Small Sample Volumes at High Shear Rates: The Mooney Ewart Geometry

Claire Strasser and Senol Gezgin, Applications Laboratory Selb

Introduction

The diverse range of measurement geometries, available with the Kinexus rotational rheometer, enables rheological characterization of a wide array of materials across various applications.

Some applications require small volumes, for example, in the pharmaceutical industry, where materials are often expensive and tested on limited quantities. This limited sample volume can be associated with applications, requiring high shear rates, for example, for spraying.

Mooney Ewart System

The Mooney Ewart system (figure 1) is a special cup-and-bob geometry used for applications which combine small sample quantities with high shear rates. The sample is placed into the annular gap between two cylinders of defined geometry. While the outer cylinder (cup) is stationary, the co-axial inner cylinder (bob) rotates at a defined speed. The gap is smaller than for other cup-and-bob systems. That has two advantages:

- Higher shear rates can be achieved
- Lower sample volumes are required

1 Mooney Ewart geometry

Measurement Conditions

In the following, measurements performed with a cone-and-plate geometry and with the Mooney Ewart system are compared. The material tested is a silicone oil with known viscosity.

Table 1 Measurement parameters

Geometry	CP1/40 (cone/plate, cone: 1°, Ø: 4 mm)	Mooney Ewart: 0.5 to1 ml
Temperature	25°C	
Shear rate	1 to 10,000 s^{-1}	

NETZSCH-Gerätebau GmbH
Wittelsbacherstraße 42 · 95100 Selb · Germany
Phone: +49 9287/881-0 · Fax: +49 9287/881505
at@netzsch.com · www.netzsch.com

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Measurement Results

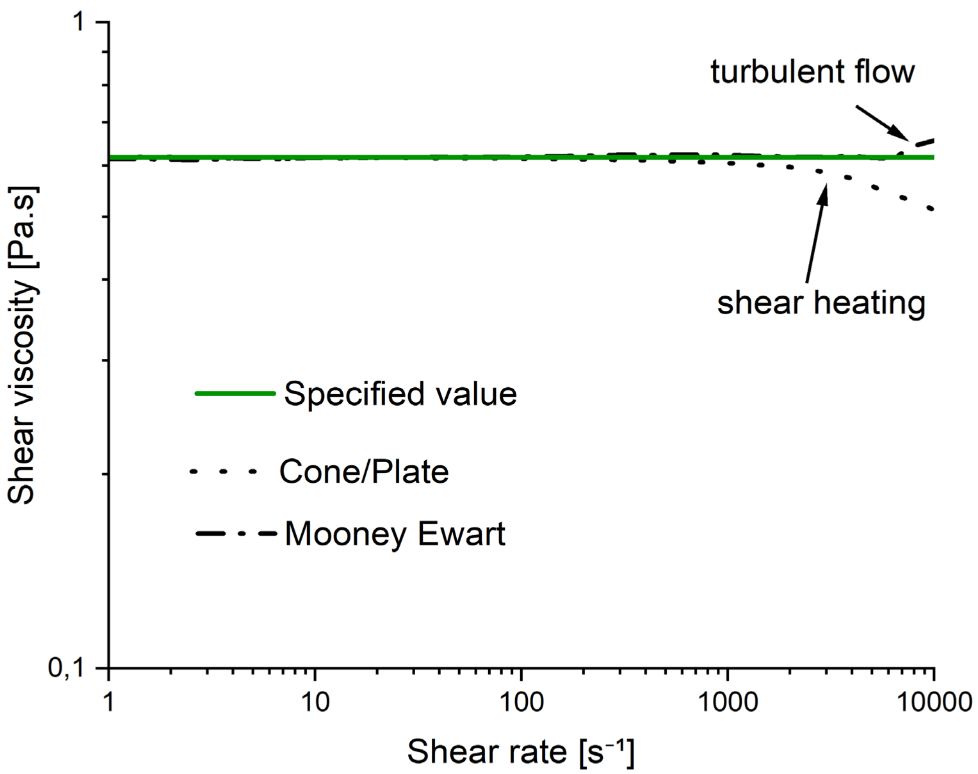
Figure 2 depicts the resulting shear viscosity curves of the two measurements compared to the expected curve of the silicone oil. In the shear rate range up to 1,000 s-1, both measurements yield the same shear viscosity values (difference between measured and specified value lower than 2%).

After that, the shear viscosity curve obtained with the cone/plate geometry indicates shear-thinning behavior. This is due to the temperature increase of the sample caused by shear heating. In contrast, the curve obtained with the Mooney Ewart system further reflects the expected Newtonian behavior of the sample. Beginning at 6,300 s^{-1}, the laminar flow becomes instable due to centrifugal forces, resulting in secondary flow (Taylor vortex). This leads to an apparent increase in shear viscosity.

This comparison of the shear viscosity curves recorded with the two geometries demonstrates the expanded shear rate range achieved using the Ewart Mooney system as compared to that achievable with the cone/plate geometry.

Conclusion

Rheological measurements in a cone/plate system are generally limited to a specific shear rate range due to gap emptying at high shear rates. Applications related to higher shear rates require another method, for example the Rosand capillary rheometer. Here, shear rates up to 1,000,000 s^{-1} are possible. However, they require a larger amount of material. A solution for expanding the shear rate range for low sample volumes is to work with the Ewart Mooney system in the Kinexus rotational rheometer.



2 Silicone oil. Shear viscosity curves measured with a cone/plate system versus with the Mooney Ewart geometry.

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at@netzsch.com · www.netzsch.com