United States Patent Office 3,023,454 Patented Mar. 6, 1962

3,023,454

HYDRAULIC QUENCHING AND GRANULATION OF MOLTEN MATERIALS

Charles R. Kuzell, Phoenix, Morris G. Fowler and John H. Davis, Jr., Douglas, Leonard Klein, Scottsdale, William J. Uren, Douglas, and Irvine Macdougall, Warren, Ariz., assignors to Phelps Dodge Corporation, New York, N.Y., a corporation of New York

Filed Mar. 8, 1960, Ser. No. 13,589
11 Claims. (Cl. 18—2.5)

This invention relates to hydraulic quenching and granulation of molten magmas, metallic compositions, and the like.

In certain processes of treating copper matte in a copper converter for the production of blister copper there is produced a molten magma containing predominant amounts of iron oxides. Such a process is disclosed in the pending application of Kuzell et al., Serial No. 13,593, filed March 8, 1960. In that application there is disclosed a process of treating copper matte in a copper converter at a temperature in the vicinity of 2400° F. without the addition of a siliceous flux whereby a molten magma is produced which is predominantly iron oxide; this magma or product being called Ferramag. The Ferramag, by reason of its high content of iron oxide and comparatively small amount of iron in the form of silicate, provides a source of iron or "raw material" for the production of sponge iron. In order to render this "raw material" amenable to reduction to sponge iron, it is necessary to comminute the Ferramag into particles of a size which are suitable for treatment with reducing agent for the reduction of the iron oxide material to sponge iron form.

This invention provides a method and apparatus for the hydraulic quenching and granulation of molten Ferramag to produce solid particles of sizes which are amenable to treatment with reducing agent to produce sponge iron. And although the invention for purposes of illustration will be described in connection with the quenching and granulation of molten Ferramag, it will be understood that it is applicable to the hydraulic quenching and granulation of many other molten materials where it is desired to change the material from molten state to closely controlled small particle sizes in solid form.

The sponge iron which is referred to herein may be considered to be in the form of porous, sponge-like solid particles of metallic iron which are pseudomorphs which, generally speaking, have retained the sizes and shapes of the solid particles of iron oxide from which they have been reduced pyrometallurgically to the solid but spongy metal without having passed through an intervening liquid phase. One method and apparatus which is suitable for the reduction of the granulated Ferramag to sponge iron is disclosed in the pending Kuzell et al. application for patent, Serial No. 13,592, filed March 8, 1960.

In accordance with one manner of practicing our invention molten Ferramag which has been skimmed from a copper converter at a temperature of about 2400° F. is poured in a controlled comparatively small stream so that it flows by gravity in the form of a free-falling continuously flowing sheet-like stream of molten magma. While the continuously flowing sheet-like stream is freely falling it is subjected to the continuous impact of a multiplicity of jet streams of water directed to exert forces on the falling molten material in directions across the vertical path through which the molten material is freely falling and it is also subjected to additional sprays of water, thereby to cause an almost instantaneous breaking up of the molten mass into small particle sized globules which are meantime so quickly cooled that the individual globules or particles are prevented from agglomeration and are trajected into the mouth of an inclined launder

along with the water. The jets and streams of water are directed with sufficient force and the amount of water is sufficient to freeze and quench the globules to granules and to carry the granulated particles submerged in a flowing stream of water for sufficient time to cool the granulated particles substantially to atmospheric temperature after which the granulated iron oxide material is separated from the water.

Although the novel features which are believed to be characteristic of the invention are pointed out in the annexed claims, the invention itself as to its objects and advantages and the manner in which it may be carried out may be better understood by reference to the following description taken in connection with the accompanying drawings forming a part hereof, in which

FIG. 1 is a top plan view of the granulation apparatus;

FIG. 2 is a side view in elevation of the granulation apparatus;

FIG. 3 is a front view of a portion of apparatus, this view being taken from a position looking toward the front or pouring spout end of the pouring ladle;

FIG. 4 is a partial side view in elevation of the apparatus, this figure being on a larger scale than FIGURE 1;

FIG. 5 is a side view of a portion of the apparatus showing in larger scale the water jet arrangement;

FIG. 6 is a view on line 6—6 of FIG. 5;

FIG. 7 is a view on line 7—7 of FIG. 5; and

FIG. 8 is a side view of the portion of the apparatus shown in FIG. 7.

Referring now to the drawings in which like reference characters indicate like parts throughout the several views, the apparatus, in general, comprises a holding and pouring ladle **10** in which is charged a batch of molten Ferramag to be granulated; and adjustable, tiltable spoon **11** into which molten charge is poured from ladle **10** and from which a controlled, regulated sheet-like stream of molten charge may be poured; a water jet and spray arrangement **13** contrived to eject streams or jets and sprays of water into the falling stream of molten charge to break up the molten Ferramag into small globules and rapidly chill them; an inclined launder **14** of generally V-shape in cross section into which the water is directed; the water carrying with it the granulated Ferramag down the inclined launder **14** to a separator **15** in which the granules of Ferramag are separated from the water and delivered into a conveyor **16** to be transported to any desirable place for subsequent use or treatment. The apparatus is mounted and supported on a suitable supporting structural steel framework, designated generally by reference character **17**.

Molten Ferramag which may be skimmed from the copper converters at a temperature in the neighborhood of 2400° F. may be charged into the pouring ladle **10** by transporting a batch of the molten Ferramag in a suitable ladle or container by means of an overhead crane (not shown) and pouring it into a charging launder **20** suitably supported on the structural steel framework **17** and leading into the ladle **10**.

The holding and pouring ladle has oppositely disposed trunnions **21**, **22** resting in bearing links **23**, **24**, pivoted at **25**, **26** to suspension links **27**, **28** which are supported on a fabricated cross beam **29**, in turn supported by the structural steel framework **17**. Hence, the pouring ladle **10** may be tilted about the trunnion pivots **21**, **22** to regulate the pouring of the molten Ferramag from its pouring spout **30** into the pouring spoon **11**. A sprocket chain **31**, having one end secured to a bracket on the ladle **10** at the back near its bottom is trained over a suitably mounted, rotatable sprocket wheel **31***a*. The other end of the chain is secured to the piston rod of an hydraulic cylinder **32** mounted on the framework **17**. This arrangement provides power-operated means for tilt-