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**Predicting melting of mineral dust in gas turbine engines**

1. **Introduction**

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**general**

* Smialek: Fine particles, less than 10 μm, are able to bypass the particle separators and enter the cooling and combustion systems. (Smialek, 1992) (S Arabian sand)
* Bansal: volcanic ash may cause serious damage by erosion as it passes through the jet engine or by plugging the cooling holes of the combustor liner and the blades resulting in premature failure. To improve efficiency, future jet engines will operat at higher temperatures than thecurrent engines. next generation turbine engines for operation at temperatures of (1482–1649 1C). At these elevated operating temperatures, desert sand or runway dust ingested into turbine engines will fully decompose and melt into a viscous and corrosive slag-like material of calcium magnesium aluminosilicate (CMAS) composition.
* Walsh: The combination of extreme temperature and residenceime can lead to sand even melting inside the turbine component. With increasing temperatures of gas turbine engines and the development of new cooling designs, it is critical to evaluate the effects of ingested sand particles.
* Zhao: Since the surfaces of components in future engines are likely to be cyclically exposed to temperatures of 1250 °C and above







**melting points; minerals**

* (Smialek, 1992) 1713 °C for SiO2 quartz, 1391 °C for CaO•MgO . 2SiO 2 diopside, and 1540 °C for CaSO4..
* (Bansal 2014) X-ray diffraction analysis of quartz(SiO2), calcite(CaCO3), gypsum (CaSO4.2H2O), NaAlSi3O8, Mg2(Al3.9Si5.1O18) andMg3Al2(SiO4)3 phases; 34%SiO2 (Quartz),41%CaSO4.2H2O (Gypsum),11%CaCO3 (Calcite),7%NaAlSi3O8 (Albite),and 5% Mg2(Al3.9Si5.1O18) andMg3Al2(SiO4) (Middle east dust)
* **Engelbrecht: Ambient Sampling; Middle East (Qatar);** fractions, from 0.5 *μ*m to 10 *μ*m diameter particles, ; Figure 10A presentsIn this fashion, we interpreted Ca-Mg particles as dolomite, Ca-richas calcite, Si-Al-Mg rich as clay, Si-rich as quartz, and so on.The ‘bin’ with the highest mass fraction at all 15 sites is Si-Al-Mg (clay), varying from 27% for UAE to 59% for Tallil.
* calcium magnesium aluminosilicate-like (CMAS-like) glassy deposits in the hot sections of engines
* Singh: Metal temperatures were shown to be the most important parameter for particle deposition. At temperatures above 1000 oC, sand particles started melting and promoted blocking of cooling holes. Land et al.[17]; Particle ingestion is excessive while takeoff and landing when engines are in ground proximity and running at full power[1]; According to studies by Edwards and Rouse[7], high sand ingestion can reduce engine stability by eroding blade profiles and lowering the compressor efficiency, as a result of which the line of operation is closer to the surge line.; Figure 5.4 shows the probability of sticking for sandparticles based on viscosity*visc P* with temperature. Sticking probability rises exponentially as the

particle approaches softening temperature.

* *Taltavull,* It is increasingly clear that gas turbines, particularly aeroengines, are susceptible to damage caused by ingested particulate, such as sand, fly ash and volcanic ash, often referred to generically as calcia-magnesia-alumina-silica (CMAS). Such particles may melt, or at least soften, in flight, making it more likely that, if they strike solid surfaces within the turbine, they will adhere to them on impact. Ongoing increases in turbine entry temperature clearly raise the danger of this happening and

### Alkali feldspars

The [alkali feldspars](https://en.wikipedia.org/wiki/Alkali_feldspar) are as follows:

* [orthoclase](https://en.wikipedia.org/wiki/Orthoclase) ([monoclinic](https://en.wikipedia.org/wiki/Monoclinic))[[8]](https://en.wikipedia.org/wiki/Feldspar#cite_note-orthoclase-8)—KAlSi3O8
* [sanidine](https://en.wikipedia.org/wiki/Sanidine) (monoclinic)[[9]](https://en.wikipedia.org/wiki/Feldspar#cite_note-sanidine-9)—(K,Na)AlSi3O8
* [microcline](https://en.wikipedia.org/wiki/Microcline) ([triclinic](https://en.wikipedia.org/wiki/Triclinic))[[10]](https://en.wikipedia.org/wiki/Feldspar#cite_note-microcline-10)—KAlSi3O8
* [anorthoclase](https://en.wikipedia.org/wiki/Anorthoclase) (triclinic)—(Na,K)AlSi3O8

### Plagioclase feldspars

The plagioclase feldspars are [triclinic](https://en.wikipedia.org/wiki/Triclinic). The plagioclase series follows (with percent [anorthite](https://en.wikipedia.org/wiki/Anorthite) in parentheses):

* [albite](https://en.wikipedia.org/wiki/Albite) (0 to 10)—NaAlSi3O8
* [oligoclase](https://en.wikipedia.org/wiki/Oligoclase) (10 to 30)—(Na,Ca)(Al,Si)AlSi2O8
* [andesine](https://en.wikipedia.org/wiki/Andesine) (30 to 50)—NaAlSi3O8—CaAl2Si2O8
* [labradorite](https://en.wikipedia.org/wiki/Labradorite) (50 to 70)—(Ca,Na)Al(Al,Si)Si2O8
* [bytownite](https://en.wikipedia.org/wiki/Bytownite) (70 to 90)—(NaSi,CaAl)AlSi2O8
* [anorthite](https://en.wikipedia.org/wiki/Anorthite) (90 to 100)—CaAl2Si2O8

**Case**

* The State of Qatar experienced a sandstorm on the night of April 1, 2015, lasting approximately

12 hours, with winds of more than 100 km/h and average particulate matter of approximately 10 μm in

diameter.

* uring the night of Wednesday, April 1, 2015,a massive sandstorm struck the ArabianPeninsula. The storm lasted from late on theevening of April 1 into the morning of Thursday,April 2. The fact that the preponderance of PM was10 μ or less in diameter meant that the storm represented

a serious threat for respiratory complications.

* The half-dozen or so sandstormsthat are expected in Doha each year tend to have

readings in the 10,000 to 15,000 μg/m3 range. the current storm readings(on multiple instruments around Doha) exceeded1,000,000 μg/m3.

The storm reached Qatar around 2200 local time on

Wednesday night, April 1. The Qatari national weather service

reported the storm brought high winds (up to 70 km/h)

carrying so much sand and dust that by 0038 local time

Thursday, April 2, the bureau issued a warning of near-zero

visibility. Weather maps (Figure 2) portrayed the size of the

storm and its track over time.

The storm severity was characterized by twin peaks of

activity. The initial peak occurred early Thursday morning on

April 2 within an hour or so after midnight local time. As the

storm moved through Doha, a second peak of activity

occurred the same day between 0600 and 0700 local time.

While winds continued to be higher than normal for 2 days,

the worst of the sandstorm had largely abated (in Qatar) by

1000 (local time) on Thursday, April 2. In

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1. **Modelling**

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Health System Response and Adaptation to the Largest

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