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Water Jet Shooting Each Other and Nano-grade Microbe Cells Crusher

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Abstract: Through researching the special nozzles, we shoot fan-shape water jet and shoot each other to crush microbe cells and achieve control of particle size. In the test of crushing microbe cells, we find that density of water jet and the size of the nano-particle is in proportion, for the expression of its function: \( y = f(x) \). We create the expansion distance between water molecules formulation: \( r = r_0 \times \eta \) and other mathematical models. When the expansion of multiples \( \eta_n = 1 \), the distance between water molecules \( r_0 = 0.4 \) nm, the size of particle is less than nano-grade, when \( \eta_n = 2.6 \sim 250 \), \( r_\approx 1 \sim 100 \) nm, get the broken nano-particles; when \( \eta_n > 250 \), \( r > 100 \) nm, the size of broken particle is greater than nano-grade. Accordingly we developed a water jet microbe cells crusher. We get the Chinese invention patents with No.ZL03143321.9.

Key words: water jet, jet generator, microbe cells

I. Introduction

Water jet technology has 30 years of history in exploitation of coal, ores, and in factories, mines cleansing[1,2]. In the late 1960s, the University of Missouri in the United States developed of water jet cutting (water saws, water knife) [1,2] and agreed invention patents. But there is no report about water jet crushing microbe cells (microsubstance) at home and abroad [1, 2, 3]. Water Jet technology and nano-microbe cells crusher are urgent need of special equipment and core technology in microorganism fermentation, extraction of cells and ultra-fine processing industries. The invention of the water jet technology has improve to a new level.

II. Research Methods

A. Research and design the nozzle of water jet Crusher [4,5,6,7,8,9,10,11,15]

The nozzle is the core engine of the water jet crusher and can launch a fan-shaped water jet and control the density of water jet (that is, the distance between water molecules). If the needs of smaller particles, the distance between water molecules should be smaller. If the biological needs of larger particles, the distance between water molecules should be bigger, with direct proportion of its function: \( y = f(x) \). The fan-shape water jet is fired through nozzles. Please see Figure 1.

In Figure 1, we can see from d4, d3, d2, d1 the water density is different. We summarised the distance between water molecules expansion multiplier formulation[6,7,8] in accordance with the relevant principles of mathematics.

the expansion of multiples \( \eta_n \) wher dn,
\[ \eta_n = \frac{S_n}{S_0} = \frac{\pi \left( \frac{d_0}{2} \right)^2}{\pi \left( \frac{d_n}{2} \right)^2} = \left( \frac{d_0}{d_n} \right)^2 \quad n = 1, 2, 3 \quad (1) \]

The expansion formula of the distance between water molecules [6,7,8]
\[ r_n = r_0 \times \eta_n \quad (2) \]

\[ \eta_n = \frac{S_n}{S_0} = \frac{\pi \left( \frac{d_0}{2} \right)^2}{\pi \left( \frac{d_n}{2} \right)^2} = \left( \frac{d_0}{d_n} \right)^2 \quad n = 1, 2, 3 \quad (1) \]

\[ r_n = r_0 \times \eta_n \quad (2) \]

**FIG.1** A schematic diagram of water intermolecular distance enlargement

**FIG.2** A sketch map of parts assembly and shoot water jet

\( r_n \) denotes the distance between water molecules after expansion, \( r_0 \) denotes the original distance between water molecules before expansion, \( r_0 = 0.4 \) [7] nm; \( \eta_n \) for the expansion of multiples. According to Figure 1 and calculation we can know \( r_1 < r_2 < r_3 < r_4 \), and \( r \) controls particle size for \( r \) denotes the size of the place where water jet fail to impact of microbe cells, as for the control of the production of biological particles broken the basis of data.

Now, living examples of diameters of biologic particles obtained by the machine were illustrated. Structure of the spray nozzle was presented in figure 1. Water jet in left and right spray pipes where the interval between the water molecules \( r_0 \), \( r_0 = 0.4 \) nm, was interfused 10%-12% of microbe cells and given strong pressure \( P \) which was strong enough to crush microbe cell. The size of obtained biologic particles was calculated as follows:

With the practical measuring values:
\( d = 1.2 \) mm, \( d_1 = 2.4 \) mm, \( d_2 = 4.8 \) mm, \( d_3 = 9.6 \) mm, \( d_4 = 19.2 \) mm.

The interval between the water molecules at the position \( d_1 \) may be calculated: \( r_1 \),
\[ r_1 = \eta_1 \times r_0 = \frac{d_1^2}{d_0^2} \times r_0 = \frac{2.4^2}{1.2^2} \times 0.4 = 1.6 \text{ nm} \]

By the same way we can know, \( r_2 = 6.4 \text{ nm}, r_3 = 25.6 \text{ nm}, r_4 = 102.4 \text{ nm} \).

When \( \eta_0 = 1 \), \( r_0 = 0.4 \) nm, the size of particle is under nano-grade. When \( \eta_0 = 2.6 \sim 250, r_n = 1 \sim 100 \) nm, the particles are just nanograde. When \( \eta_0 > 250, r_n > 100 \) nm, the particles are upper nano-grade.

**B. Determine the structure of water jet microbe cells crusher [4,5,6,7,8,9,10,16]**

Injector nozzle assembly in 3 suites, the waste microbe cell evenly mixed into water. When fired through the nozzles the two fan-shape water jets carrying secretly the microbe cell shoot each other and toward the waste microbe cell at the same time. The microbe cell can be crushed into nano-grade particle. Nozzle assembly diagram 2.

In figure 2, 1 and 2 denote left and right spray nozzles, 3 and 4 denote left and right spray pipes, 5...
and 6 denote left and right water jet flows of carrying secretly microbe cells, and 7 denotes the crushed particles from water jet flow shooting each other. The suite (1) means that the machine crushes the microbe cells into particles under nano-grade, the suite (2) means that the machine crushes the microbe cells into particles just nano-grade and the suite (3) means that the machine crushes the microbe cells into particles upper nano-grade. The three suites of spray nozzle and spray pipe are assembled one machine and we call it nano-grade microbe cell crusher.

C. The design for water jet microbe cells crusher[4,5,6,7,8,17]

We do some experiments with the developed model machine and establish mathematical models and then zoom in to develop production water jet machines.

The calculation formula of the diameter d of the nozzle can be determined. It was described in following sections.

\[ \Phi = 1.233 \times \frac{Q}{\sqrt{P \times n}} \times \omega \times \Psi \]  (3) 

d: diameter of spray pipe, unit: mm. Q: spray flux, unit: L/min. P: jet flow pressure, unit: Mpa. n: number of spray nozzle, unit: quantity. \( \omega \): quotient of water flux quotient, \( \omega = 0.60 \sim 0.85 \). \( \Psi \): quotiety of spray nozzle efficiency, \( \Psi = 0.75 \sim 0.95 \).

The calculating formula of velocity of jet flow (v) of the machine was described as the following:

\[ V = \frac{Q}{\pi r^2} \]  (4) 

V: velocity of jet flow, unit: m/s. Q: flux of jet flow, unit: m³/s. r: semidiameter of spray nozzle, unit: m.

Calculating formula of impulsive force (F) of jet flow effect of the machine was described as following:

\[ F = \frac{m(v - v_0)}{t} \]  (5)

F: an impulsive force of receiving 1g of particles. unit: kgm/s². m: 1g of particles, unit: g. v: velocity of jet flow as striking 1g of particles, unit: m/s. v₀: muzzle velocity of jet flow, unit: m/s, v₀=0. t: expending time of jet flow as striking 1g of particles, Unit: s. t=6.0x10⁻³/s.

The calculating formula of sectional area (S) of spray pipe in the machine was described as the following:

\[ S = \pi r^2 \]  (6) 

S: sectional area of spray pipe, unit: m². \( \pi \): 3.14. r: semidiameter of spray pipe, unit: m.

The calculating formula of jet flow (Q) of the machine was described as the following:

\[ Q = S \times V \]  (7) 

Q: jet flux, unit: m³/s. S: sectional area of spray pipe, unit: m². V: velocity of jet flow, unit: m/s.

The calculating formula of Electromotor power (N) of nanograde microbe cell crusher is as the following:

\[ N = \frac{\psi P_s Q_N}{600n_p} \]  (8) 

N: Electromotor power, unit: W. P: jet flow pressure, unit: Mpa. S: sectional area of spray pipe, unit: m². Q: jet flux, unit: m³/s. N: number of spray nozzle, unit: quantity. \( \psi \): quotient of jet flow efficiency, \( \psi = 0.75 \sim 0.95 \).
N: power of engine, unit: kw. ψ: Coefficient of transformation \( \frac{P_{\text{max}}}{P_{\psi}} \), \( P_{\text{max}} = 0.52-0.54 \). \( P_{\psi} \): rated working pressure, unit: Mpa. \( Q_{\text{r}} \): rated working flux, unit: L/min. \( \eta_{\text{r}} \): efficiency of engine, unit: 80%-90%.

According to the above calculation, The machine consists of 3 parts: the motivity source, switch cabinet, jet generator and the system of jet shooting each other. The working situation of the machine was recorded in Table 1, and modeling can be seen figure 3.

Water Jet microbe cells crusher its specifications are: CHKD4000L, CHKD3600L, CHKD3000L, CHKD2400L, productivity is per hour for 4000 kg, 3600kg, 3000kg, 2400kg. Production is applicable for industrial production.

Table 1. The general working situations of the machine

| PS(L/h) | DCP(Mpa) | φ(mm) | \( V \)(m/s) | \( 1g \)(Mpa) | S(\( m^2 \)) | \( N \)(kw) |
|---------|----------|-------|-------------|--------------|-------------|------------|
| 4000    | 70-140   | 1.57  | 578.9       | 96.5         | 1.9x10^-6   | 50-100     |
| 3600    | 70-140   | 1.49  | 588.2       | 98.0         | 1.7x10^-6   | 45-90      |
| 3000    | 70-140   | 1.36  | 592.8       | 98.8         | 1.4x10^-6   | 38-75      |
| 2400    | 70-140   | 1.21  | 609.1       | 101.5        | 1.1x10^-6   | 30-60      |

1. PS—productive scales. 2. DCP—designing crushing pressure. 3. φ—diameter of spray pipe of productive machine. 4. \( V \)—velocity of jet flow of productive machine. 5. \( 1g \)—receiving impulsive force of \( 1g \) particles. 6. \( S \)—sectional area of spray pipe of productive machine. 7. \( N \)—power of engine.

D. Water jet microbe cells crusher visual effects [7, 8, 9, 10, 11, 12, 13, 14, 18, 19]:

In Figure 2 (1), when \( \eta_{\text{n}} = 1 \), \( r_{\text{n}} = 0.4 \) nm, under 100MPa pressure, the size of particle of beer yeast cell after broken is about 0.3~0.9nm (the original size 3~8 \( \mu \)m). It can be seen with Hitachi H-700 electronic lens zooming 100,000 times, its visual effect can be seen in Figure 4.

When \( \eta_{\text{n}} = 2.6 \sim 250 \), \( r_{\text{n}} = 1 \sim 100 \) nm, under 100MPa pressure, the size of particle of pseudomonas and acermonium after broken is about 20~40nm (the original size of pseudomonas 0.5~1.5\( \mu \)m and acermonium 2~4\( \mu \)m), its visual effect can be seen in Figure 5.

When \( \eta_{\text{n}} > 250 \), \( r_{\text{n}} = > 100 \)nm, under 100MPa pressure, the size of particle of beer yeast cell after...
broken is range from 1～6nm (the original size 3～8 μm). Its visual effect can be seen in Figure 6.

![FIG.5. The enlarging 48000 times facsimile picture of pseudomonas and acremonium after crushed by the machine.](image1)

![FIG.6. The enlarging 3000 times facsimile picture of yeast after crushed by the machine.](image2)

### III. Results and discussion

1. We developed water jet microbe cell crushing machine in accordance with the theory of enlarging the distance between water molecules. Its specifications are: CHKD4000L, CHKD3600L, CHKD3000L, CHKD2400L. It is possible to realize industrial production that hourly production capacity 4000kg, 3600kg, 3000kg, 2400kg. The development of the machine ended the history that the microcosmic materials cannot be crushed, and the machine has become important member of crushing family.

2. The role of time when water jet crusher crushed microbe cells into nano-grade particles was 3 / 1000 second for an instant broken. The material doesn’t heat easily and is sure of protecting its living creature.

3. The biological particles of nano-grade produced by the machine contain the protein content of 10-50 percent. They can be used in the fermentation industry instead of the nitrogen materials. The machine can realize circle economy of waste microbe cell to ferment industry and cleansing production and can be the professional tools for the extraction of cells within the industry to provide more, faster, better.

4. The formula of enlarging the interval between the water molecules: \( r_n = r_0 \times \eta \) was set up, when \( \eta_n = 1 \), \( r_0 = 0.4 \) nm, the size of particle is smaller than nano-grade. When \( \eta_n = 2.6-250 \), \( r_n = 1-100 \) nm, the particle is nano-grade. When \( \eta_n > 250 \), \( r_n > 100 \) nm, the particle is bigger than nano-grade. According to this discovery, we developed nano-grade microbe cell crusher and ended a history that the microcosmic substance cannot be crushed.

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