Volcanology

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Jet turbines hotter than the volcano!

The aviation hazard posed by volcanic ash rose to worldwide prominence during the 2010 eruption of Eyjafjallajökull, Iceland, which caused enormous disruption to air travel across western and northern Europe. Two new studies from researchers in the Department of Earth and Environmental Sciences at LMU provide insight into what happens when ash is ingested by an airplane engine.

Ash venting episode at Santiaguito volcano, Guatemala

The pan-European airspace problem during the 2010 eruption of Eyjafjallajökull highlights just how the interactions between aviation and ash can affect everyone. Ash can harm jet turbines through abrasion of components or by melting onto engine parts. Critically, when volcanic ash melts in the hot zones of jet engines, it can stick and coat turbine interiors. Sticking of ash is particularly problematic as it may significantly affect the flow of air through the turbine. Deposition in spaces designed for air-cooling may clog, reducing the efficiency with which the engine is kept from overheating.

LMU volcanologists, together with colleagues across Europe, are addressing the hazard posed by volcanic ash clouds on aviation. In two recently published complementary papers, the researchers have characterized the 'sticking potential' of volcanic ash and considered the appropriateness of test sands currently used by the aviation industry for assessing the durability of jet engines. The 'sticking potential' is a way to evaluate whether a material is capable of depositing onto high-temperature components of a commercial jet engine, an effort critical in assessing whether or not it is safe to fly through volcanic ash clouds. The team, led by Professor Donald Dingwell, has taken a multi-disciplinary approach by combining the industry's material science methodologies with an understanding of volcanic processes, and is therefore able to offer tremendous insight into how the high temperatures in jet engines affect fine-grained volcanic materials.

Ash sintering and jet engine operation

Using volcanic ash samples from Eyjafjallajökull (Iceland) and Santiaguito (Guatemala) volcanoes, the researchers use melting experiments to understand the fundamental behaviour of ash at temperatures anticipated for various jet engine components. 'Volcanic ash rapidly melts and sinters together at the temperatures in the hot zone of commercial jet engines. This suggests that the probability of ash sticking to jet engine working parts may be high,' says Dr Wenjia Song, lead author of one of the publications. He explains that implementation of a new standardized protocol (used in coal combustion and gasification) allows them to experimentally determine the fusibility of volcanic ash at relevant temperatures. Study co-author Fabian Wadsworth adds that 'the rates we estimate are minima considering that, in jet engines, volcanic ash may be abraded and milled to finer grain sizes and may be heated far more rapidly than our first experiments.'

The work also establishes the chemical and physical uniqueness of volcanic ash with respect to hazard. 'We've shown that crystalline sands are not a suitable proxy to investigate the impact of volcanic ash on jet engines' says Dr Ulrich Kueppers, lead author of the second study, as 'ash can melt and stick to material at lower temperatures than previously believed, thereby arguing for a more serious risk to aviation than currently envisaged and the need for appropriate testing material.'

With the current level of air traffic, understanding the generation, transport and impact of volcanic ash is a top priority. 'Everyone who relies on air travel as a means of transportation or for financial solvency will benefit, either directly or indirectly, from this research,' says study co-author Dr David Damby. 'Eruptions in populated areas aren't likely to stop in the immediate future. We hope that our ongoing work will reduce uncertainty about the consequences of flying through ash and contribute to informed decision making by authorities during future air-traffic disruptions, but also to increase the public's faith in these decisions since they'll be based on sound, communicable evidence.'

These studies are part of ongoing projects funded by the European Research Council (ERC), the Alexander von Humboldt-Foundation, AXA Research Funds and the EU-funded Marie Curie Initial Training Network VERTIGO. The research is published in Geophysical Research Letters and the Journal of Applied Volcanology.

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