Physical, structural and thermal properties of basalt – clay mixes

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Abstract

Jordanian basalt was added to china clay on different mixes up to 60% by weight. Physical thermal and structural properties were studied. Mixes basalt have showed a remarkable increase in density with increasing basalt addition. porosity was property greatly affected with increasing the firing temperature. Maximum reduction in porosity was observed at high firing temperature for all mixes and this will cause increase in hardness values.

The different phases were determined by X-ray analysis. The expansion coefficient decreases with increase of the basalt content . No strong difference of the heating rate are observed on the properties of the thermal expansion after firing at 1100°C for all mixes.

Introdction

Basalt is will known as rock found in virtually every country around the world. It is main uses is as a crushed rock used in construction industrial and highway engineering (1) .Basalt fine powders and fibers are superior to use in terms of thermal stability, heat and sound insulation properties, vibration resistance and durability (2 , 3) .

Basalt powders together with carbon or ceramic powders as well as various metals is the most advanced and exciting area of application, as they can develop new hybrid composite materials and technologies (4) .

Gamlen and Lyng showed that melting of basalt result in the recrystallisation of substantially higher proportion of pyroxenes and bring about improvement of the mechanical property as well (5). They have the advantage an primary basalt in showing homogeneous crystalline texture. Holmstrom studies the effect of basalt on the sintering tendency of various clays (6) . He added basalt up to (75%) to siliceous clay and farce between 950 and 1150° C.The greatest effect was obtained by the addition of (50%)basalt .He concluded also that during annealing , the formation of neogenic anorthite ane wollastonite occur very intensively .

The present work aims to following the effect of basalt addition on the pure china clay . Physical, thermal and structural properties of basalt – clay mixes studied .

Experimntal work

Jordanian basalt dark – brown color from AL-Aqaba and china clay used in this study . Chemical and mineralogical percent composition of clay and basalt are given in Table 1. Differential thermal analysis (DTA) of raw materials was exmined at the selected temperature using instrument type (Netzsch , sta , 409) .This raw materials were ground separately to pass around 250 mesh sieve . The main grain size of raw material used lies between 20 –30 μ m . The proposed mixes are given in Table 2 . The disc samples 5 cm and 2.5 mm thickness were fabricated according to ceramic techniques under a pressure of 45 KN , dried at 140 ° C and fired between 900 and 1150 °C , with heating rate 5 °C / min .

Bulk density and porosity were determined according to the ASTM- C 830 (7) . Samples in the form of bars (8*0.5*1 cm) were processed under the same condition and fired at the selected temperature to measure the linear thermal expansion , with a heating rate of.

10° C / min, and 5° C / min up to 1100° C. The main crystalline phases mullite, enstatite and quartz in the mixes were quantitactively determined by X-ray diffraction analysis, using the internal standard CaF_2. Mohs scale of mineral hardness was used measure the hardness for all specimens.

Result and discussion

The results of thermal properties for raw materials determined from a DTA curve are given in Fig (1) . It shows a distinct endothermic peaks at 550 ° C and 940 ° C for china clay and basalt respectively . This may be indicating the presence of silica (quartz) and kaolinite as shown of the clay mineral in table (1) . The mineralogical constitution (Table 1) of the basalt also revealed the presence of large amount of feldspar ane pyroxene which is probably cause the endothermic peak (8 , 9) .

The results of apparent porosity and bulk density properties determined are shown in Fig (2) and (3) respectively , which gives an idea about the behavior of the mixes during firing . Fig (3) shows that increasing the basalt in the mixes highered the value of density considerably . Mixes of A-40 and A – 60 showed bulk density of 2.37 and 2.43 g/cm^3 at 1000 and 1100 c respectively . Mixes A-20 and A-40 on other hand have the same value of density at 950 ° C, but behave differently above this temperature . Results of porosity of all mixes showed a drop occurring with increasing the firing temperature (Fig 2). Yhe A-20 decreased from 22% at 900 ° C to 7.57% at 1150 ° C compared with mixer A-60 at the same temperature which gives 13.4% and reached to 2.55% at 1150 ° C . It was presumed that the basalt usually starts to melt at 1050 °C giving a less viscous liquid . It goes into

complete solution with increasing temperature (5) . This melt acts on the mineral and quartz present as impurity in (Table 1) . The interface between basalt and claymineral could diffuse and expected .
transformation present with increasing basalt mixes which is expected close the pores under influence of surface tension to fill the pores .
The results of the main crystalline phases present in the mixes are determined by X-ray diffraction analysis , which are summarized in table (3) . The X-ray finding that mullite content is nearly constant in the mixes irrespective of the clay content .
The present of quartz decreases with high basalt mixes . Quartz present as impurity in the clay as detected by mineralogical constitution (Table 1) . The einstitute content , on the other hand , increase with basalt content . The results of the thermal expansion coefficient between (100-1100 ° C) are shown in Fig (4) . The expansion coefficient decreases with increase of the basalt content . A significant increasing in thermal expansion values are recorded also at high temperatures due to porosity reduction for all mixes . Also it can be seen that in Figure (5) the lower heating rate(5 °C /min) gave approximately similar expansion than the higher rate after firing at (1100 ° C) of clay – basalt mixes .
Figure (6) shows the results of obtained from the hardness test at different mixes . It shows that at high temperature , there is a small increase change in hardness values especially above (600 ° C) . This is due to heating effect which leads to reduce the porosity . The reduction in porosity will cause rising in the density of material mixes as previous explained and seen in Fig (3) . These mixes also showed a reasonable hardness between (600 1100 ° C) of 3-4.5 Mohs . The hardness value increases with increase of basalt content . which gives a high mechanicaaal properties with all basalt mixes . Some workers (5, 6) support these results by assuming that increase of mechanical hardness due to the decrease in porosity with the lowest percent of undisolved quartz on basalt – clay mixes .

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Table (1) Typical chemical and minerlogical analysis of the raw materials

Composition	Raw Materials	
	China clay	Basalt
SiO2	53.11	50.99
Al2O3	33.44	13.89
Fe2O3	0.51	4.08
FeO	0.23	6.68
TiO2	-	2.35
CaO	0.11	11.43
MgO	0.30	7.11
Loss on ignition	11.33	2.62
Total	99.03	99.19

Mineral constitution	Raw Materials	
	China clay	Basalt
Feldspar	-	60.31
Quartz	17.21	-
Pyroxene	-	32.07
Olivine	-	3.11
Kolinite	80.35	-
Iron ore	-	8.15

Table (2) Experimental Mixes

Mixes	Weight %	
	China clay	Basalt
A – 20	80	20
A – 40	60	40
A - 60	40	60

Table (3) : X – Ray Diffraction Analysis

Mixes	Crystalline Phases %		
	Mullite	Quartz	Enstatite
A – 20	25.21	8.50	2.15
A – 40	24.09	6.07	3.35
A - 60	24.50	3.45	4.08

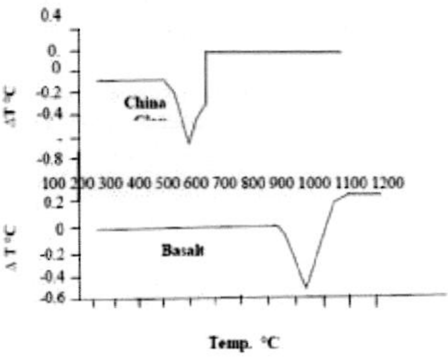

Fig (1) DTA of raw materials

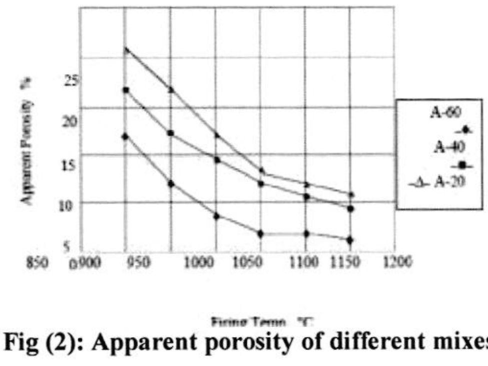

Fig (2): Apparent porosity of different mixes

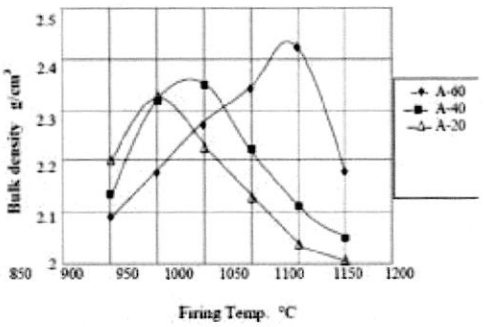

Fig (3) Bulk density of different mixes

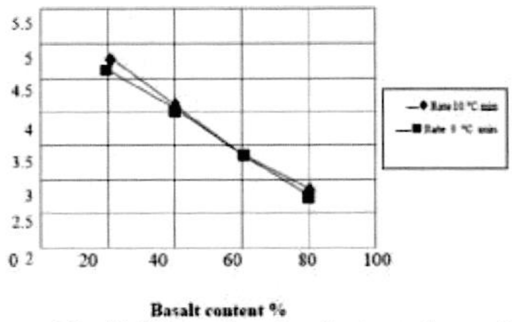

Fig (5) Effect of mode of rate on thermal expansion coefficient after firing at 1100 °C

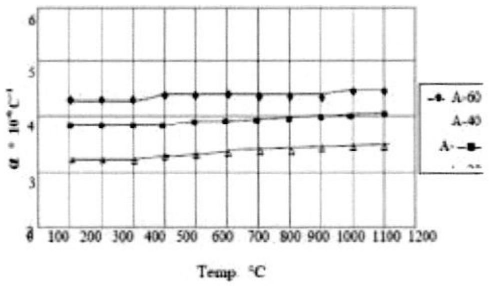

Fig (4) Thermal expansion coefficient of different mixes

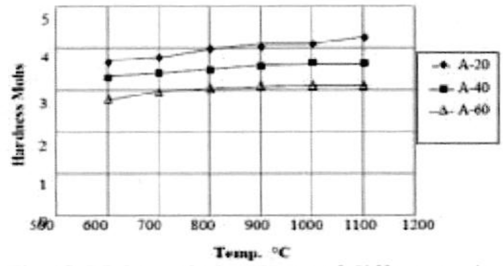

Fig (6) Mohs scale hardness of different mixe

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دراسة الخواص الفيزيائية التركيبية والحرارية لخلائط من البازلت – الطين الصيني

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الملخص

تناول البحث دراسة الخواص الفيزيائية التركيبية والحرارية لنماذج محضرة باستخدام ميتالوروجيا المساحيق من مزج مساحيق من البازلت الاردني بنسب وزنية تصل الى 60% من الطين الصيني . اكدت النتائج التجريبية بزيادة قيم الكثافة الظاهرية عند ازدياد درجات حرارة الحرق لكافة نسب قيم البازلت المضافة ، كما لوحظ انخفاض شديد في قيم المسامية مع ارتفاع درجات حرارة الحرق لجميع العينات المدروسة ، مقرونا بزيادة ملحوظة في قيم الصلادة الميكانيكية.

اما نتائج الفحوص التركيبية فقد اكدت بوجود اطوار بلورية مختلفة تم تحديدها من تحليلات الاشعة السينية . الفحوصات الحرارية اظهرت انخفاض واضح في قيم معامل التمدد الحراري مع زيادة نسب البازلت المضافة ، كما لوحظ عد تاثير واضح الى قيم معدل التسخين المستخدمة بصورة كبيرة على خاصية التمدد الحراري . بعد حرق جميع النماذج بدرجة حرارة $1100C^{o}$ درجة مئوية .