APPLICATION **NOTE**

# Demonstrating the Performance of the ARC® 254 Magnetic Stirring Device

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1 NETZSCH ARC® 254

## Introduction

The NETZSCH ARC® 254 (fig. 1) is an accelerating rate calorimeter capable of carrying out so-called thermal runaway tests and worst-case scenario tests. The objective of this measurement technology is to find the hazardous potential with respect to temperature of a sample or reaction mixture under adiabatic conditions. Adiabaticity in particular means 'without any heat exchange'. If all the heat of reaction remains inside a reaction vessel and is not able to dissipate heat to the environment, the temperature is going to rise and thus the speed of reaction will increase. This will result in a self-accelerating reaction mechanism. As soon as this scenario is studied or known, all real-word conditions, which are usually not fully adiabatic but rather exhibit heat losses to the surrounding, can be calculated and classified.

If samples need to be mixed, a magnetic stirrer can be used. Mechanical stirring devices would, of course, also be an option, and would most probably be more powerful. However, a mechanical connection into the sample vessel (figure 2) would act as a heat pipe and thus reduce the quality of an adiabatic sample environment. Magnetic stirring is a good compromise, but it is difficult to predict how effective stirring will be, especially since it is not possible to have a look inside the vessel. The vessel material must be pressure-tight and resist fast pressure changes; therefore metals, especially titanium, are usually the material of choice.

2 Sample vessel inside the NETZSCH ARC® 254

NGB · Application Note 205 · DE · 0321 · Technical specifications are subject to change.



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3 NETZSCH Kinexus rotational rheometer

## Measurement of the Viscosity of Three Polyglycol Samples

In order to estimate whether or not a liquid or chemical reaction mixture will be properly mixed, the viscosity is a good measure. The viscosity describes the flow behavior of a liquid. The higher the viscosity, the higher the resistance to flow.

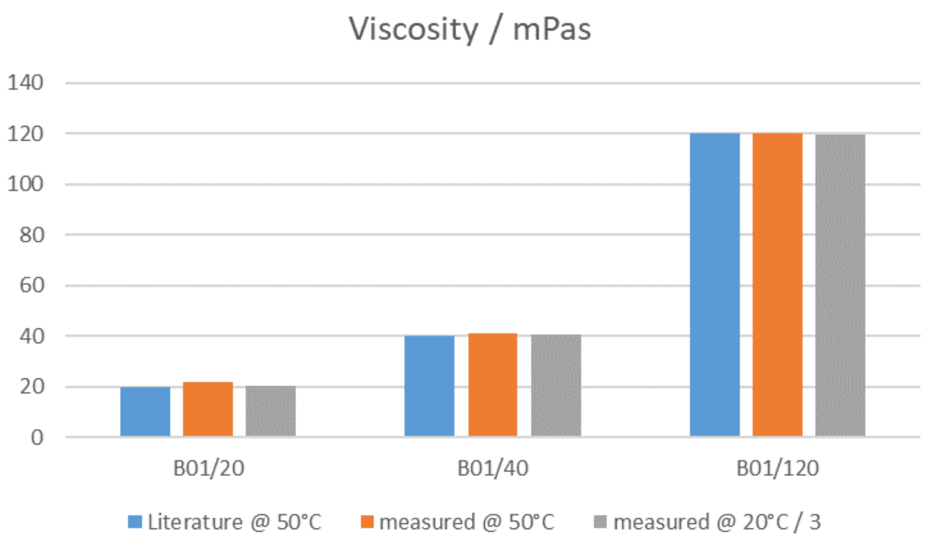
Dynamic viscosity is given in the SI unit Pa·s and is usually compared with the property of water at 20°C with 1.0 mPa·s.

Three polyglycols (polypropylene glycol mono bythyl ether with different viscosities were tested in order to determine the force of the magnetic stirring device inside the NETZSCH ARC® 254. Since viscosity is a temperature-dependent property and literature values for viscosity of the polyglycols were only available for 50°C, the corresponding viscosity values at 20°C and 50°C were tested using the NETZSCH Kinexus rheometer. The measured values at 50°C are in good agreement with literature values.

**Tab 1.** Measurement conditions of the Kinexus measurements

| Kinexus Measurement Configuration | |
|---|---|
| Upper geometry | Parallel plate with 40-mm diameter |
| Lower geomtery | 65 mm lower pedestal |
| Measurement gap | 0.5 mm |
| Measurement parameters | Table of shear rates |

On the other hand, the strong temperature dependency of the viscosity was confirmed when changing the sample temperature from 50°C to 20°C. The difference of just 30 K in temperature triples the viscosity values for all three samples as depicted in figure 4.




4 Comparison of the results for viscosity for three polyglycols measured with the NETZSCH Kinexus rotational rheometer. For better comparison, all values at 20°C (grey) are divided by 3.





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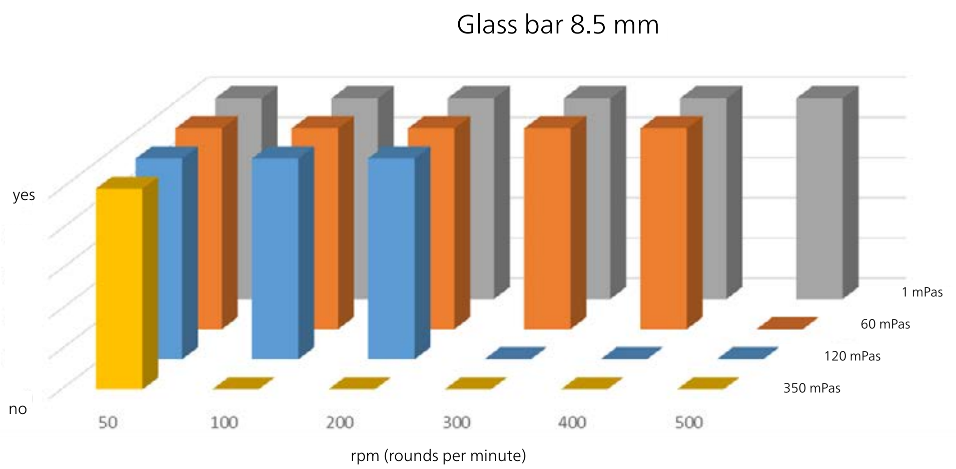
## Magnetic Stirring Performance

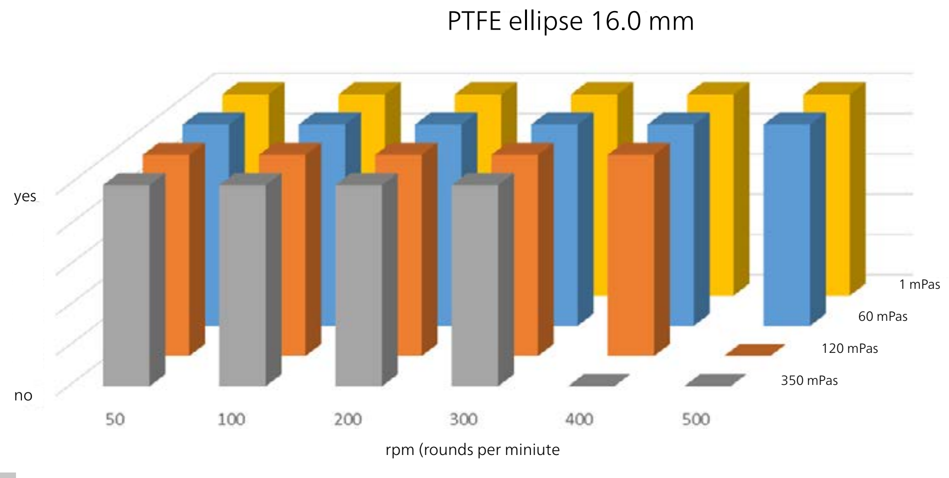
The efficiency of the magnetic stirring device was investigated using two types of vessels: one having the standard dimension of 8 ml (Ø = 2.54 mm), and one having the large dimension of 130 (Ø = 60 mm). For standard thermal runaway test, the vessels made of metal as described above have to withstand the pressure build-up from the decomposition reaction. That's why vessels made of glass are an exception, but here, of course, they were used in order to see whether or not the stirring bar is moving. Each time, the vessel was filled with polyglycol to the equator level of the spherical vessel. Various dimensions and shapes of stirring bars were tested, including glass-covered and PTFE-coated stirring bars; also, various rotation speeds were applied. All results can be found in the manual; some results are summarized in figures 5 and 6, where ‚yes' means, stirring with that speed is possible and ‚no' means, stirring with that speed is not possible.

## Literature

[1] BYK-Chemie GmbH, Wesel, Germany
[2] Manual NETZSCH ARC 254




**5** Efficiency of stirring inside the ARC® 254 using different media and varying rotation speed for a glass-coated stirring bar of 8.5 mm




**6** Efficiency of stirring inside the ARC® 254 using different media and varying roation speed for a PTFE-coated, ellipsoid-shaped stirring bar of 16 mm





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