Graphite progress update

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22 July 2013
Thermal shock

- Graphite has good thermal shock resistance \((R)\)
  - use as crucibles, moulds, dies, and electrodes
- Unirradiated (calculated)
  - POCO ZXF-5Q \(\approx 47\) kW/m
  - Toyo Tanso IG-430 \(\approx 112\) kW/m
- Reduces with irradiation
- Reduces with oxidation

\[
R = \frac{k\sigma_T}{\alpha E}
\]
Thermal shock

Thermal shock resistance of graphites before and after irradiation to $11-15 \times 10^{20} \text{n/cm}^2 (>0.18 \text{ MeV})$ at 750-1000ºC (Sato et al., 1989)

Thermal shock resistance of graphites before and after irradiation to $16-17 \times 10^{20} \text{n/cm}^2 (>0.18 \text{ MeV})$ at 600-850ºC (Sato et al., 1980)

Thermal shock resistance of oxidised IG-430 graphite (Kurumada et al., 1997)
Summary

- **LBNE**
  - POCO ZXF-5Q, 1 dpa, \( \leq 300^\circ C \), no oxidation

- **T2K**
  - Toyo Tanso IG-430, 1 dpa, 700 to 800\(^\circ\)C, \( \sim 8\% \) oxidation

- No ‘show stoppers’ found
  - no obvious better choice of grade
  - recommend (scoping) thermo-mechanical analyses
    - irradiation-induced dimensional and materials properties changes
    - oxidation
  - recommend further calculations (or experiments) on thermal shock resistance