SOME PROPERTIES OF GREEN (UNSINTERED) AND SINTERED MUDSTONE

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Introduction

Mudstone belongs to the family of sedimentary rock. The particular mudstone of interest is found in the Kuala Belalong River and its tributaries in the Temburong district. In this project, some physical properties of green and sintered mudstone have been investigated. The properties are heat of absorption and/or emission during sintering, mass changes, shrinkage/expansion rate, densification rate, thermal expansion, porosity, physical structure of the green and sintered mudstone. The research was conducted from November 2002 to March 2003 with most of the characterization done at the School of Materials Engineering, Nanyang Technological University, Singapore.

Green and sintered mudstone

Fig. 1 shows the green (unsintered) and sintered mudstone. The green mudstone has a dark greyish appearance and is densely packed in layers formation. The sintered mudstone is reddish brown and has a high porosity inside with a hard outer shell. Preliminary results show that when the mudstone is sintered to 1200 °C, it changes its bulk volume by more than 60% with a corresponding change in bulk density from a green (unsintered) bulk density of about 2.6g/cc to a sintered bulk density of 0.7 g/cc as demonstrate in fig. 2. The expansion rate at 1200 °C continues to increase at a steady rate for up to 3 hours and gradually stop thereafter.

Fig. 1. Green (A) and sintered (B) samples of mudstone
Fig. 2. Light weight sintered mudstone floating on water

Thermo mechanical analysis (TMA) of mudstone

TMA results show that the material expands from 1150 °C onwards. This is unlike normal ceramics and clay materials. It becomes quite porous inside with an almost non-porous hard outer shell. Fig. 3a is a typical TMA result for this material as compare to normal Kaolin clay shown in fig.3b.

![Graph showing TMA results]

Fig. 3a. TMA of mudstone showing expansion starting from 1150 °C.
Fig. 3b. TMA of Kaolin clay

Thermo gravimetric analysis

TGA results shows that thermal reaction is exothermic with rate of highest weight loss at a temperature range of 800-1000 °C probably due to burning off of organic matters. Fig. 4 shows a typical TGA result for this material. There is no expansion resulting from this mass lost but rate of volume contraction is maximum indicating an increase in density as shown in fig. 5. Possible maximum densification occurring between that temperature ranges. The mass loss at 1200 °C is minima but volume expansion occurs at this temperature. The decrease in density above 1150 °C is attribute to an increase in volume due to sample expansion as indicated in fig. 3a. The theoretical model for mechanism of volume expansion at 1200 °C is being investigated.
**Fig. 4.** TGA result of mudstone

**Fig. 5.** Density of sintered mudstone versus sintered temperature. The green sample is sintered for 2 hours at each sintered temperature.

**X-ray Diffraction analysis (XRD)**

XRD indicates that the green material is mostly illite (56%) and chlorite (30.7%) and the sintered material is mostly mullite (85%), which is hard substance.

**Scanning electron microscopy (SEM) analysis and porosity determination**

SEM results show that the sintered rock is very porous below the surface with micro and macro porosities. Fusion of the surface during sintering gives it an almost non-permeable
surface. Fig. 6 shows a hard almost non-permeable surface of the sintered rock. Fig. 7 shows the porosity level below the surface. Porosity is estimated at 70%.

Fig. 6. SEM of sintered sample’s surface

Fig. 7. Level of porosity below the surface of the sintered rock. Courtesy of Dr. J. Warren, Petroleum Geoscience, UBD.

Further Work
Potential commercial use of such materials for insulation purposes in the form of tiles, as lightweight aggregate for building construction, as fire retardant materials, paving stones, ornamental floating rock.
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