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(71) Applicant: Horii, Kiyoshi
No. 8-15-501 Kamimeguro 5-Chome
Meguro-ku
Tokyo(JP)

Applicant: CHEMICAL IND. Co., LTD.
3-28-2-chome, Kasuganishimachi
Hirakata, Osaka(JP)

(72) Inventor: Horii, Kiyoshi
5-8-15-501, Kamimeguro
Meguro-ku, Tokyo(JP)

(74) Representative: Davies, Christopher Robert et al
Frank B. Dehn & Co. Imperial House 15-19 Kingsway
London WC2B 6UZ(GB)

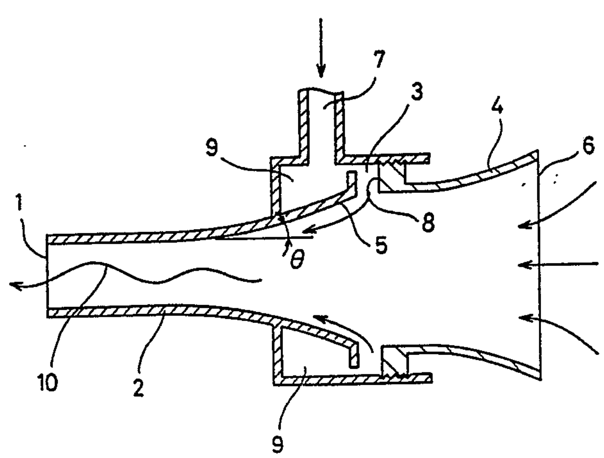
(54) Cutting method and apparatus.

(57) The present invention provides a novel method for cutting comprising performing cutting by ejecting a fluid by a Coanda spiral flow generated through introduction of a pressurized fluid.

Furthermore, as an apparatus for the application of the present method, the present invention provides an apparatus for cutting comprising a rotatable and movable Coanda spiral flow generating nozzle having an annular slit (3) for introducing a pressurized fluid transversely to a nozzle ejecting port (1) and a curved wall (5) running from said slit to said ejecting port.

Cutting efficiency may be largely improved. Wear resistance of a nozzle may be more excellent. In case of using hard cutting particles, they may be uniformly dispersed throughout the fluid.

FIG. 1



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CUTTING METHOD AND APPARATUS

The present invention relates to a method for cutting and an apparatus for the application thereof. More particularly, the present invention relates to a method for jet cutting and an apparatus for the application thereof, which are excellent in cutting efficiency with a uniform cut surface and permit inhibition of production of burrs.

For cutting a metal object, a high temperature gas flame melting-cutting method using gas combustion and a liquid jet cutting method adopted under conditions which do not permit use of flame e.g. in a tank for storage of an oily material, have conventionally been known.

For example, the liquid jet cutting method is popularly known as a water jet cutting method using high pressure water, and is widely applied for cutting steel sheet. This method is employed also in building sites where powder cannot be used for cutting or breaking rocks and concrete.

A typical jet nozzle used for the liquid jet cutting method is illustrated in Fig. 3. High pressure water is introduced from a high-pressure water inlet (B) toward a nozzle exit (A), while introducing hard particles from a cutting particles inlet (C) provided transversely, and cutting is conducted by means of a jet flow ejected from the nozzle exit (A). Hard cutting particles may be omitted in this case.

While the jet cutting method is very useful as a cutting method applicable under conditions making it difficult to use fire, the conventional method and apparatus have several points to be improved.

More specifically, in the conventional method, the jet flow ejected from the nozzle exit (A) shown in Fig. 3 rapidly diffuses so that it is difficult to concentrate the jet flow onto the portion to be cut. Furthermore, a cut surface is apt to be ununiform and production of burrs is inevitable. When using hard cutting particles , the nozzle inner wall suffers seriously from being worn.

These defects are inevitable in the generation of a jet flow based on the introduction of high-pressure water, and this naturally limits the applicability of the liquid jet cutting method. There has, therefore, been a strong demand for improvement of cutting efficiency, homogenization of a cut surface, inhibition of occurrence of burrs, and reduction of nozzle wear.

The present invention has an object to provide a novel jet cutting method based on a jet flow which avoids at least some of the aforementioned defects in the conventional method.

Furthermore, the present invention has another object to provide a new apparatus for the application of said jet cutting method.

Viewed from one aspect the present invention provides a method for jet cutting comprising performing cutting by ejecting a fluid, wherein the fluid is provided with a Coanda spiral flow generated through introduction of a pressurized fluid.

In a preferred embodiment the pressurised fluid is water and the ejected fluid contains hard cutting particles.

Viewed from another aspect the present invention provides apparatus for jet cutting comprising a nozzle and means for introducing a pressurised fluid into a fluid flowing in use through said nozzle, whereby to generate a Coanda spiral flow in said fluid flowing through said nozzle.

Preferably the pressurised fluid is introduced through an annular slit in the nozzle and the nozzle is generally conical, the inner wall being convexly curved at least from where the pressurised fluid is introduced towards the nozzle exit.

Viewed from another aspect the present invention provides an apparatus for jet cutting comprising a rotatable and movable Coanda spiral flow generating nozzle having an annular slit for introducing a pressurized fluid transversely to a nozzle ejecting port and a curved wall running from said slit to said ejecting port.

The Coanda spiral flow used in the present invention was discovered by the present inventor as a state of movement different from a turbulent flow while being under the conditions of movement of a fluid belonging the turbulent region, unlike the laminar flow or a turbulent flow known as the conventional concept of fluid movement. A method for forming the Coanda spiral flow has already been proposed also by the present inventor.

More particularly, the Coanda spiral flow is a flow of a fluid which runs at a high velocity in the pipe direction while forming a spiral, and can be formed by adding a vector in the pipe radial direction to the flow vector of the fluid introduced in the pipe direction. In this case, a negative pressure having a strong sucking force is formed on the side opposite to the running direction of the Coanda sprial flow, and high velocity Coanda layer based on the spiral flow near the pipe inner wall is formed.

The present invention may perform cutting of a metal, an inorganic material, cement or other solids by the use of the features of such a Coanda spiral flow. One of the most important things in using the present method and apparatus is to concentrate velocity distribution on the running axis relative to the running direction of the Coanda sprial flow. This concentration is never observed in a conventional jet flow based on a turbulent flow. This concentration of velocity distribution permits improvement of cutting efficiency with a uniform cut surface and inhibition of burr occurrence.

An embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings wherein:-

Fig. 1 is a sectional view illustrating an embodiment of a nozzle of an apparatus of the present invention;

Fig. 2 (a) and (b) are drawings illustrating velocity distributions of the jet flow in an embodiment of a method of the present invention and the conventional method, respectively; and

Fig. 3 is a sectional view illustrating a conventional water jet cutting nozzle.

Fig. 1 illustrates an embodiment of the present invention as a Coanda spiral flow generating nozzle which has been developed for use in efficient mixing of abrasive and for improved focusing of water jet streams in high pressure abrasive water jet cutting applications. The development of the nozzle was based on the spiral flow theory. To obtain a focused jet flow, the nozzle is designed with an annular slit connected to a generally conical tube. Pressurized fluid is supplied through this slit and the fluid, passing through the generally conical tube, is deformed to the spiral flow with the maximum axial flow on the axis, caused by Coanda effect and the instability of turbulence.

In the embodiment shown in Fig. 1 there is an annular slit (3) for pressurizing and introducing a fluid such as water on a main tube (2) directed toward a nozzle exit (1), and this slit (3) is provided with a supply pipe (7) for supplying a pressurized fluid.

The main cylinder (2) has a diameter becoming similarly and gradually larger from the nozzle exit (1) toward the slit (3) and a wall surface (5) of the main cylinder (2) is formed to be smoothly curved. The end opposite to the nozzle exit (1) is provided with an auxiliary cylinder (4) with an inlet (6) for a mixed flow of a fluid, or a fluid and hard cutting particles. At the opposite side of the wall surface (5) opposite to the slit (3), a wall surface (8) of the auxiliary cylinder (4) is bent at right angles or at an acute angle.

The interval of the slit (3) may be adjustable. There is no particular limitation on the structure of the supply pipe (7) supplying a pressurized fluid. Furthermore, a distribution chamber (9), for example, may be provided for the purpose of ensuring uniform supply.

For the main cylinder (2), the inclination angle (θ) should preferably be such that tan dθ is about 1/3 to 1/10.

In a Coanda spiral flow generating nozzle, such as has been described above, pressurized water as a pressurized fluid may be introduced from the slit (S) into the main cylinder (2). This permits synthesis of the motion vector of the pressurized water and the motion vector of the fluid such as water and air from the inlet (6), thus forming a spiral motion (10). This spiral motion (10) brings about concentration of fluid velocity in the running axis direction. forming a high velocity concentrated flow, Since a Coanda layer is formed in the main cylinder (2), wear of the nozzle inner wall is inhibited even when hard cutting particles are mixed in a pressurized fluid. When mixing particles such as alumina, SiC, Si_3N_4, BN, WC, etc., their dispersion is homogenized.

The nozzle has been developed in at least preferrd embodiments for use in efficient mixing of abrasive and for improved focusing of water jet streams in high pressure abrasive water jet cutting applications.

In at least preferred embodiments the jet stream is more stable and concentrates the particles to the axial area of the jet flow caused by the characteristics of a spiral jet. That is the maximum axial flow on the axis and a rotational flow around the axis.

In at least preferred embodiments, in cutting, the pressure of the fluid such as water can be appropriately set, and any of metals, inorganic materials such as alumina garnet, or the like may be used appropriately as hard cutting particles. It may not always be necessary to use those hard cutting materials.

Pressurized fluid may be water or other fluid or a mixed liquid. The object to be cut may be any of metals, inorganic materials and other solids.

Embodiments of the present invention are further illustrated by means of the following examples:-

EXAMPLE 1

The nozzle shown in Fig. 1 was used. An exit diameter of the nozzle was 19 m/m.

A distance of 50 m/m was provided between the nozzle exit and a sample, and a concrete wall as the sample was cut. In this case, water pressurized at 400 kgf/cm^2 was ejected, without the use of hard cutting particles.

The sample was cut to a depth of 18 cm. Cutting was conducted by the conventional water jet method under the same conditions. The sample was cut only to a depth of 10 cm. The cut surface was rough with innumerous fine burrs occurring on it. The cut width was more than twice as large as in the cutting by the Coanda spiral flow of the present embodiment.

Additionally, when mixing in alumina particles, the cut depth increased even to about 26 m/m.

EXAMPLE 2

Velocity distribution of a jet flow from a nozzle of 8 mm was evaluated.

A velocity of 43 m/sec was set at a position of 4 cm from the nozzle tip, and comparison was made with the conventional water jet.

Velocity distributions of an embodiment of the Coanda jet with pressurized water of 4.8 kgf/cm^2 and the conventional water jet are shown in Figs. 2 (a) and (b).

As is clear from the comparison of velocity distribution of 20 m/sec, i.e., expanses (ℓ) of the velocity, velocity concentration is far higher in the Coanda jet of the present embodiment than the conventional jet.

According to at least preferred embodiments of the present invention, as describe above, the following effects are available when performing cutting with the use of a jet flow based on a Coanda spiral flow:

1) Since diffusion of the jet is smaller and the energy exerts its effect concentrically in the running direction, the cutting efficiency may be largely improved.

2) Wear resistance of the nozzle may be excellent.

3) Hard cutting particles may be uniformly dispersed throughout the fluid.

For these advantages, it may be possible to achieve far more useful method and apparatus for cutting than the conventional ones.

Claims

1. A method of jet cutting comprising performing cutting by ejecting a fluid, wherein the fluid is provided with a Coanda spiral flow generated by introduction of a pressurized fluid.

2. A method as claimed in Claim 1, wherein said pressurized fluid is water and hard cutting particles are ejected.

3. A method as claimed in claim 1 or 2 wherein said pressurised fluid is introduced into a fluid flow in a nozzle through an annular slit in said nozzle to generate said Coanda sprial flow.

4. A method as claimed in claim 3 wherein said nozzle is generally conical, the inner walls being convexly curved from said annular slit towards the exit of said nozzle.

5. Apparatus for jet cutting comprising a nozzle and means for introducing a pressurised fluid into a fluid flowing in use through said nozzle, whereby to generate a Coanda spiral flow in said fluid flowing through said nozzle.

6. Apparatus as claimed in claim 5 wherein said nozzle has an annular slit through which said pressurised fluid can be introduced into said fluid flow.

7. Apparatus as claimed in claim 5 or 6 wherein said nozzle is generally conical, the inner walls being convexly curved from said means for introducing a pressurised fluid towards the exit of said nozzle.

8. An apparatus for jet cutting comprising a rotatable and movable Coanda sprial flow generating nozzle having an annular slit for introducing a pressurized fluid transversely to a nozzle ejecting port and a curved wall running from said slit to said ejecting port.

FIG. 1

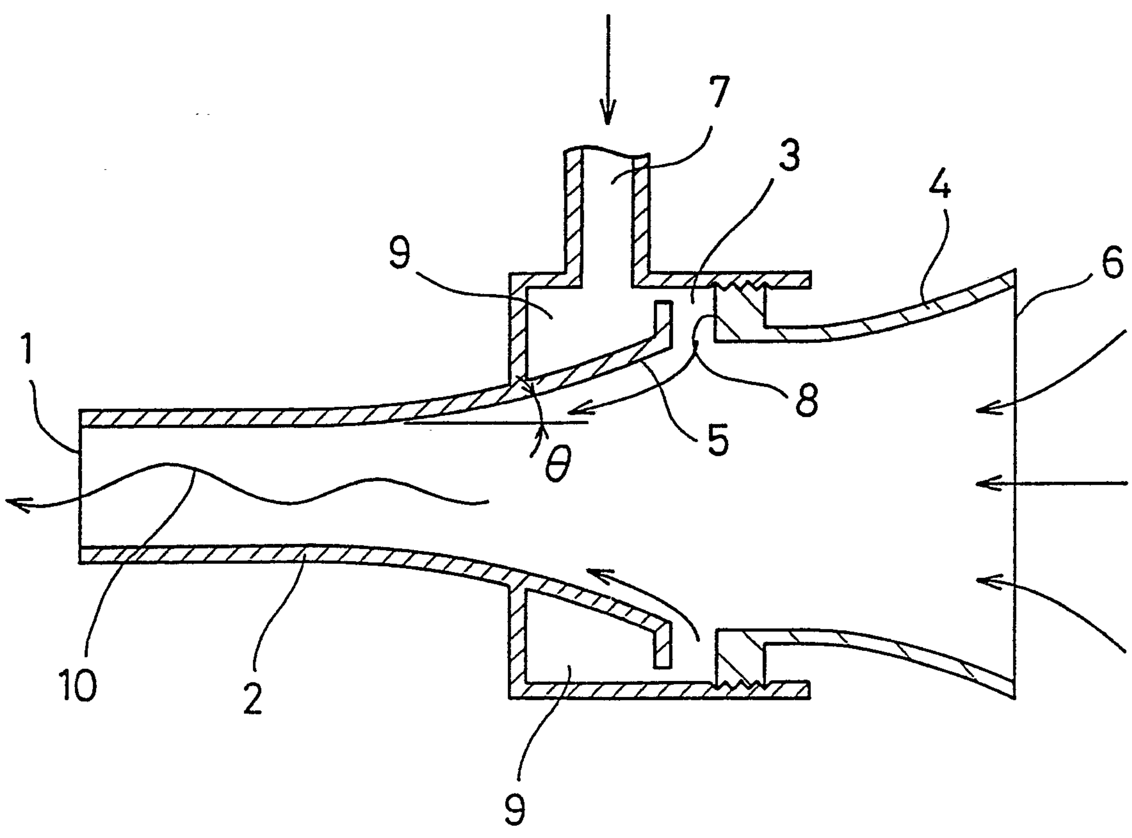


FIG. 2 (a)

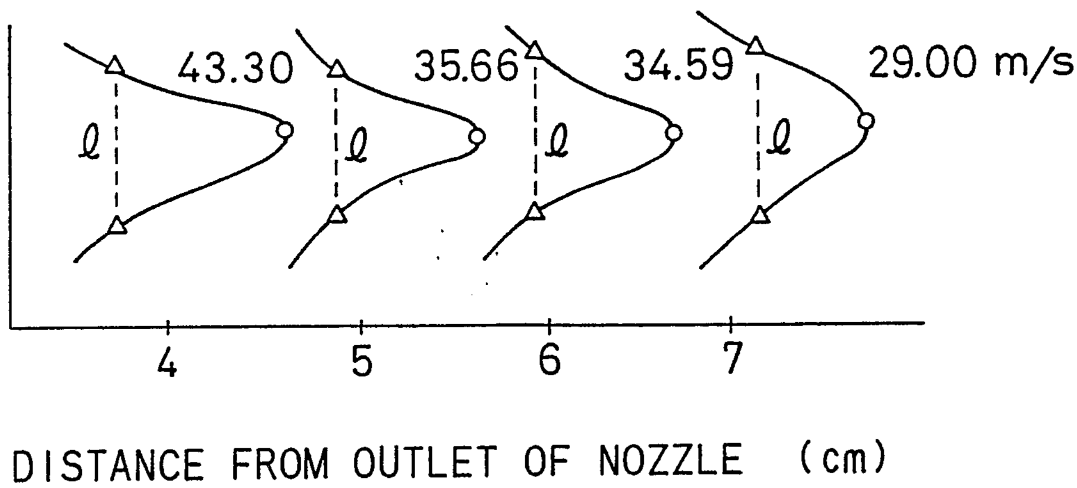

43.30
35.66
34.59
29.00 m/s
ℓ
4
5
6
7
DISTANCE FROM OUTLET OF NOZZLE (cm)

FIG. 2 (b)

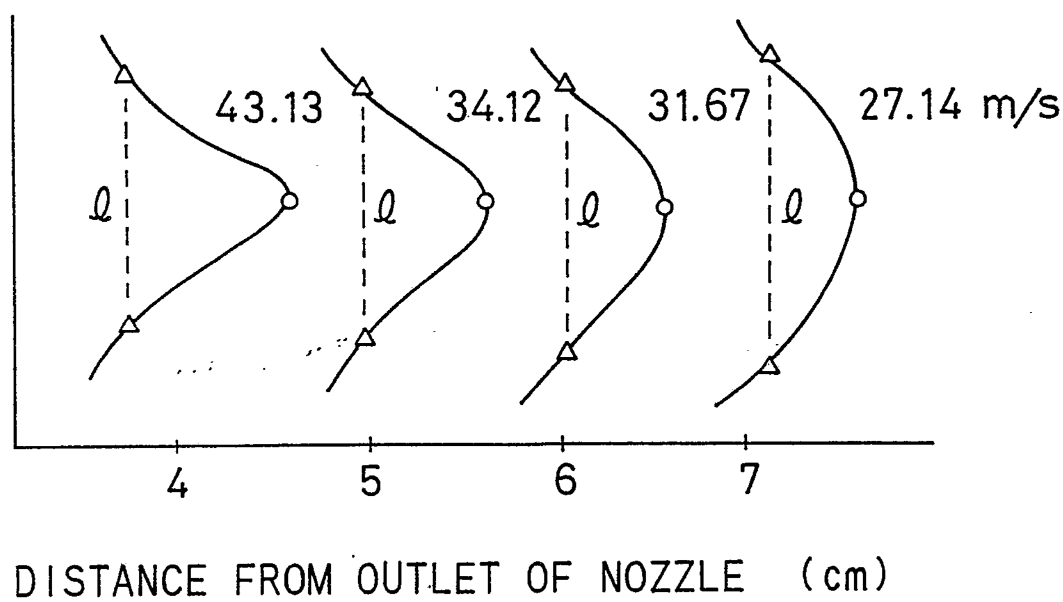
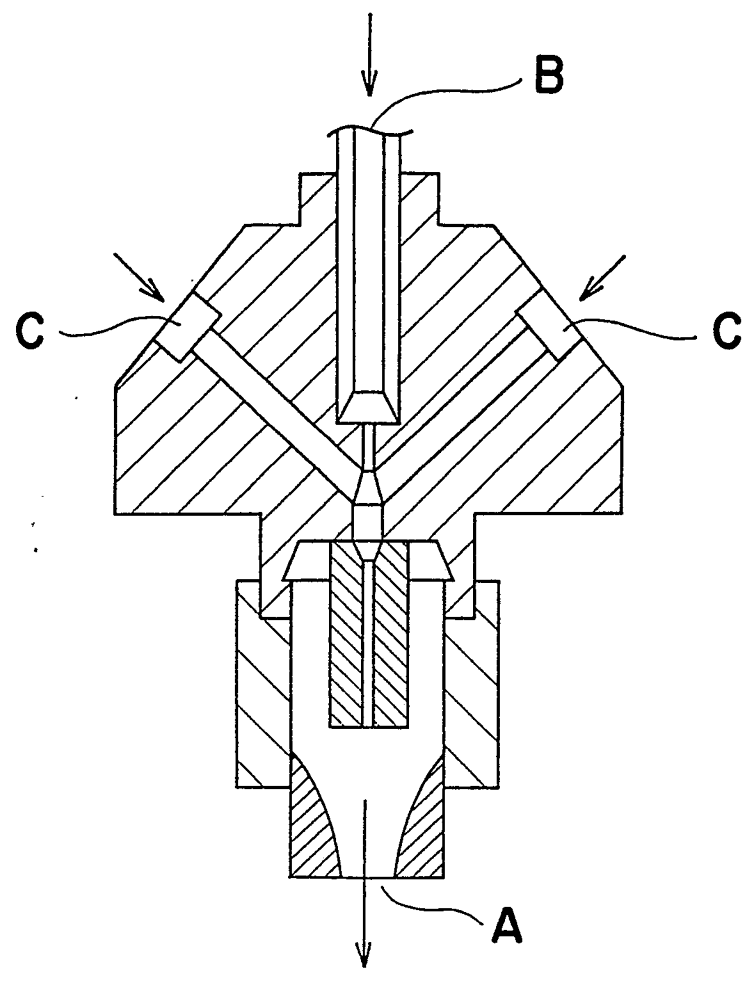

43.13
34.12
31.67
27.14 m/s
ℓ
4
5
6
7
DISTANCE FROM OUTLET OF NOZZLE (cm)

FIG. 3



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EUROPEAN SEARCH REPORT

Application number

EP 90301539.4

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int Cl 5)
X	SOVIET INVENTIONS ILLUSTRATED, P,Q sections, week 8710, April 22, 1987 DERWENT PUBLICATIONS LTD., London, P 42 * SU-1245-349 (WLADIMIR POLY) *	1	B 24 C 5/04
X	& SU - A1 - 1 245 349 (POLY) * Fig. 1-3 * ----	1	

TECHNICAL FIELDS SEARCHED (Int Cl 5)
B 24 C 5/00
B 26 F 3/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	25-04-1990	TRATTNER

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
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