JURNAL
Pendidikan, Sains, Sosial dan Agama
SEKOLAH TINGGI AGAMA BUDDHA NEGERI RADEN WIJAYA WONOGIRI

SYNTHESIS AND CHARACTERIZATION OF BARIUM HEXAFERRITE (BHF) COMPOSITE MATERIALS DOPING FLY ASHES, PORLAND CEMENT, VERMICULITE, CRISTALLINE SILICA AS FIRE PROOFING PROTECTION ON STEEL BEAM IN THE OIL REFINERY INDUSTRY

Veryyon Harahap[1], Siska Ayu Kartika[2]
[1,2]Jurusan Teknik Mesin, Universitas Balikpapan, Indonesia
veryyonharahap11@gmail.com

Article History:
Received: 19 Agustus 2024 ***Revised: 30 November 2024*** *Published: 31 Desember 2024*

Abstract

In the modern era, the use of technology and fire protection equipment has become part of the needs of the oil refinery industry. This material functions to retain heat from fire with a temperature of 1000 oC. But apart from the convenience provided, it turns out that this material also has negative effects on the body that is exposed to dust. In this research, a composite-based heat-resistant material will be made from natural red sand with a ratio of 50:50 (wt%) between matrix and filler. Composite preparation has been carried out using the wet milling method with toluene media. Barium M-Ferrite as matrix and Fly Ashes, Porland Cement, Vermiculite, Cristalline as fillers which are used as the main raw materials for making composites. From the results of the X-Ray Diffraction (XRD) test on BaFe12O19 powder as a matrix, it shows that the phase formed by a single face and hexagonal crystal structure has lattice parameters a=5.929 Å and c= 23.41 Å space group (P 63/mmc); hexagonal structured composite samples (JCPDS file No. 39-1433). The results of surface analysis using Scanning Electron Magnetic (SEM) show that the composite has the finest and smallest particle sizes. The true density result of the composite is 5.386364 g/cm3.

Keywords: *Barium M-Ferrite, , composites, Tahan Api*

INTRODUCTION

Fire is an incident caused by unwanted and difficult to control fire which can endanger humans and result in losses and material damage. Fire problems still often occur, therefore it is necessary to control the danger or prevention, namely increasing awareness to prevent fires (R. A. Aritonang, 2023). Data from the National Disaster Management Agency (2015) in Indonesia found 969 cases of fires from 2012 to June 2015. Fire cases have increased every year. In 2012 there were 53 cases of fire, in 2013 there was an increase of 86%, namely 400 cases of fire, in 2014 there was an increase of 15%, namely 472 cases of fire. The many cases of fire have caused considerable losses, therefore the company's development must provide a protection system in an effort to prevent fires and provide facilities and facilities used to

deal with fires. prevent fires (Ikramullah, 2024). This proves that fire is a serious problem and must be handled properly in order to maintain the security and safety of workers as regulated in Law Number 1 of 1970 concerning Occupational Safety. According to the Indonesian National Standard (SNI) number 03-3985-2000, fire is a phenomenon that occurs when a material reaches a critical temperature and reacts chemically with oxygen which produces heat, flame, light, smoke, water vapor, carbon monoxide or other products and effects. Fires are caused by various factors, but in general the causes of fires are human factors and technical factors (BN. (2015) No. 182). Material Physics is developing very rapidly, this is a demand that must be met along with development of Fire Handling in oil refineries. Researcher Lots offer various draft For make it easier, help And answer oil refinery fire problems . Temperature in the building or pipe rack that caught fire can reach maximum ± 1200 ºC and average temperature (800 – 900) ºC, temperature at a steel blanket thickness of 10 mm achieved 480 ºC after 30 minute, 680 ºC after 60 minutes and 800 ºC after 90 minutes (Arizal, MZ (2016)). The steel segment is released from the surface, this occurs at temperatures between 300 ºC and 600 ºC. Gradual release will then occur due to the formation of cracks in the concrete plane, at temperatures of 600 and 900 the concrete becomes very weak and brittle (Harahap & Sidabutar, n.d.). In addition to temperature, the duration of the fire greatly affects structural damage, many regulations require that each structural element must be fire resistant for 2 hours (Kodur, VKR and Shakya AM (2013)). Anticipation that can be done includes providing a layer on the exposed surface to reduce heat propagation, so that the concrete structure can still withstand the design load and can be reused without repairs that require a lot of costs. The tendency of building structures is getting higher, high-quality concrete is needed to get beams, columns with economical cross-sections and floors with minimum thickness (HASANAH, 2022). High quality concrete has begun to develop and is widely used because it has the advantage of high structural performance in buildings, both in service conditions, ultimate conditions, and long-term durability (Harahap, 2022). Based on the above problems, a study will be conducted on "Synthesis and Characterization of Barium Hexaferrite (Bhf) Composite Material Doping Fly Ashes, Porland Cement, Vermiculite, Crystalline Silica as Fire Proofing Protection on Steel Beams in the Oil Refinery Industry " (Tarihoran, 2024).

Literature Review

Barium hexaferrite can be synthesized by sol gel auto combustion method. Different mole ratios of Ba2+/Fe3+ can produce BHF with different magnetic properties. (Chen, W., Zheng, J., And Lee, Y. (2012)). Barium hexaferrite with a mole ratio of Ba2+/Fe3+ of 1:11.5 has a remanence and coercivity value that is between the ratios of 1:12 and 1:11. Barium hexaferrite with a mole ratio of Ba2+/Fe3+ of 1:12 has the same crystal parameters as the ratio of 1:11 (HANDOYO, 2024). The microstructure of barium hexaferrite heated at a temperature of 1000 °C still has many pores compared to that heated at a temperature of 1000 °C. *Barium M-Ferrite* as a matrix and Fly Ashes, Porland Cement, Vermiculite, Cristalline as fillers are used as the main raw materials. for composite manufacturing. Wet milling process of material composite done during 1 Hours of use tool *high energy milling* (HEM). Next, the calcination process uses *a furnace* . temperature 1000 °C during 1 O'clock is Wrong One material Which own ability For absorb wave Radiation (Wulandari, Nur,

Gafira, & Aritonang, 2024). *Barium M- hexaferrite* has high saturation magnetic polarization (78 emu/g), which consists of anisotropic uniaxial crystals strong, high Curie temperature (450°C) and magnetic field large coercivity (6700 Oe), associated with very both in chemical stability and resistance to corrosion (S. Aritonang, Xaviera, Devina, Panjaitan, & Nareswari, 2024). By Because own Medan coerciveness Which very big cause characteristic anisotropic material increases so that its absorption properties increase the more strong. So as potential main For used as material standard in composite manufacturing (S. Aritonang, Hijrianisa, Pratita, Ningrum, & Pangestu, 2024).

Vermiculite is a naturally occurring clay mineral that has a layered structure with water between the layers. Swollen vermiculite is produced in a similar manner to perlite by heating milled and sieved material to 1000°C. Clays (Vermiculite) (2:1) The second group of clays with exchangeable cations is vermiculite (Christina, 2024). Vermiculite has a talc-like structure in which some of the Fe3+ has been replaced by Mg2+ and some of the Al3+ has been replaced by Si4+, with the resulting charges balanced by hydrated interlayer cations, the most common being Mg2+. The layer charges typically range from 0.6 to 0.9. Vermiculite is distinguished from smectite by XRD after being saturated with MgCl2 and dissolved in glycerol (Naibaho, Humaidi, Rianna, & Diana, 2024). This results in an interlayer expansion of 14.5 Å instead of the 18 Å characteristic of smectite (although there may be exceptions to this rule). Vermiculite is much less common in sedimentary rocks than smectite, probably because it is most commonly a clay formed from soil, while coarsely crystalline vermiculite deposits are formed from the alteration of igneous rocks (IMANIAR, 2022).

Portland cement is a binder used in the manufacture of concrete, mortar, and plaster. This cement has adhesive and cohesive properties, meaning it can bind aggregate grains together to form a solid mass (S. Aritonang & Murniati, 2024). Fly Ashes Fly ash consists of non-combustible materials in coal, small amounts of carbon, and oxides of silicon, aluminum, iron, and calcium. Crystalline silica, or quartz, is a mineral commonly found in the earth's crust and is the most common form of crystalline silica (Himanshi et al., 2023). Quartz is hard, chemically inert, and has a high melting point. Quartz has a variety of uses, such as:

Raw materials for making glass, pottery, ceramics, bricks and artificial stone

A common component in building products and other materials containing or consisting of stone, gravel, clay, or sand (Reddy et al., 2022).

However, quartz can also be harmful to health:

1. The International Agency for Research on Cancer (IARC) classifies quartz as a known human carcinogen.
2. Long-term exposure to respirable silica can cause silicosis and potentially lung cancer.
3. Exposure to silica can cause chronic inflammation and fibrosis in the lungs and other organs.
4. Other health effects of silica exposure include:
    a) Systemic autoimmune disease

b) Bronchitis
c) Chronic obstructive pulmonary disease

To prevent respirable silica exposure, the most effective and cost-effective way is to ensure that the material has a low quartz content (Alatas, Z. (2015)) .

Fireproofing is part of *fire protection and is a* passive fire extinguishing measure. *Fireproofing* itself is a material that provides resistance to building structures made of steel, concrete, or iron against the power of fire for some time (Shaterian, Yulchikhani, Aghasadeghi, & Hassani Ardeshiri, 2022).

Fireproofing is a material used in building construction as a passive fire extinguisher. For this service, of course Arcon is the solution for providing fireproofing services. Fire is definitely something that no one wants to experience. Unfortunately, until now there are still many cases of fire with various causal factors (Suganya, Kishor Kumar, et al., 2022). To prevent loss of life and the large losses due to this disaster, a building needs to apply *fireproofing* to their construction. What is *fireproofing* ? Here is a further explanation.

Fireproofing is part of *fire protection and is **a*** passive fire extinguishing measure. *Fireproofing* itself is a material that provides resistance to building structures made of steel, concrete, or iron against the force of fire for some time (Godara et al., 2022). This material is also able to prevent deformation or changes in building structures caused by fire. So, this *fireproofing* plays a role in protecting building structures made of steel, concrete, or iron from the force of exposure to heat from fire for a certain duration. To prevent loss of life and large losses due to fire, large buildings such as office buildings, malls, or hotels are required to implement *fireproofing*.

Types of *Fireproofing*

1. ***Fireproofing* Based on Material Type**

The selection of ***fireproofing*** based on materials is generally also adjusted to the condition of the area. The goal is that this initial step can function more precisely and economically. Here are the types:

1. *Cementitious fireproofing* is the material most often applied to buildings.
2. *Ablative materials or non-cementitious based materials*.
3. *Insulation based materials*
4. ***Fireproofing* Based on Location**

In addition to being distinguished by material, the selection of ***fireproofing types*** must also be considered based on location. The types are:

1. For buildings that have six floors or a height of not less than 23 meters, the technique is... the appropriate one is *the High Rise Building* .
2. For buildings that contain fuel or fossils, the appropriate method is *Petrochemical* .
3. ***Fireproofing* For Columns**

The materials used as *fireproofing covering* for columns are:

1. *Fireproofing* Spray or *Spray*

The application is by spraying or *sprayed fire-resistive material* (SFRM). This is quite popular but also a dangerous method. Functioning as a steel column insulator, this *spray* is able to protect the construction from high temperatures.

The most commonly used materials are cement, gypsum, *vermiculite, mica* , or *bauxite* . This method is considered to speed up the work but can cause health problems (Godara et al., 2021).

1. *Intumescent Paint*

Intumescent Paint has a more beautiful fire-resistant appearance on coated construction. *Intumescent Paint* is more often applied to coated columns so that the thickness of the fire-resistant material can be controlled.

Video of fireproofing we do:

***Fireproofing* Provider Services**

If you are looking for a service to install ***fireproofing*** on your building, then **Arcon, a fireproofing service provider,** is the solution. Engaged in the field of construction services and construction material suppliers, Arcon provides the best and professional services. Arcon has experience working on various projects not only in Jakarta but also Central Java, East Java, Sumatra, and Papua (Suganya, Kumar, et al., 2022).

Figure 1. Fire Resistant Protection Composite

Synthesized by wet milling method. In this study, Synthesis and Characterization of Barium Hexaferrite (Bhf) Composite Material Doping Fly Ashes, Porland Cement, Vermiculite, Crystalline Silica as Fire Proofing on Steel Beams in the Oil Refinery Industry done with method wet milling with media toluene . Barium M-Ferrit as matrix and Fly Ashes, Porland Cement, Vermiculite, Cristalline Silica as a filler used as the main raw material for composite manufacturing. Wet milling process of material composite done during 15 minute use tool high energy milling (HEM). Next, the calcination process uses a furnace . temperature 1000 °C during 3 O'clock is Wrong One material Which own ability Withstands heat up to 1000 °C. (Imagine And Thank you, 2011). Then done characterization on material composite with

mass and BaFe 12 O 19 50% wt which shows that the structure is heterogeneous with structure crystal hexagonal. So that worthy used as material For absorber wave electromagnetic that is radiation X-ray in laboratory radiology (Hambali & Doyan, 2021). analysis surface use Scanning Electron Magnetic (SEM) show that composition barium ferrite 50% + 50% zinc oxide has a size of the finest and smallest particles. From testing XRD, SEM, shows that sample composite the obtained ability as material Heat resistant to temperatures up to 1000 °C with coated composite on Prek Pipe steel beams in Oil Industry refineries.

METHODS

Purification Fe3O4 on Sand Red

Sand red Which contain Fe Which will used as material main use material BaM first clean it from the material not required. The cleaning process is carried out by sand separation. red with magnet permanent so that content iron on red sand can be separated from impurities. Then cleaned up with use toluene Which alcohol is added to it to clean it sand powder surface, this is done as many times as three time during 15 minute (Urbano-Peña et al., 2024). After washed with use toluene sand red dried in oven at a temperature of 1000 o C for 3 hours. After that For reduce size particle from sand red done with use HEAD (High Energy Milling) with speed turn 150 rpm during 1/2 O'clock.

Synthesis BaM (BaZnxFe12-xO19) with Wet Method Milling

Making heat-resistant material coating based on composite done with method Wet Milling with media toluene (Shariff et al., 2021). Barium M- Ferrite as matrix and Fly Ashes, Porland Cement, Vermiculite, Crystalline Silica as a filler that used as the main raw material for manufacturing composite (Effendi & Setiawan, 2017). Process milling composite done for 15 minutes using High Energy Milling (HEM). Furthermore process calcination use furnace on temperature 800 °C during 1 hour.

Characterization Composite

Composite samples were characterized by use X-Ray Diffraction (XRD) For know phase Which formed And structure crystal, Pycnometer For test density powder, For know characteristic magnets and Scanning Electron Magnetic (SEM) for know morphology (Yousaf et al., 2021).
Diagram Flow Research
Flow chart of barium hexaferrite composite manufacturing / zinc oxide on study This can seen on Picture 1.

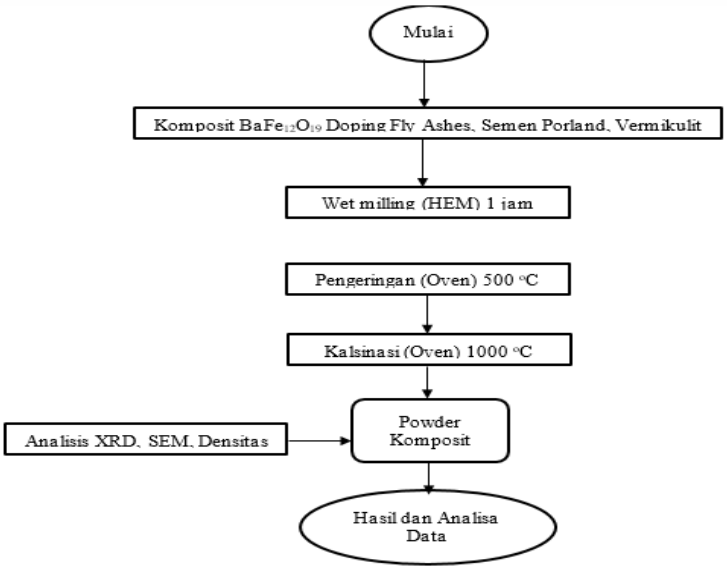


Figure 2. Diagram Composite synthesis flow

RESULTS AND DISCUSSION

Analysis Structure Crystal

Analysis structure crystal BaM done with use XRD on reach corner between 15-65 o Which aiming For identify phases Which formed on BaM (Table 1). Figure 2 shows XRD pattern of BaM sample as matrix and Fly Ashes, Porland Cement, Vermiculite, Crystalline Silica as filler. For BaM powder sample (matrix) which has been ground with wet milling and mixing for 1/2 hour and Which calcined on temperature 1000 o C during 3 hours . Parameters lattice BaFe12O19 a = 5.89 A, c =23.19 Å Three highest peak intensities BaFe12O19 there is on field d (110), (017) And (114)
with an angle of 2θ around (30.3), (32.2) and (37.1). It can be seen that the three highest peaks of ZnO are found in the plane (101, 002, 100) with corner 2θ as big as (36.2, 34.4, 31.8 o). These results can be compared with research previously Where reported third field the are at angles 2θ of approximately 31.7, 34.3, and 36.2 o (Arta, Arifin, & Yudantoko, 2020).

Table 1. Composition From Mixture Material

Komposisi massa Serbuk komposit	Massa
(matriks)	urni (%wt)
(filler)	Murni (%wt)
Komposit	50 % wt

Milling (HEM) with wet milling 15 minute temperature drying 1000 o C during 3 O'clock . Results observation XRD powder Composite shows the formation of a single face peak and hexagonal crystal structure. Diffraction peaks those produced by XRD are in each field And 2θ. Intensity peak No changed still is in the d hkl plane and the sample angle 2θ respectively each can be seen in Table 2. In the analysis using Match software has a phase, which indicates the presence of a composite . state that structure heterogeneous.

On Picture 3 shown pattern XRD from BaFe 12 O 19 sample pure Which prepared with High Energy.

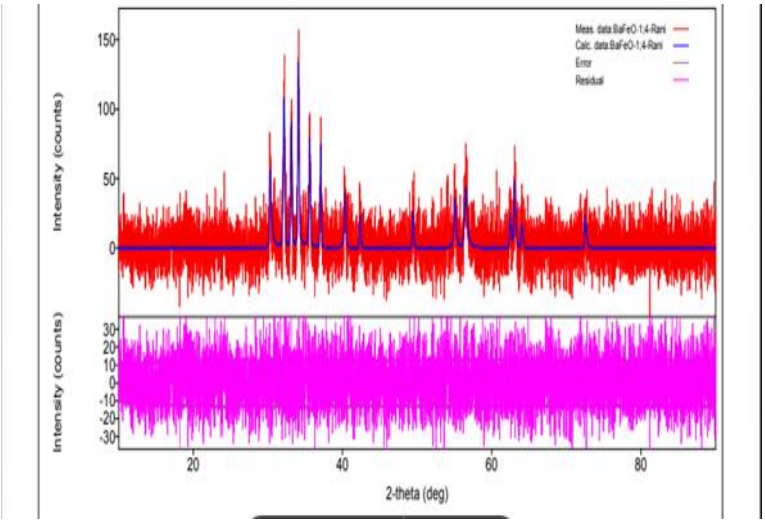


Figure 3. XRD Pattern Of Composite Powder

Table 2. Variation Of Composite Composition (%Wt).

With a composite composition of 50% (%wt)			
Matrix		Filler	
2θ [º] And d hkl		2θ [º] And d hkl	
23.01	006	31.80	100
30.33	110	34.42	002
30.84	008	36.25	101
32.21	017	44.67	101
37.10	114	47.55	012
40.34	018	56.58	110
42.45	023	62.89	013
42.45	025	66.35	200
55.09	026	67.96	112
56.63	127	69.07	201
63.11	0211	76.95	203
72.64	220		

Study Chen et al, (2012) reported that The diffraction peak patterns show good agreement. with the XRD pattern of pure barium ferrite. The XRD pattern is also given for comparison. It has been observed that the peaks shown fit the pattern, Which show existence structure formed heterogeneous . Study other Which related with phase BaFe12O19 own structure crystal hexagonal space group (P 63/mmc) which parameter the grid a = 5,895 A, c = 23.199 Å Also has report a number of researcher (Ruzek, Ville, Velex, Boni, & Marchesse, 2019).

Analysis True Density Sample Pure And Composite (%Wt)

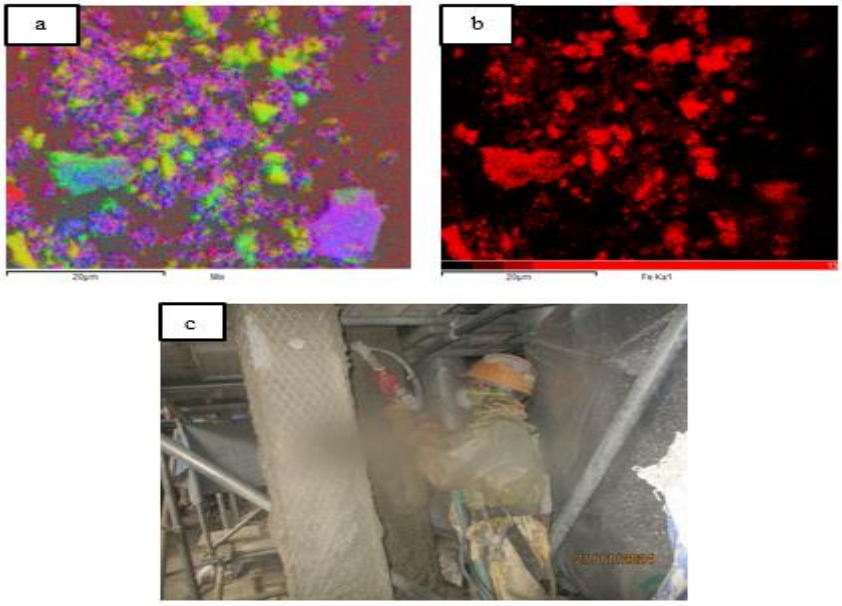
Results measurement true Density on BaFe12O19 And composite with Pycnometer can seen in Table 3. This true density measurement is to find out the density of the powder that affects size particle.

Table 3. Measurement True Density Bafe12o19 And Composite

Composition (%wt)	ρ ethanol (g/cm^3)	ρ sample (g/cm^3)
0%	0.79	5.215019
25%	0.79	5.287008
50%	0.79	5.386364
75%	0.79	5.431089
100%	0.79	5.521614

Analysis SEM (Electro Magnetic Scan) Composite (%wt)

Hexagonal crystal structure and for the average particle size average below 20 μm. It appears that with the composition Composite with a composition of 50+50 (%wt). So morphology surface composite seen the more fine And small. Matter This very close the relation with distribution doping on composite (Lubis, Darmawan, Raynaldo, & Lumbodro, 2021). Barium hexaferrite have magnetic properties Which Enough tall, so that between particle BaFe 12 O 19 with doping tends to form aggregates (Hadi & S Si M Si, n.d.). The more tall composition doping so aggregation between grain Barium hexaferrite will the more reduce, so that morphology surface composite will looks the more fine.



Picture 4. A) Bafe 12 O 19 Sample Pure (%Wt); B) Sample Composite (%Wt) And C) Fire Resistant Composite Protection On Steel Beams

CONCLUSION

Composite material has been successfully created with Composition 50%+50% wt. use High Energy Milling (HEM) with wet milling in the media toluene. From results test X-Ray Diffraction (XRD) on powder BaFe12O19 as matrix show that phase Which formed single face And structure crystal hexagonal own parameter lattice a=5,929 Å And c= 23.41 Å space group (P 63/mmc). Sample composite Which hexagonal structured (JCPDS file No. 39-1433). So In the analysis using match software there are two phase, namely BaFe 12 O 19 , which indicates the presence of BaFe 12 O 19 Composite. state that structure crystal heterogeneous. Results test true density show that in the composite composition of 50%+50% wt is density will the more Good For made into as absorber hot. Results analysis surface use Scanning Electron Magnetic (SEM) shows that the barium composition ferrite 25% + 75% composite own size particle Which most fine And small.

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