NEW TYPE OF METAL TARGETS

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Now the technologies based on interaction of high-intensity beams with substance of a target are being intensively developed. As a target it is possible to use the new type of monodisperse metal targets. The principal advantages of new targets type are: target cooling isn't required; there is no induced activity: the target can be used many times; small dispersion on the speed, the size and interaction points with a beam. The basis of a target is the jet of molten metal, following in the vacuum chamber .Under the influence of the special disturbance superimposed on the liquid jet, the jet disintegrated into identical drops. In the vacuum chamber the drops freeze and form into the solid granules. It is possible to receive monodisperse targets from different metals, alloys and salts (diameter of targets is from 30 µm to 1.5 mm). Dispersion by the sizes and speed is less than 1%. The technique allows to receive not only continuous targets, but also hollow targets with dispersion on thickness of wall within 1…2%.

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INTRODUCTION

Now the technologies based on interaction of high-intensity beams with substance of a target are being intensively developed.

The interaction of high-intensity beams with a substance of a target will allow: to create the compact sources of protons for a radiography; will give the chance to make isotopes and to develop new methods in nuclear medicine; will allow to make experiments on nuclear physics on super-short periods [1].

Now for research of interaction of high-intensity beams with a target material wide usage has been gained the metal targets of the following types: wire targets and targets from a foil [2]. The main advantage of these targets is ease of fabrication. However there are also essential disadvantages: the targets need cooling; there is the induced activity, a fast damage of a target surface [3].

Instead of existing target types it is possible to use the new type of monodisperse metal targets developed by us.

The principal advantages of new targets type are: target cooling isn't required; there is no induced activity: the target can be used many times; small dispersion on the speed, the size and interaction points with a beam.

Theoretical basis of target operation is Rayleigh-Weber's theory for viscous liquids [4]. According to this theory the jet breaks up to drops with the minimum dispersion on the speed and the sizes (monodisperse drops) at a certain relationship between a jet speed, jet diameter and frequency of external excitation.

The operation of the installation on receiving targets is shown in Fig. 1.

Constructional target elements are: the crucible with molten metal; the generator of monodisperse drops; the system of vacuum chambers and sluices; a trap. Additional elements of a target are: the system of pressure stabilizing, excitation system, charging system and deviation system. If drops charge beforehand by using the charging system, it is possible to control a path of a drop flow having given controlling signals on deviation system. It is very important feature of new metal targets. Flow control gives the chance precisely to coordinate the moment of interaction of a target with a beam.

Based on the principle described above, it is possible to create the ecologically-sound and waste-free installations on receiving targets.

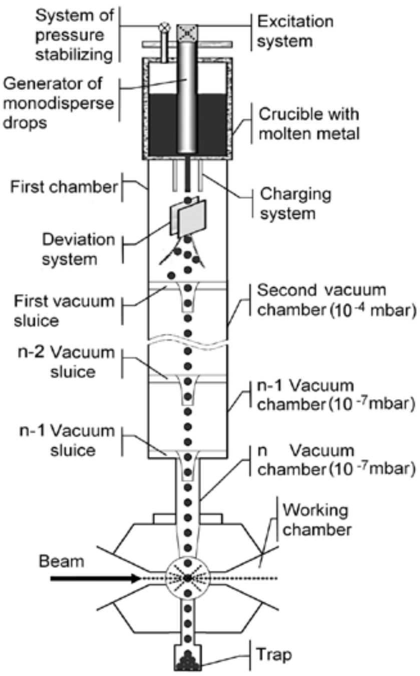

Fig. 1. The principle of target operation

The installation operates as following. The jet of molten metal follows from the drops generator in the first chamber filled with cooling gas. The jet breaks up to identical drops in response to external excitation imposed on the fluid jet. There is a preliminary cooling of drops due to interaction to gas in the first chamber. Passing through sluices and vacuum chambers, drops freeze and become solid granules. Monodisperse solid granules arrive in the working chamber where there is an interaction to an accelerating or laser beam. Sluices provide the minimum leaking in the working chamber. For reduction of leaking it is possible to use two and more vacuum chambers separated among themselves by sluices.

1. THE EXPERIMENTAL INSTALLATION

For study of heat-physical problems of receiving monodisperse metal targets the experimental installation is created.

Installation offers possibilities to study heat-physical problems of receiving monodisperse metal targets from different metals and their alloys with a melting temperature to 1600°C. Layout of basic installation elements and its appearance are provided in Fig. 2 and Fig. 3

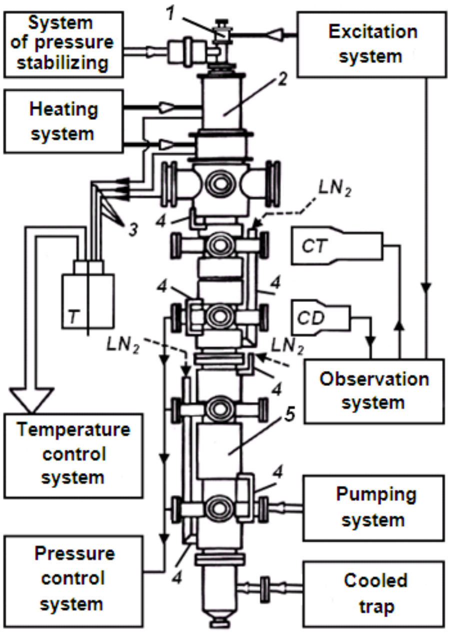

Fig. 2. Layout of basic installation elements

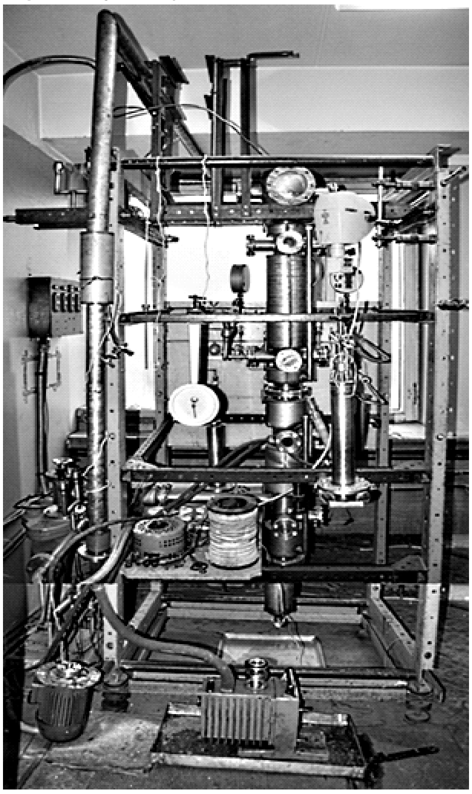

Fig. 3. Appearance of installation

Installation consists of the following main systems: the drops generator 1 with excitation system, heating system with the crucible 2, the heat-exchanging chamber 5 with external part 4, a cooled trap, system of pressure stabilizing, temperature control system with thermocouple sensors 3, pressure control system, observation system and pumping system. By means of heating system metal is molten in the crucible 2. There is excess pressure over a melt in the crucible. Pressure is regulated and supported at necessary level by means of stabilizing system. Helium purified from oxygen arrives on an input of stabilizing system. The jet of liquid metal will be formed on an output of the crucible. Capillary waves are created on a jet using excitation system and a piezoelement 1. The jet breaks up to monodisperse drops at a certain relationship between a jet speed, jet diameter, viscosity and frequency of external excitation. It is possible to receive the metal jets with diameters from 30 to 400 µm changing diameter of an exit orifice of the crucible.

The jet disintegrates on drops in the heat-exchanging camera 5 filled with pure helium. Helium has the greatest thermal conduction. It allows to cool the falling drops very quickly.

Monitoring over the heat-physical processes in the heat-exchanging chamber is carried out by means of the pressure control system and temperature control system. For pressure control the sensors of Balzers firm of the following types are used: APR 260 (1000 mbar), APR 265 (5000 mbar) and TPR 260. Indications of sensors were digitized in the measurement unit of pressure of TPG 265 "Balzers" and arrived on a computer. The measurement error of pressure made: for sensors of APR type ±10mbar, for sensors of TPR type $\pm 10^{-4}$ mbar.

Thermocouple sensors 3 were used for control of temperature. Indications of sensors were digitized in the measurement unit of temperatures and arrived on a computer input. The measurement error of temperature makes ±0.3 K. Processing of sensors indications and visual observation of the information was carried out by means of a computer.

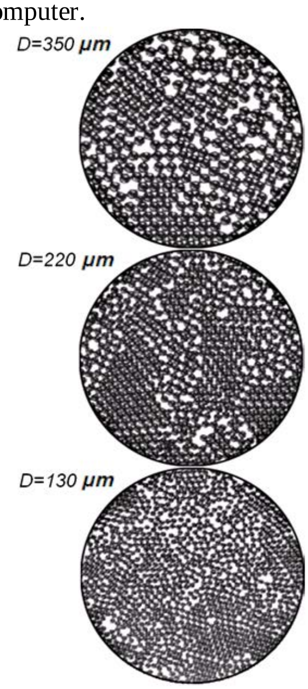

Fig. 4. Photo of granules from steel with a granules diameter from 130 to 350 µm

Monitoring over the jet disintegration on drops develops by means of observation system, strobotac of ST-MPEI and a digital television camera of CD (PixelFly firm “Pro.imaging”). Strobotac provided illumination of the jet and drops short light pulses (with durations of 1 µs.). Start of strobotac was carried out by a signal with a frequency, the synchronous signal frequency, given on the drops generator. The digital television camera of CD was used for fixing of the processes of formation of drops.

For pumping of the heat-exchanging chamber the pumping system was used before filling with helium.

2. THE EXPERIMENTAL RESULTS

By means of the experimental installation were received the monodisperse granules from different metals (Pb, Sn, Sb, Zn, Al, Cu,Ag,Au, Nd and steel). Diameter of granules is from 30 µm to 1.5 mm. Dispersion by the granules diameter is 1…2%. The granules have the spherical form. The coefficient of nonsphericity doesn't exceed 1%. As an example the photo of granules from steel with a granules diameter from 130 to 350 µm is provided in Fig. 4. For the accelerated cooling of drops the external part 4 of the heat-exchanging chamber 5 was filled with liquid nitrogen (see Fig. 2).

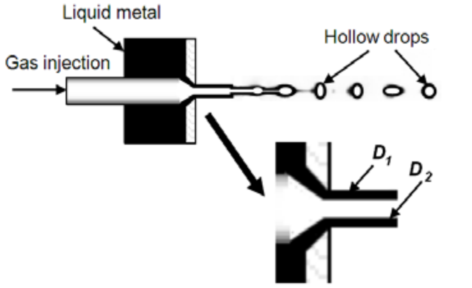

Fig. 5. The scheme of receiving hollow drops

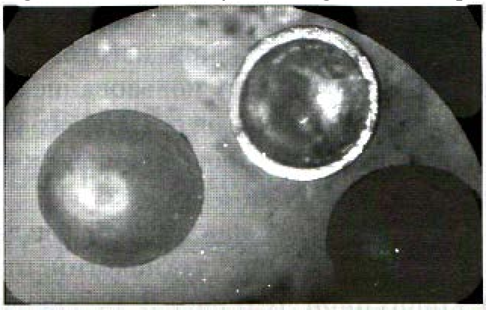

Fig. 6. Photo of hollow copper granules

Experiments on receiving the hollow granules were conducted. The crucible was specially made for this purpose. The exit orifice of the crucible was provided by two coaxial holes. The molten metal jet followed through an external hole, and gas was injected into a jet through an internal hole. The scheme of receiving hollow drops is shown in Fig. 5.

The metal and gas expenditure is defined experimentally at the jet disintegration into hollow monodisperse drops. Photo of hollow copper granules with outer diameter of 1.4 mm and wall thickness of 30 µm are shown in Fig. 6. Dispersion of the hollow granules on diameter, wall thickness and nonsphericity is 1…2%.

CONCLUSIONS

Thus, the developed experimental installation allows to receive the continuous monodisperse metal targets from different metals and their alloys with a melting temperature to 1600°C. Dispersion on diameter of targets is 1…2%. Besides, stimulated capillary disintegration of jets can be used for receiving hollow metal targets. Dispersion of hollow granules on diameter, wall thickness and nonsphericity is 1…2%.

Experiments showed that the main problems of receiving metal targets consist in receiving a melt jet.

With high temperatures there can be an erosion of crucible material because a melt interact to a crucible material. Therefore it is necessary to select the crucible material stable to melt influence in each case.

When receiving thin jets with diameters of smaller 10 µm, there is an additional problem in filtration of a melt from solid impurity.

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НОВЫЙ ТИП МЕТАЛЛИЧЕСКИХ МИШЕНЕЙ

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В настоящее время наиболее бурно развиваются технологии, в основе которых лежит взаимодействие высокоинтенсивных пучков с веществом мишени. В качестве мишени можно использовать новый тип металлических мишеней – монодисперсные металлические мишени. Основные преимущества нового типа мишеней: не требуется охлаждения мишени; нет наведённой активности: мишень можно использовать много раз; малый разброс по скорости, размеру и точке взаимодействия с пучком. Основу мишени составляет струя расплавленного металла, вытекающая в вакуумную камеру. Под действием специального возмущения, накладываемого на жидкую струю, струя распадается на одинаковые капли. В вакуумной камере капли замерзают и становятся твёрдыми гранулами. Монодисперсные металлические мишени можно получать из различных металлов, сплавов и солей (диаметр мишеней от 30 мкм до 1,5 мм). Дисперсия по размерам и скорости меньше 1%. Можно получать не только сплошные мишени, но и полые мишени с дисперсией по толщине стенки в пределах 1…2%.

НОВИЙ ТИП МЕТАЛЕВИХ МІШЕНЕЙ

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В даний час найбурхливіше розвиваються технології, в основі яких лежить взаємодія високоінтенсивних пучків з речовиною мішені. Як мішень можна використовувати новий тип металевих мішеней – монодисперсні металеві мішені. Основні переваги нового типу мішеней: не потрібне охолоджування мішені; немає наведеної активності: мішень можна використовувати багато разів; малий розкид за швидкістю, розміром і точкою взаємодії з пучком. Основу мішені складає струмінь розплавленого металу, витікаючий у вакуумну камеру. Під дією спеціального обурення, що накладається на рідкий струмінь, струмінь розпадається на однакові краплі. У вакуумній камері краплі замерзають і стають твердими гранулами. Монодисперсні металеві мішені можна отримувати з різних металів, сплавів і солей (діаметр мішеней від

30 мкм до 1,5 мм). Дисперсія за розмірами і швидкістю менше 1%. Можна отримувати не лише суцільні мішені, але і порожнисті мішені з дисперсією за товщиною стінки в межах 1…2%.