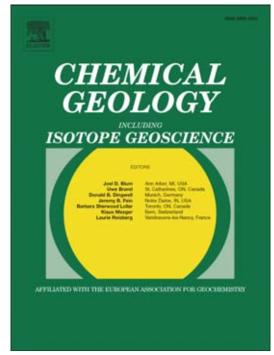
Accepted Manuscript



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PII: S0009-2541(16)30625-8
DOI: doi:10.1016/j.chemgeo.2016.11.024
Reference: CHEMGE 18157

To appear in: *Chemical Geology*

Received date: 11 March 2016
Revised date: 13 November 2016
Accepted date: 16 November 2016

Please cite this article as: Giehl, C., Brooker, R.A., Marxer, H., Nowak, M., An experimental simulation of volcanic ash deposition in gas turbines and implications for jet engine safety, *Chemical Geology* (2016), doi:10.1016/j.chemgeo.2016.11.024

An experimental simulation of volcanic ash deposition in gas turbines and implications for jet engine safety

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Abstract

The protracted grounding of commercial aircraft throughout Europe due to the Eyjafjallajökull volcanic eruption in Iceland April 2010, has alerted the public to the potential dangers of aircraft encounters with ash clouds. One of the most serious issues is the failure of jet turbines due to the deposition of molten silicate ash particles on hot turbine components. In this study, we highlight the influence of volcanic ash composition, crystal/glass ratio and resulting bulk viscosity on the interaction of ash particles with hot turbine blades and vanes.
A range of volcanic materials are used to simulate ash melting during transport through the combustor and deposition on a turbine blade of nickel superalloy material commonly used for the hot components in jet engines. The results show how 'on-blade' accumulation of molten particles can lead to efficient adhesion (wetting) and subsequent rapid accumulation of further molten material in some circumstances. In other cases particles form a cinder-like layer or entirely bounce off the blade. Any deposits will disrupt the air flow in the turbine, clog the cooling system and eventually cause the engine to stall. However, the cinder deposits can be removed in our experiments (as well as 'in-flight' for a real engine) by shutting off the heat source, allowing the deposit to quench and dislodge by thermal stress cracking. However, this currently recommended airplane safety procedure will not work for more basaltic melts which wet the blade surface more efficiently. Our experiments demonstrate how the nature of the incoming ash particle strongly influences the type of deposit formed, the important parameters being bulk ash composition, crystal proportion and particle size.

Highlights

- Experiments are the first to simulate the dynamic interaction of volcanic ash particles with turbine blade material in a realistic thermal regime
- Bulk/glass volcanic ash compositions, crystal/glass ratio and grain size control interaction behavior with turbine blades
- Relying on 'in-flight' removal of ash coatings by closing down turbine engines is a questionable safety procedure