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DETERMINATION OF VISCOSITY FOR METAL POWDERS

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ABSTRACT

Foams and other highly porous materials with a cellular structure are known to have many interesting combinations of functional and structural properties. The foam production methods can be classified according to the state of the raw materials. The metal foam can be produced from a liquid metal, powder metal, metal vapour and metal ions [1]. This work is focused on a production of metal foams by the SRFS-Process. The SlipReactionFoamSintering (SRFS)-Process is a powder metallurgical method for producing open-cell metallic foams. Advantages of this method are foaming at room temperature, allowing very good process control by various parameters, a wide range of matrix materials is applicable and pore structure can be precisely adjusted. The basis of the method is a metal suspension. For the metal suspension fine metallic powders are mixed with dispersant, solvent and concentrated phosphoric acid [2], [3]. The aim of this project is the measurement of the viscosity of the metal powder. For this experiment two types of iron base powder were used: NC 100.24-sponge iron and ASC 100.29-water atomized powder.

Keywords: metal foam, SRFS-Process, metal powder

1. INTRODUCTION

Experimental work is consisted from a determination of viscosity for the two types of powders. The viscosity is mainly influenced by the powder parameters and the solvent. The most important powder parameters are morphology, flowability, apparent density, particle size distribution etc. The mixing process is an important part of the SRFS-Process. The mixing time could influence on the viscosity and in accordance with that, the samples were tested for non-constant and constant shear rate for 4 and 30 minutes, respectively.

2. EXPERIMENTAL WORK

The viscosity of the metal powders in this experiment was determined by the rotational method. The Fig. 1 shows the apparatus was used for viscosity testing. The test samples were continuously shared between two surfaces, in the rotational method. The cylindrical surface was static and "the paddle" which was rotating. The viscometer "Rotovisco RV3" measures the shear stress in Skt units (not in Pascal units). Standard constants are given by the suppliers for each a rotating part. Thanks to these constants it is possible to calculate the viscosity in Pa x s units (Pascal second units). For needs of this experiment a special rotating part was manufactured. The standard rotating parts can not used for fluid tests with a high amount of solid materials. Since, it is not a standard part of the viscometer; it was not possible to calculate a shear stress in Pa (Pascal) unit. It means that a viscosity values are given in Skt x s units (Skt seconds units). The aim of this experiment was more to determine a qualitative behavior of the metal powders during viscosity testing and therefore the shape of flow curves was enough for conclusions about powder behaviour. Four samples were tested for each powder (sample weight 50 g).

Figure 1. The viscometer "Rotovisco RV3" by HAAKE, [4]

It was not possible to take more voluminous sample because with increasing the mass of sample, the rotating part could not be able to rotate.

3. RESULTS AND DISCUSION

Fig. 2- 3 present the flow curves of the viscosity measurements for ASC 100.29 and NC 100.24 powders. During the viscosity test, the shear rate was increased from 0 to 300 min^{-1} within 2 minutes than decreased to 0 min^{-1} within the same time. For this apparatus, it is possible to control a curve damping from 1 to 10. The curve damping of 2 was chosen. A small damping factor was taken, because even small changes in the shear stress should be pointed out, during the measuring. The figures show, that the influence of the powder production route on viscosity is very important. The water atomized ASC 100.29 powder has a lower viscosity than NC 100.24. The more regular morphology of the ASC 100.29 powder decreases the friction between particles and this result in lower viscosity. The almost spherical shape and smooth surface of particle decreased a friction between particles and decrease viscosity. The friction does not influence only on the behavior. During the mixing, the particles are twisted by impact between each others. The movement is higher if the particles are more irregular and cliffy. This is probably one of the reasons why the curve does not have the linear form on the beginning of measurement. At higher shear rate, the powder starts to flow in laminar layer. The curve has a linear form. The shear stress is visible decreased for NC 100.24 in the area of 150 min^{-1} and a behavior in a line form shows after that. The NC 100.24 powder has the flat shape. It oriented into the flow direction by the shear rate of 150 min^{-1}. The particles pass between the rotating part and the wall of cylinder without the inhibition. From that point energy is less dissipated and the particles start to laminar flow. For the ASC 100.29 powder, there is the same behavior, only the characteristic point of transformation is not so much distinctly. The characteristic point is different because the NC 100.24 powder is more flat than the ASC 100.29 powder.

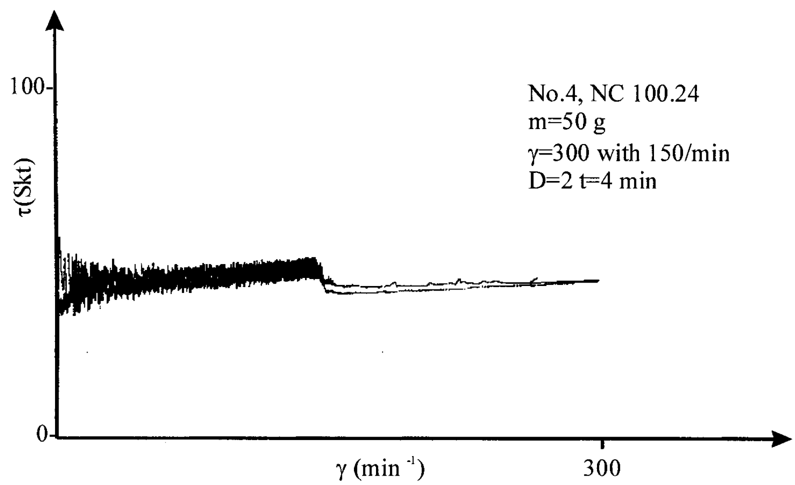

Figure 2. Flow curve of the sample No.4 for NC 100.24 powder, the non-constant shear rate, [4]

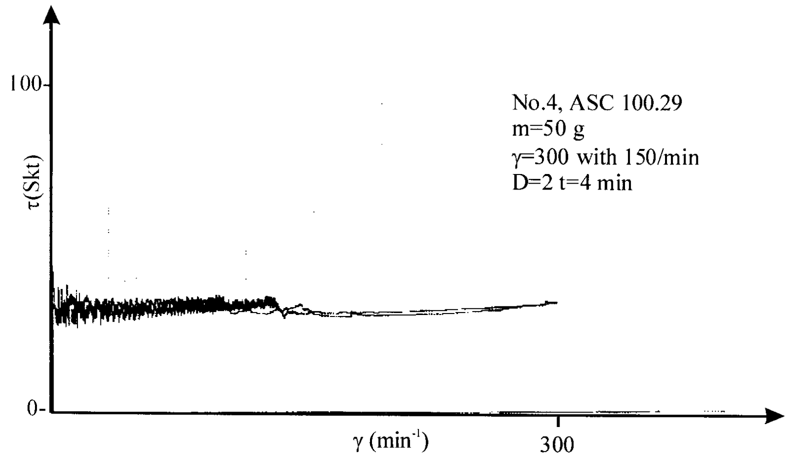

Figure 3. Flow curve of the sample No.4 for ASC 100.29 powder, the non-constant shear rate, [4]

Chemical or physical changes in the sample can be tracked with measurement of the viscosity with a constant shear rate for a longer time period. The test was consisted of applying a constant shear rate for 150 min^{-1} and monitoring for 30 minutes. On this way it is possible to determine a phenomena like chemical reaction, sedimentation etc. The next figures prove that the water atomized powder has lower viscosity than the iron sponge. During the viscosity measuring for 30 minutes it can not be noticed big changes, except the friction between particles, Fig 4 - 5. The particle size is decreased by friction and increased by agglomeration.

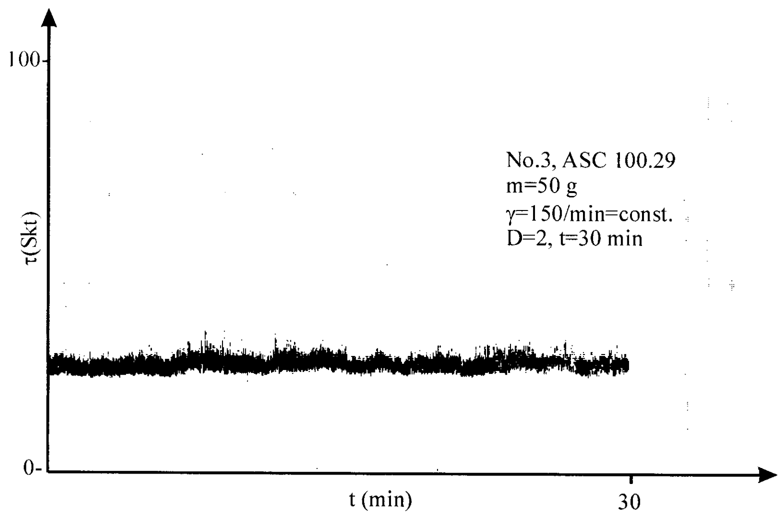

Figure 4. Time curve of the sample No.3 for ASC 100.29, the constant shear rate, [4]

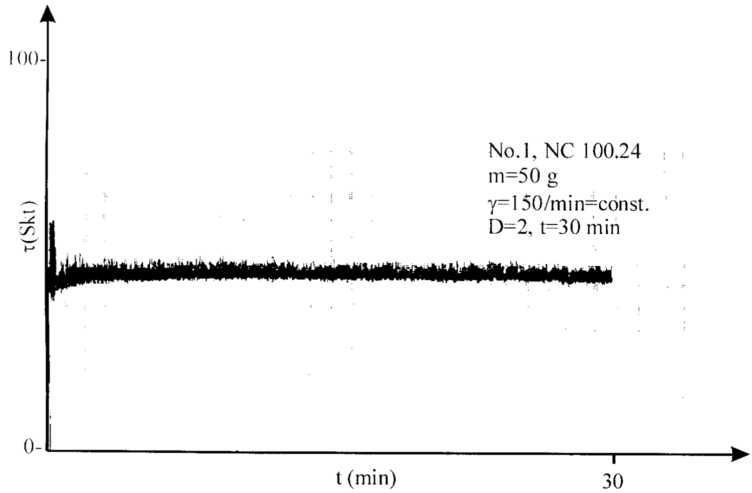

Figure 5. Time curve of the sample No.1 for NC 100.24, the constant shear rate, [4]

4. CONCLUSIONS

The SRFS process is the new method to produce the open-cell metal foams. This process has some advantageous such as the production on room temperature, the various metal and alloys could be used etc. It is possible to adjust the density of the foam and the pore form through several process parameters. The viscosity is one of the process parameters, very important in the production of metal foam. The pore structure and homogeneity are depended by the viscosity. The influence of the powder production route is very important for the viscosity. The water atomized powder has a lower viscosity than the iron sponge. According to the shape of flow curves, a metal powder belongs to the group of Non-Newtonian Fluids and is described as Bingham plastic. The certain amount of force is needed for the metal powder to start a flow. This force is called the yield stress [4].

Acknowledgements

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