheffield, S1 4DE, United Kingdom
[b] Department of Mechanical Engineering, University of Sheffield,
Sir Frederick Mappin Building, Mappin Street, Sheffield, S1 3JD, United Kingdom

KEYWORDS
Abradable materials; NiAl; Turbine Sealing

ABSTRACT
Modern aero-engines require increasing levels of performance and working efficiency. One of the ways this is achieved, is by increasing combustion temperatures in order to exploit leaner fuel combustion regimes. This in turn leads to hotter turbine temperatures, and an increased performance demand on turbine sealing systems. In the turbine, the sealing system comprises of a shroud containing a fin, which is mounted onto the end of the blades, along with an abradable material used to coat the turbine casing. The fins on the end of each blade in concomitance form a ring, which incurs into the abradable lining, producing a seal and thus minimizing axial gas flow [1]. A typical abradable system presently used in the hot section of the turbine, comprises of a nickel based superalloy honeycomb structure, combined with a nickel aluminide filler. However, this system has been found to harden as a consequence of thermal ageing leading to wear of the sealing fins, and gas flow leakage.

In this study, the performance of the aforementioned sealing system is investigated with a range of different fillers, each containing differing ratios of nickel and aluminium. Tests are conducted on a high speed abradable test rig, where the incursion conditions between a single sealing fin and the abradable are replicated. Tests are undertaken on both as manufactured and aged test samples, with thermal ageing performed at 1000°C for 100 hours. Sealing fins manufactured from Inconel 718 were used for all tests, with incursions performed at the same rate and to the same depth in each case. During the tests, stroboscopic imaging was used to monitor wear of the fin, along with a dynomometer and pyrometer to measure force and temperature respectively. Post-test, the worn grooves on the abradable samples and the fins are imaged, and the abradable sectioned and analysed using optical microscopy. Elemental analysis is also undertaken to determine material transfer between the abradable and fin, and vice versa.

The ratio of aluminium to nickel in the filler was found to have a significant impact on the wear behaviour of the sealing system. In the case of a stoichiometric mix of aluminium and nickel in the filler, the un-aged abradable was difficult to cut, resulting in high levels of fin wear. This led to cyclic peaks in force and temperature, culminating in the removal of compacted abradable material with accompanying sparking. A similar mechanism was observed in the case of the aluminium rich filler, whereas in the nickel rich case, good cutting with negligible fin wear was recorded. At the aged condition, this trend was reversed, with the aluminium rich filler minimising fin wear, due to its inherent brittleness leading to good fracture and dislocation on contact with the fin.

REFERENCES
[1] Sporer, D, Refke, A, Dratwinski, M, Dorfman, M, Sulzer Metco plc., Giovannetti, I, Giannozzi, M, Bigi and M, GE Oil&Gas plc.. ‘’New high-temperature seal system - Increased efficiency of gas turbine,’’ 2008, Sulzer Technical Review, 2/2008.