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PROCESS AND APPARATUS FOR MAKING ALUMINUM PARTICLES

Filed March 29, 1962

2 Sheets-Sheet 1

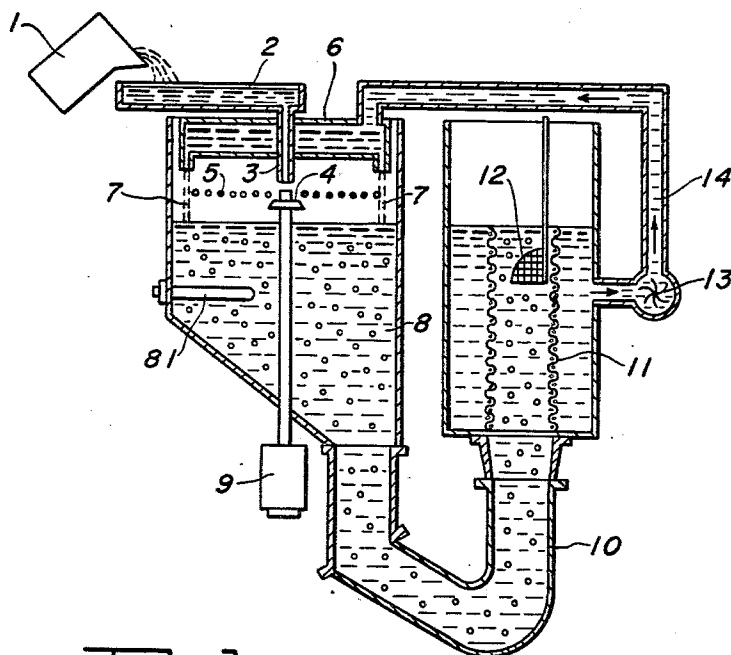


FIG. 1.

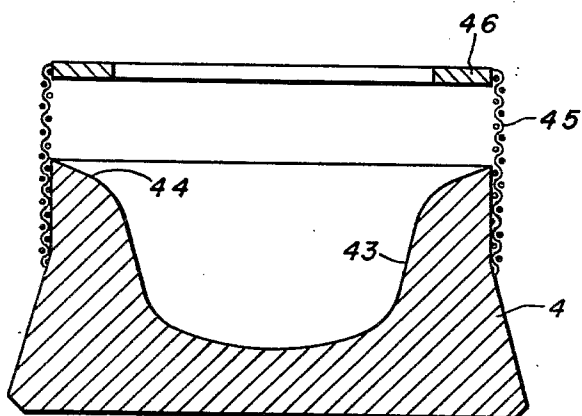


FIG. 3.

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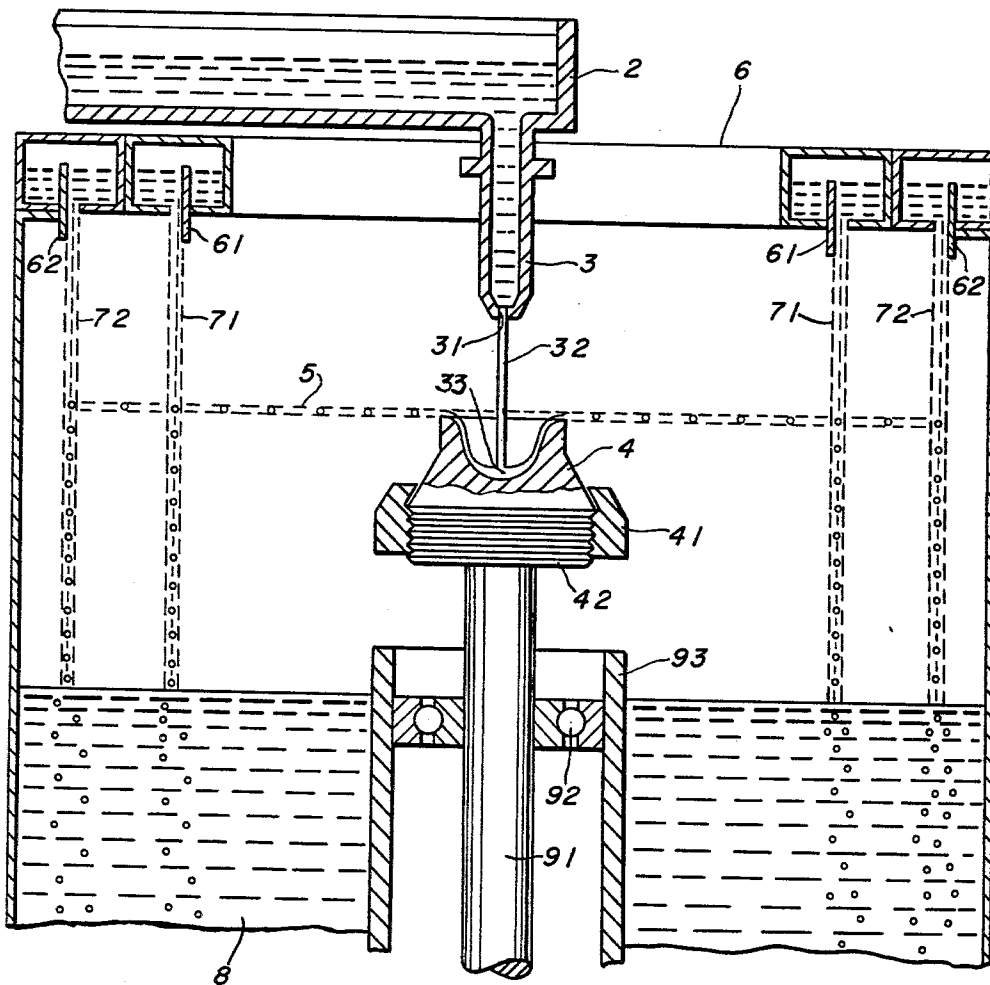


FIG. 2.

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PROCESS AND APPARATUS FOR MAKING ALUMINUM PARTICLES

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This invention relates to a process and apparatus for making aluminum particulate, such as generally spherical aluminum particles, and more particularly relates to continuously producing such particles by centrifugal dispersion of aluminum in molten form and subsequent cooling thereof.

Aluminum as generally used herein, embraces both aluminum of various grades of purity and aluminum base alloys.

The steel industry has long used aluminum as a deoxidant. Generally spherical aluminum particles are desirable for use in deoxidizing steel in order that the particles may flow readily through a pouring device into the ladle or mold of molten steel.

Generally spherical aluminum particles are also useful as propping agents for increasing the productivity of oil wells. In this use, the hard dense oil-bearing formation is fractured by means of hydraulic pressure, and the aluminum propping agent is then pumped into the fracture where it supports the formation while at the same time providing a permeable path for the oil to flow to the well bore. When the propping operation is performed at a considerable depth, it is particularly difficult to find a suitable propping agent that can satisfactorily withstand the tremendous pressure. Aluminum particles which have substantial compressive strength have been found useful as a propping agent to prevent closure of the fractures at such depths, especially when in generally spherical form.

A generally spherical or equi-axed form of aluminum particle is therefore desired for use in deoxidizing steel and as an oil well propping agent, as well as for other purposes, and the provision of a process and apparatus for producing such particles is one of the objects of this invention.

The general object of this invention is to provide an improved process and apparatus for economically producing generally spherical aluminum particles, and particularly a continuous process, and apparatus therefor, to produce aluminum particles in relatively equi-axed, smooth-surfaced form and of substantially uniform size.

In accordance with this invention, the aluminum particulate may be made in the following manner. Molten aluminum is allowed to fall vertically in a thin, uniform stream onto the center of a rapidly rotating disc or cup. As is well known, molten metal has a considerable surface tension. The metal may be forced by the speed of the rotating surface into a liquid metal layer that will break up into globular particles. Thus, the molten aluminum striking the rotating cup is acted upon by centrifugal force, causing it to conform to the contour of the surface and move progressively toward its periphery until it is finally thrown out in discrete globules or particles. Generally an increase in rate

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of rotation of the surface produces a decrease in particle size. In accordance with the invention, the particles are intercepted in flight by a vertical curtain or envelope of water which partially cools the particles and carries them downwardly into a water bath where further cooling takes place.

For a better understanding of the invention and its other details, objects and advantages, reference may be had to the accompanying drawings in which:

FIG. 1 is a diagrammatic sectional view of the particle producing apparatus, showing the elements thereof and their general relationship.

FIG. 2 is a detailed sectional view, on a larger scale, of a portion of the apparatus of FIG. 1 with some modifications.

FIG. 3 is an enlarged sectional view of a cup and fence assembly that may be used in the apparatus shown in FIGS. 1 or 2.

Referring to the drawings, particularly FIG. 1, there is shown a ladle 1 for pouring molten aluminum into a trough 2, which has a discharge spout 3 for release of the molten aluminum from the trough 2. The molten aluminum issues from the spout 3 and falls onto the center of a disc or cup 4, which has an upwardly concave surface and which is rotated about a substantially vertical axis by a motor 9. The stream of molten aluminum striking the rotating surface 4 is acted upon by centrifugal force causing the molten aluminum to be thrown outwardly in the form of particles 5. A water ring 6 is situated above and around surface 4 in such a manner that is a substantially cylindrical sheet-like envelope of downwardly-directed cooling water 7 is disposed around and spaced from the rotating surface. The generally radial flight of the particles 5 is arrested by the curtain of water 7 which is desirably maintained at a temperature above about 150° F. to minimize distortion of the particles. The particles 5 are carried into an underlying body of water 8, in a suitable container where further cooling of the particles takes place. The water from the bath 8, which may be heated when necessary by immersion heater 81, is circulated through a connecting pipe 10 to a riser screen 11 which retains the aluminum particles until removed by a suitable means such as a catch basket 12. A pump 13 is used to circulate the water in the system, through connecting pipe 14, back to the water ring 6.

Referring to FIG. 2, there is shown with more particularity the means for forming and solidifying the particles. It will be noted that spout 3 has at the bottom thereof an orifice 31 which permits the molten aluminum to fall in a thin, uniform stream 32 onto the center of the cup 4, mounted on a shaft 91, which rotates on a vertical axis in bearing 92. The cup 4 is attached to the rotatable shaft 91 through a base and collar 41. The vertical shaft 91 and its bearing 92 is housed in a surrounding sleeve 93 which protects the shaft and bearing from the bath water 8. The metal stream 32 striking the rotating cup 4 is acted upon by centrifugal force causing the molten metal to form a thin sheet 33 which assumes the inside contour of the cup 4 while rising progressively toward the periphery of the cup until finally it is flung off the periphery of the cup. By adjusting the flow rate of the stream of molten aluminum and the peripheral speed of the rotating surface the molten metal is dispersed therefrom in the form of droplets. The molten particles 5 are thrown

outwardly from the surface of cup 4 about its axis in generally radial flight. In this case, they are intercepted in flight by water curtains 71 and 72. When, due to high rotation speeds, the velocity of the particles 5 is such that they pass through the first water curtain 71, it is advantageous to have a second water curtain 72, the thickness of each being about $\frac{1}{4}$ to $\frac{3}{4}$ inch and being in substantially uninterrupted liquid phase, i.e. not in the form of a spray or discrete droplets. The particles intercepted by the two concentric envelopes of cooling water are partially solidified and carried down into the water bath 8 for final cooling. To aid in an even flow of water for the first water curtain 71 a baffle 61 within the water ring 6 is provided. Similarly, for the second water curtain 72 there is also provided a baffle 62.

Referring to FIG. 3, a preferred cup and fence assembly is shown with more particularity. The cup 4 is constructed from any suitable material. Satisfactory results have been obtained when the cup 4 is made of suitably protected plain carbon steel or cast iron. The inside surface of the cup 4 is upwardly concave and generally tulip shaped, with the lower portion of the side wall 43 rising at an angle of about 15° to the vertical, and with the upper portion of the side wall 44 near the periphery tapering outwardly to an angle of about 15° to the horizontal. The cup 4 is desirably fitted with a cylindrical woven wire cloth fence 45 having a multiplicity of superimposed rows of substantially uniform-sized openings constituting orifices through which a molten metal may pass under the action of centrifugal force. The wire fence 45 is attached to the cup about the periphery of the concave surface. The orifices provided by the woven wire cloth fence 45 correspond to the desired particle size. Under centrifugal force the thin sheet of molten aluminum tends to rise toward the top of the wire fence 45. Therefore, it is advantageous to provide a lid or intumed lip 46 to retain the molten aluminum within the fenced area until the metal is forced through the orifices in the wire fence.

The following examples will illustrate the nature of the present invention; however, the invention is not intended to be limited to these examples.

Example I

Molten aluminum alloy consisting essentially of 6% silicon and the balance aluminum was heated in a furnace to a temperature between 1300 and 1400° F. The molten metal was continually poured into a trough to maintain a 15 inch head of molten metal. The diameter of the cup was $3\frac{1}{2}$ inches and it was rotated at about 1400 r.p.m. (equivalent of a peripheral speed of 15,400 inches per minute) by means of a half horse power variable speed D.C. motor. A stream of molten metal was fed into the cup at a rate of 200 pounds per hour. During the operation the aluminum particles assumed a spheroidal shape as they were thrown from the periphery of the cup toward the curtain of water located at a radial distance from the cup of about 15 inches. The water curtain was $\frac{5}{16}$ inch thick and the water was maintained at a temperature above 150° F. by means of an immersion heater in the bath in order to prevent splattering and distortion of the particles upon contact. The particles intercepted by the water curtain appeared to partially solidify and were carried into the bath for final solidification. 29% of the aluminum particles obtained from this operation were both in the range of -10 to $+16$ Tyler mesh size and generally spherical.

Example II

The procedure in Example I was followed but with a cylindrical $\frac{3}{4}$ inch wide strip of No. 10 Tyler mesh woven wire fence, being employed. The fence was capped with an intumed lip and attached to the outside wall of the cup so that approximately half of it extended above the cup's upper periphery. 44% of the aluminum particles produced from this operation were both in the range of -10 to $+16$ Tyler mesh size and generally spherical.

Example III

A similar test as that of Example II above was conducted except for these modifications: a 5-inch diameter cup with a wire fence capped with an intumed lip was used, the rotating speed of the cup was adjusted to produce droplets of molten metal (about 1000 r.p.m.) which had an initial velocity of 15,700 inches per minute, the metal flow rate was increased to 1100 pounds per hour, and a second curtain of water $\frac{1}{4}$ inch thick at a radial distance from the fence of about 20 inches was employed. 42% of the aluminum particles produced were both in the range of -10 to $+16$ Tyler mesh size and generally spherical.

What is claimed is:

1. In a process for making substantially equi-axed, smooth-surfaced aluminum particulate wherein a stream of molten aluminum is directed downwardly onto an upwardly concave surface which is rapidly rotating about a substantially vertical axis, the molten aluminum is thrown centrifugally from such surface and thereby dispersed about its axis in the form of molten particles in generally radial flight, and the molten particles are water cooled to produce solid particles, the improvement comprising providing at least one substantially cylindrical sheet-like envelope of downwardly-directed cooling water in substantially uninterrupted liquid phase around and spaced from the rotating surface and entering an underlying body of water, arresting the flight of the molten particles within the downwardly-directed cooling water while they are still moving in a generally radial direction, initially cooling them in such downwardly-directed water, and carrying them in such downwardly-directed water into the underlying body of water.
2. In a process according to claim 1, the further improvement for making substantially equi-axed, smooth-surfaced particles comprising adjusting the flow rate of the stream of molten aluminum and the peripheral speed of the rotating surface to disperse therefrom molten particles in droplets, and quenching the molten droplets in the downwardly-directed water and the underlying water without distortion by impact.
3. In a process according to claim 1, maintaining at least two concentric envelopes of cooling water, each in a thickness between about $\frac{1}{4}$ and $\frac{3}{4}$ inch.
4. In a process according to claim 1, maintaining the downwardly-directed cooling water at a temperature above about 150° F., whereby distortion of the particles during quenching is minimized.
5. Apparatus for making substantially equi-axed, smooth-surfaced aluminum particulate comprising means for downwardly directing a stream of molten aluminum, an upwardly concave surface located beneath said means and adapted to be rotated about a substantially vertical axis to centrifugally throw particles of molten aluminum therefrom in generally radial flight, means for rotating said surface, means for discharging at least one substantially cylindrical sheet-like envelope of downwardly-directed cooling water in substantially uninterrupted liquid phase around and spaced from said rotatable surface for arresting the flight of the molten particles, cooling them and carrying them downwardly, and a water container surrounding said rotatable surface and said discharging means for collecting the down-

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wardly-directed water together with the particles
arrested and carried therein.

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