



HEAT-EMITTING PAINT FOR COATING INNER SURFACE OF
INDUSTRIAL FURNACE

Technical Field

5 The present invention relates, in general, to a heat-emitting paint for coating the inner surface of an industrial furnace such as a thermal cracking furnace, a thermal treating furnace, an annealing furnace, and a heating furnace to improve fuel efficiency and, in particular, to a ceramic paint with high emissivity, mostly consisting of ilmenite with high blackness, being stable under a high temperature oxidative atmosphere.

10 Background Art

As well known to those skilled in the art, total energy generated from fuel used as a heat source in various industrial furnaces such as a thermal cracking furnace used in the petrochemical industry, a calcining furnace or a heating furnace in the ceramic industry, a thermal treating furnace and an annealing furnace in the steel industry can be classified into three types of energy: energy transferred to a heated body in the industrial furnace, energy transferred to a heat refractory material of the industrial furnace, and some other energies such as preheating energy and dissipated energy. In particular, energy generated from the fuel is mostly absorbed to the heat refractory material.

20 The heat refractory material constituting the industrial furnace absorbs energy and reemits the energy to the heated body in a form of radiant heat, in accordance with Kirchhoff's law. According to Kirchhoff's law, if a body absorbing energy is an ideal black body, emissivity ϵ is equal to absorptivity α , i.e. $\epsilon = \alpha$.

25 But a true ideal black body does not actually exist, and so emissivity of a material is expressed in a ratio relative to the ideal black body, and all materials have intrinsic emissivities.



Meanwhile, a proportion of radiation energy in the industrial furnace is rapidly increased with an increase in temperature in the furnace and, in particular, heat transfer is mostly accomplished by radiation energy at high temperatures. For example, when a temperature in the industrial furnace is about 800°C, near infrared rays exist in an equal ratio to far infrared rays in the industrial furnace. On the other hand, when the temperature is increased to 1000 to 1300°C, a proportion of near infrared rays (0.8 to 4 μm) is increased to 90 % or higher and about 5 % visible rays are generated. Accordingly, if a material does not absorb near infrared rays, it is difficult to expect that the material will emit near infrared rays absorbed to itself in the form of radiant heat, thereby improving fuel efficiency.

However, materials which sufficiently absorb near infrared rays are exceedingly rare on the earth, and some materials absorbing near infrared rays are readily oxidized by heat and so do not endure thermal stress for a long time.

Refractory bricks and ceramic fibers have been widely used as conventional heat refractory materials for inner surfaces of industrial furnaces, but these materials do not absorb near infrared rays, and thus they do not sufficiently emit desired radiant heat.

The absorptivity of refractory bricks is 75 to 80 %, that is to say, the emissivity of the refractory bricks is 0.75 to 0.80 at a relatively low temperature, but when the temperature in the furnace is over 1000°C, absorptivity of the refractory bricks rapidly decreases. In addition, the refractory bricks rapidly deteriorate at high temperatures.

Further, the ceramic fibers are disadvantageous in that their surfaces are glassified by heat. When the surface of a ceramic fiber is glassified, the surface develops luster to reduce the absorptivity of the ceramic fiber to about 30 %, thus it is not expected to obtain desired radiant heat from the glassified ceramic fibers.

As described above, the refractory bricks or the ceramic fibers used as the conventional heat refractory materials for the industrial furnaces have an emissivity of 0.75 to 0.80 at a relatively low temperature, thus securing improved fuel efficiency at that temperature. However, when an industrial furnace is

operated at a high temperature, the emissivity is rapidly reduced, and the blackness is gradually lowered due to the glassification and deterioration of the refractory bricks or the ceramic fibers, thus inevitably reducing fuel efficiency.

Accordingly, there remains a need to develop a technology, in which a
5 heat-emitting paint with high emissivity is coated on an inner surface of industrial furnaces to improve energy efficiency and lengthen the expected life span of the heat refractory material.

Useful as the heat-emitting paint of the present invention are graphite and silicon carbide in consideration of color and emissivity. Graphite has
10 highest emissivity but readily reacts with oxygen in the atmosphere to be carbonized, and so is not preferable to be used as the heat-emitting paint of the present invention.

Meanwhile, a heat-emitting paint, mostly consisting of silicon carbide (SiC), for coating the inner surface of the industrial furnace, is commercialized
15 and selectively applied to some industrial furnaces.

The silicon carbide-based paint comprises a composition consisting of hydrocarbon powder with fineness of 200 mesh or less as a main component, and a small amount of binder and additives, and used in a mixed slurry form of the composition and water. At this time, the mixed slurry is coated on the inner
20 surface of an industrial furnace to a thickness of 0.5 to 1.0 mm using a spray gun.

As described above, the industrial furnace coated with silicon carbide-based heat-emitting paint is advantageous in that time required to heat the industrial furnace to a desired temperature is shortened, the amount of energy emitted to the heated body is desirably increased, and the amount of energy
25 dissipated to the outside of the industrial furnace is decreased, thereby improving fuel efficiency.

At this time, the fuel efficiency depending on the kind of industrial furnace and operating conditions is improved by about 2 to 20 %.

The main reason why the silicon carbide-based heat-emitting paint
30 provides improved fuel efficiency to the industrial furnace is that the heat emissivity of the inner surface of the furnace is desirably increased.

However, silicon carbide is readily oxidized at 800°C or higher under an oxidative atmosphere. If oxidized, silicon carbide (SiC) is converted into silica acid (SiO₂) and the color of the silicon carbide-based paint whitens to reduce blackness (emissivity) of the paint, thus being poor in fuel efficiency. Accordingly, it is not desirable to apply the silicon carbide-based heat-emitting paint to an industrial furnace operating at 800°C or higher.

For example, when the silicon carbide-based paint is applied to a batch type forging furnace, operating at 1200 to 1250°C, used in the steel industry, silicon carbide is completely oxidized and its color whitens after an operating time of 72 hours, thereby not obtaining improved fuel efficiency.

Disclosure of the Invention

Therefore, the present invention has been made keeping in mind the above problems occurring in a conventional heat-emitting paint for coating the inner surface of an industrial furnace, and an object of the present invention is to provide a heat-emitting paint with excellent durability, which has higher emissivity than a heat refractory material of the inner surface of the industrial furnace, is physically and chemically stable under an oxidative atmosphere at high temperatures, and is firmly attached to the inner surface of the industrial furnace.

The heat-emitting paint for coating the inner surface of the industrial furnace according to the present invention comprises a composition including ilmenite as a main component, a small amount of clay as a binder, and a small amount of sodium phosphate as a dispersion agent.

Best Mode for Carrying Out the Invention

According to the present invention, provided is a heat-emitting paint for coating an inner surface of an industrial furnace, comprising a composition consisting of 96 to 98.9 wt% ilmenite with fineness of 150 meshes or less, 1 to 4

wt% clay, and 0.1 wt% sodium phosphate. The heat-emitting paint is used in a mixed slurry form of 40 to 60 wt% composition and 40 to 60 wt% water based on the weight of the mixed slurry.

5 The reason why components of the heat-emitting paint are specifically limited will be described, below.

Ilmenite (FeTiO_2) as the main component contained in the paint of the present invention is a natural ore without being separately treated, and generally comprises TiO_2 and Fe_2O_3 in similar amounts as main components, and a small amount of inorganic materials, even though compositions of ilmenite vary slightly according to a mine.

10 Because of containing Fe_2O_3 as the main component, ilmenite has a black color at a high temperature, much higher emissivity than the conventional heat refractory material, and is physically and chemically stable at 1000°C or higher, thus being useful as a material for coating the inner surface of industrial furnaces operating at a high temperature.

15 Meanwhile, a heat-emitting paint has been developed, which mostly consists of titanium dioxide (TiO_2) extracted by chemically smelting ilmenite or refining titanium slag, but because this titanium dioxide based heat-emitting paint is chemically unstable at a high temperature, the paint whitens, new undesirable compounds are produced, and metal components are precipitated at high temperature to rapidly reduce emissivity of the titanium dioxide based paint. Accordingly, the titanium dioxide based paint is not commercialized.

20 Because of various chemical reactions occurring during a chemical smelting process for obtaining titanium dioxide from ilmenite, a bonding force between components constituting titanium dioxide is weakened, causing the titanium dioxide based paint to be physically and chemically unstable, and this is considered as the reason why the titanium dioxide based heat-emitting paint is chemically unstable at high temperatures.

25 However, ilmenite contained as the main component in the heat-emitting paint of the present invention is not subjected to any chemical reaction process but obtained from a natural ilmenite ore just physically crushed, so being

physically and chemically stable to have continuously high emissivity at a high temperature atmosphere.

In addition, ilmenite is crushed into powder with fineness of 150 mesh or lower to be uniformly dispersed in a mixed slurry containing a binder, a dispersing agent, and water, and desirably attached to the inner surface of the industrial furnace.

Meanwhile, the clay used as the binder functions to increase adhesive strength of the mixed slurry to stably coat the mixed slurry on the inner surface of an industrial furnace without flowing down of the slurry, and also acts as a dispersing agent. When a clay content in the heat-emitting paint is less than 1 %, it is impossible to desirably attach the mixed slurry to the inner surface of the furnace. On the other hand, when the content is more than 4 %, an ilmenite content is relatively reduced to reduce the fuel saving effect by increase of emissivity of the furnace inner surface. Accordingly, it is preferable that the clay content ranges from 1 to 4 %.

Sodium phosphate used as the dispersing agent functions to uniformly disperse the ilmenite powder and clay in the mixed slurry. Of various dispersing agents, sodium phosphate is most useful to the paint of the present invention, and has desirable dispersibility and is preferable in economic efficiency when its content in the mixed slurry is 0.1 %.

When the composition of the heat-emitting paint according to the present invention is mixed with water to produce the mixed slurry, it is preferable that 40 to 60 wt% composition is mixed with 40 to 60 wt% water based on a total weight of the mixed slurry so as to smoothly spray the mixed slurry to the inner surface of the industrial furnace using a spray gun and dry the mixed slurry without the slurry flowing down along the inner surface of the industrial furnace.

Furthermore, it is preferable that the heat-emitting paint of the present invention is coated on the inner surface of the industrial furnace in a thickness of 1 to 2 mm.

According to the present invention, the heat-emitting paint has an emissivity of 0.85 to 0.95, much higher than a conventional heat refractory

material.

As described above, because of its high emissivity, the heat-emitting paint of the present invention coated on the inner surface of an industrial furnace allows the painted inner surface to emit more energy than an inner surface not coated with the heat-emitting paint to desirably increase energy applied to a heated body, thus rapidly reaching a desired temperature of the heated body to reduce use of fuel.

A better understanding of the present invention may be obtained in light of the following examples which are set forth to illustrate, but are not to be construed to limit the present invention.

EXAMPLE

Ilmenite powder with a fineness of 150 mesh or less, clay, and sodium phosphate were mixed in a mixing ratio as described in below Table 1 to produce a composition constituting a heat-emitting paint of the present invention, and the composition was mixed with water in the same weight ratio (composition : water = 1:1) to obtain a mixed slurry used in examples and comparative examples.

At this time, the clay, manufactured by Kentucky-Tennessee Clay Co., comprising SiO_2 and Al_2O_3 as main components and a small amount of TiO_2 , Fe_2O_3 , CuO , and MgO , was used.

TABLE 1

Examples	Composition (wt%)		
	Ilmenite	Clay	Sodium phosphate
1	97.0	2.9	0.1
2	98.0	1.9	0.1
3	96.5	3.4	0.1
4	98.7	1.2	0.1
Co. Ex. 1	95.0	4.9	0.1
Co. Ex. 2	99.2	0.7	0.1

Mixed slurries according to examples and comparative examples, and a conventional hydrocarbon based heat-emitting paint (conventional example) each were put in a high temperature box type furnaces having a Kanthal heating body as a heat source, and heated for a predetermined period and then measured in terms of emissivity at different temperatures.

In other words, after the slurry was coated on a brick sample with a volume of 65 mm × 50 mm × 10 mm (t), the resulting brick sample was put in the industrial furnace, heated at a rate of 10°C/min to 600°C, maintained for 30 min at 600°C, and then measured in terms of emissivity. The resulting brick sample was then heated to 1200°C in such a way that the sample was heated to an additional 100°C and then maintained at the increased temperature for 30 min, and this procedure was repeated.

A temperature in the furnace was measured using a radiation thermometer positioned at a horizontal distance of 2 m from a surface of the brick sample. In addition, after the temperature in the furnace is stabilized, emissivities (ϵ : %) at each temperature were measured through a window positioned on a front side of the furnace by using a Pyrometer (MQ1310C-3B) manufactured by American Micron Co.. The results are described in Table 2, below.

TABLE 2

Temp.(°C)	Ex.1	Ex.2	Ex.3	Ex.4	¹ Co.Ex.1	² Co.Ex.2	Conventional Ex.
600	86.1	86.3	85.7	87.1	85.2	87.3	65.0
700	85.7	86.1	85.1	86.8	83.9	86.8	66.4
800	84.8	85.8	84.6	86.1	82.7	86.3	67.8
900	84.1	85.3	83.6	85.9	81.8	86.1	68.0
1000	85.2	85.9	84.4	87.2	83.4	87.7	72.3
1100	87.2	87.7	86.7	87.9	85.6	87.8	73.4
1200	87.9	80.0	87.1	88.1	86.7	87.9	75.7
1200°C , after 50 hours	87.9	88.0	87.1	88.1	86.7	84.2	69.2

¹Co.Ex.1: comparative example 1

²Co.Ex.2: comparative example 2

From the results of Table 2, it can be seen that in the case of emissivities of samples left at 1200°C for 50 hours, emissivities of samples according to examples of the present invention changed only slightly, but the emissivity of the sample coated with the hydrocarbon based paint (conventional example) is reduced in comparison with the initial measurement at 1200°C. This phenomenon seems to be caused by the fact that silicon carbide is oxidized on its surface exposed to a high temperature oxidative atmosphere to reduce its blackness (emissivity).

Furthermore, the surface of each sample was observed through a stream tube after operation of the furnace was stopped and an inside of the furnace was sufficiently cooled, resulting in the finding that samples according to examples of the present invention maintained their original black color, but the sample coated with the hydrocarbon based paint (conventional example) lost its original black color and its surface was glassified.

Industrial Applicability

As described above, a heat-emitting paint mostly consisting of ilmenite has an advantage of higher emissivity than a conventional heat refractory material. In particular, when applied to a furnace operating under an oxidative atmosphere at 1000°C or higher, the heat-emitting paint is not reduced in emissivity after a long time, time required to heat a heated body to a desired temperature is shortened, and the amount of energy emitted to the heated body is desirably increased, thereby reducing fuel consumption of the furnace.

For example, fuel reduction effect due to use of the heat-emitting paint according to the present invention is desirably increased by about 8 to 10 % in case of a heating furnace used in the steel and nonferrous metal industry, and by about 2 to 3 % in case of a heating furnace used in the petroleum refining and petrochemical industry.

Further, the heat-emitting paint of the present invention is advantageous in that a coated layer is formed on a surface of a heat refractory material of the industrial furnace to prevent the heat refractory material from being eroded and secure a heat-shielding effect, thereby prolonging the heat refractory material's life and improving its durability.

Furthermore, the heat-emitting paint of the present invention is readily coated on the whole inner surface of an industrial furnace in the form of a slurry with a desirable viscosity using a spray gun, and the sprayed slurry is firmly attached to the inner surface of the furnace due to caking of clay added as a binder to the slurry, thereby securing excellent workability during coating the inner surface of the furnace with the heat-emitting paint.

The present invention has been described in an illustrative manner, and it is to be understood that the terminology used is intended to be in the nature of description rather than of limitation. Many modifications and variations of the present invention are possible in light of the above teachings. Therefore, it is to be understood that within the scope of the appended claims, the invention may be used otherwise than as specifically described.

Claims

1. A heat-emitting paint for coating an inner surface of an industrial furnace, comprising:

5 a composition consisting of 96 to 98.9 wt% ilmenite with fineness of 150 meshes or less, 1 to 4 wt% clay, and 0.1 wt% sodium phosphate,

said heat-emitting paint being used in a mixed slurry form of 40 to 60 wt% composition and 40 to 60 wt% water based on a weight of the mixed slurry.