

A NEW CENTRIFUGAL ATOMIZATION TECHNIQUE OF SPRAY ROTATION FOR POWDER PREPARATION^①

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ABSTRACT A centrifugal atomization equipment of spray rotation with high pressure fluid as actuating medium was designed. Because high pressure fluid on one hand forms fluid kinetic pressure lubrication at rotary pair, on the other hand drives rotary plate rotate at high speed when spraying at high speed from the ends of hollow leaves of leaf-type rotary plate, the rotary speed of the plate is up to 30 000 r/min, not only increases the fine powder ratio of equipment, but also the equipment possesses the characteristics of low noise, pollution-free, easy starting, stepless speed regulation, convenient controlling and so on. The fine powder ratio is higher when combining centrifugal atomization technique of spray rotation with gas atomization spray. The average diameter of Al-20Si alloy powder prepared is 7~8 μm .

Key words spray rotation centrifugal atomization rotary speed fluid lubrication

1 INTRODUCTION

Centrifugal atomization is one of the common methods of preparing metal powders, the mechanism of preparing powder is that the melted metal is thrown off at high speed along tangent direction of the rotary round plate (or rotor) thus the melt is atomized. The higher the rotary speed of the rotator is, the more the times of the melt laminarly sheared in unit time are, and the higher the fine powder ratio is^[1]. The kind of drive of present techniques is mechanical type^[2-6], the rotary speed is restricted due to mechanical friction, which results in the development of centrifugal technique being restricted. On the basis of powder preparation mechanism of centrifugal atomization being deeply investigated and analyzed, a new centrifugal atomization equipment of fluid spray rotation and fluid self-lubrication type was developed, the rotary speed of the rotator of the equipment increases 5~6 times compared with that of the mechanical driving equipment. Combining centrifugal atomization technique of spray rotation with spray powder technique of gas atomization is so-called sec-

ondary atomization, and the powder prepared is finer.

2 ANALYSES OF PRESENT TECHNIQUE

Fig. 1 illustrates present centrifugal atomization technique. Electromotor transmits driving force to rotary shaft by driving belt transmitting mechanism consisted of large driving belt wheel, driving belt and small driving belt wheel as shown in Fig. 1, so that it drives rotary plate fixed with rotary shaft, the fixed position and the bearing of shaft are undertaken by ball bearing. When the equipment starts to work, firstly the speed regulation electromotor is started, then it is accelerated gradually, at last the rotary speed of the plate is up to the speed required, when the melted metal coming from funnel drops onto the plate, it will be atomized by centrifugal force. Apparently, it is known by the mechanism of centrifugal atomization, the higher the rotary speed of the plate is, the better the effect of atomization is and the finer the powder prepared is^[1]. There exists mechanical friction in the driving belt mechanism and ball bearing of

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the equipment above-mentioned inevitably, including the friction in the elastic glide process of driving belt relative to the belt wheels^[7], the friction between rollers and inner and outer race in ball bearings, etc, so when actuating speed (rotary speed) increases, the useless work caused by friction will increase, which will result in evolution of heat and increase of abrasive wear of driving belt and bearings. Moreover, when the speed of mechanism of driving belt is up to a certain value, the belt will cause very large centrifugal force when it bypass the belt wheels, not only increasing the additional stress of the belt, but also throwing away the belt wheels and resulting in transmission failure, generally regulating, the linear velocity of the belt is no more than $25\text{ m/s}^{[7]}$. When heat evolves, the temperature will increase, the gummy material and the packing cloth layer of belts will scorch, the viscosity of lubrication oil in bearings will decrease rapidly, the phenomenon of smoking and failure will appear, generally, the temperature of the lubrication oil is no more than 65°C . There are unevenness and assembling clearance on working surface inevitably due to the processing and assembling error of the rigid roller and rigid inner and outer race of a ball bearing. They are very

sensitive to speed, when the rotary speed is up to a certain value, the strict vibration and sharp noise will be caused, therefore, the rotary speed of plate of mechanical type centrifugal atomization equipment is generally no more than $5000\text{ r/min}^{[3-5]}$, the diameter of metal powder atomized is impossible to be very fine and the speed of rapid solidification is limited, too, at this speed.

3 A NEW TECHNIQUE FOR POWDER PREPARATION

The general driving and bearing mode were absolutely changed in the powder preparation of centrifugal atomization of spray rotation, in which fullfluid spray driving and fluid kinetic pressure bearing technique were used. As shown in Fig. 2, high pressure fluid medium (either water or gas) coming from high pressure pump flows into hollow shaft, when they are pressed into special rotary joint at first and leaf-type rotary plate then through the guide flowing hole in the lower end of the hollow shaft, the leaves were designed to hollow plane wing entity, and there is a jet at the out-stretch end of the leaf, when high pressure fluid is sprayed off at high speed from the jets, it will drive leaf-type rotary

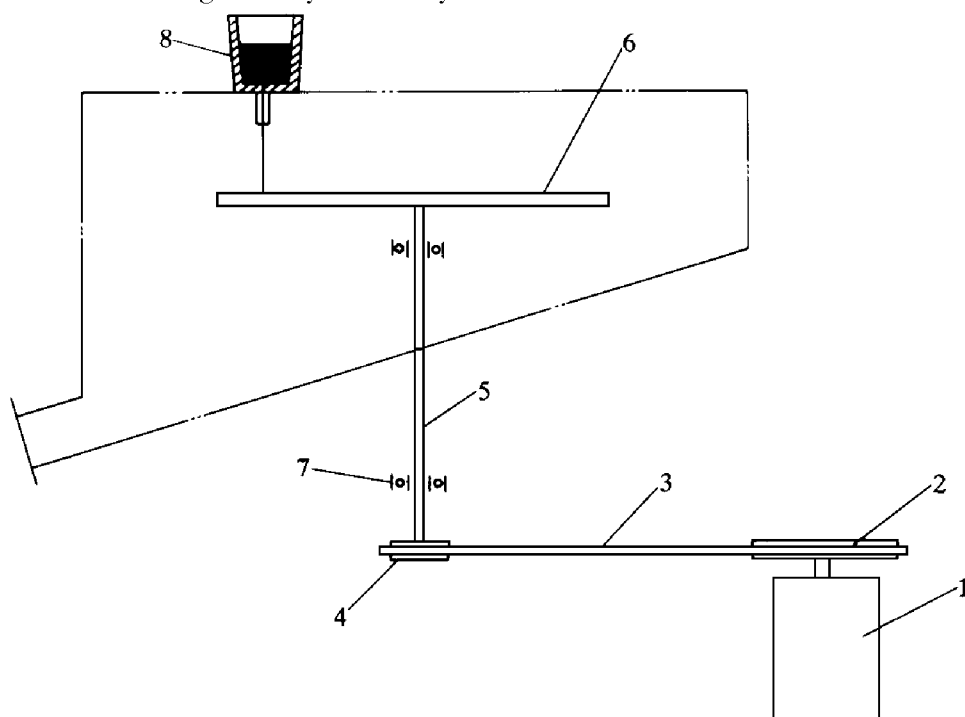


Fig. 1 A schematic diagram of mechanical type centrifugal atomization equipment

1 —electromotor; 2 —large driving belt wheel; 3 —driving belt; 4 —small driving belt wheel;
5 —rotary shaft; 6 —rotary plate; 7 —ball bearing; 8 —funnel

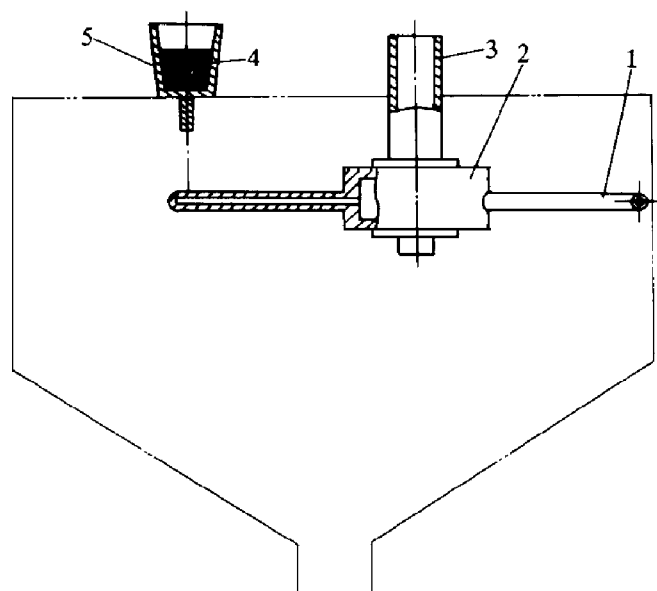


Fig. 2 A schematic diagram of centrifugal atomization equipment of spray rotation

- 1 —leaf-type rotary plate;
2 —rotary joint; 3 —hollow shaft;
4 —superheated melted metal; 5 —funnel

plate rotate at high speed. Not only the fluid static pressure bearing forms at starting stage, but also fluid kinetic lubrication forms with increase of rotary speed, because the special rotary joint has a certain clearance and shunting current and shunting pressure mechanism with hollow shaft at axial and radial direction. There won't appear rigid contact, as there is high pressure fluid film among the relatively rolling components, what being overcome is the internal friction force, i. e. layer shear force in fluid only, and the friction resistance in fluid is very small. The fluid used is generally high pressure water. If the water is pure, it won't pollute the powder, on the contrary, it will cool powder and prevent the powder from flying. When the equipment is started to work, the high pressure pump is started, the leaf-type rotary plate will be softly started, then its superheated melted metal prepared is poured into the funnel, the metal fluid from the duct of the lower end of the funnel once drops onto the leaf-type rotary plate, it is atomized immediately. This equipment can be combined with powder preparation of gas atomization, i. e. a funnel is put over a jet, a so-

called secondary atomization will be then formed (Fig. 3). The powder prepared by this method is far finer. Take Al-20 Si alloy powder preparation for an instance, the melt was superheated to 820 °C, the distance between the center of special vertical jet and the center of the leaf-type rotary plate is 200 mm and the distance between the jet and the plate is 150 mm, the rotary plate was started and its speed was up to 26 000 r/min gradually, the gas valve was switched on (N_2 is used as protecting medium and its pressure is 1.6 MPa), then the superheated alloy melt was poured into ceramic funnel preheated (the diameter of the duct of funnel is 1.8 mm), the average diameter of Al-20 Si alloy powder prepared is 7.5 μm .

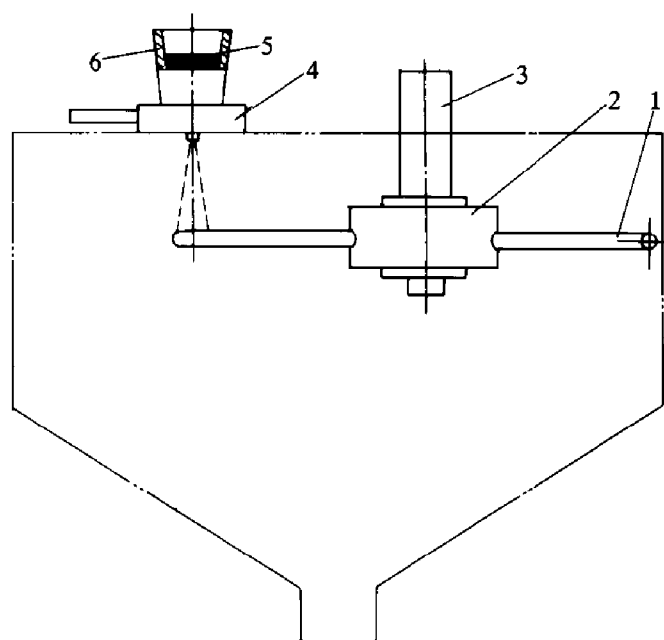


Fig. 3 A schematic diagram of equipment combining gas atomization with centrifugal atomization of spray rotation

- 1 —leaf-type rotary plate;
2 —rotary joint; 3 —hollow shaft;
4 —jet; 5 —superheated melted metal; 6 —funnel

4 CHARACTERISTICS OF THE NEW TECHNIQUE

After the operational principle of centrifugal atomization equipment of spray rotation was analyzed, the following characteristics can be summarized as follows:

(1) High efficiency

The complicated transmission components between power resource and work machine were saved, because the direct spray driving of high pressure fluid was used, therefore, the working efficiency greatly increases. At the same importing power, higher outputting power and larger driving force can be obtained.

(2) Convenient speed regulation

The pressure and volume of flow are easily regulated, therefore, the rotary speed of the centrifugal atomization equipment of the spray rotation can be arbitrarily steplessly regulated, moreover, as at the initiative starting stage the larger turning inertia of rotator or in the operation process failure occurrence result in rapid increasing of resistant moment, because the jets are normally open, spraying as usual doesn't result in any component failure, the equipment displays soft-start and flexible operation.

(3) High speed

One of the most important characteristics of the equipment is its high speed, because the joint part of hollow shaft is with leaf-type rotator is special rotary joint, and the rotary joint has the function of shunting current and shunting pressure, i. e. one part of fluid flows along radial direction, the other part firstly flows along axial direction, then turns to radial flowing, which results in radial and axial fluid kinetic pressure lubrication. The ratio of film thickness λ can be used to judge whether or not forms fluid kinetic pressure lubrication, it can be calculated by following eq.^[8]:

$$\lambda = h_0 / \sqrt{H_f^2 1 + H_f^2 2} \quad (1)$$

where h_0 —Thickness of thinnest fluid film among contacting faces, m; $H_f 1$, $H_f 2$ —Surface roughness of two contacting faces, m, whose values are related to process precision.

It is deduced by Martin A M eq.^[8] that:

$$h_0 = 4.9 \eta_0 (VR/q) \quad (2)$$

where η_0 —dynamic viscosity of fluid, for constant temperature water, it is 1, cp; V —average linear velocity of contacting faces, m; R —overall curvature viscosity of contacting faces, m, i. e. $R = R_1 \cdot R_2 / (R_1 \pm R_2)$ —shows for

curvature radius of concave; q —load of unit contacting line, $N \cdot m^{-1}$. Generally speaking, when $\lambda > 3$, the kinetic pressure lubrication of fluid can form, the higher the speed is, the more beneficial to forming kinetic pressure lubrication of fluid is; once the kinetic fluid film forms, the high pressure film will absolutely separate the contacting faces of the two relatively rotating two components, the moving part suspends relatively to the fixed one. The resistance should be overcome is internal friction resistance of fluid only, but internal friction resistance of fluid layers is very small. Thus rotary speed obtained is very high, and is usually up to 10 000~ 30 000 r/min. At so high rotary speed, the sheared frequency of metal can be increased, which results in the increasing of both fine powder ratio prepared by centrifugal atomization of metal and cooling speed of rapid solidification powder.

5 CONCLUSIONS

The efficiency of metal powder preparation by centrifugal atomization is mainly decided by the speed of rotary plate of the centrifugal atomization equipment, in normal mechanical transmission, there is mechanical friction inevitably in the driving belt mechanism, ball bearing, etc which restricts increase of rotary speed of plate.

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