On-Line Viscosity Measurements of Sugar Syrup at Two Concentrations using a Rotational Viscometer

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On-line viscometers have the advantage of circumventing the need to remove samples from the process. However, the comparison of their output signal to the viscosity measured in a viscometric flow is not straightforward[1]. On-line measurements require a flow past the measurement sensor which is not usually present in off-line viscometers. Some aspects of on-line measurements in the food industry are discussed by Wiklund (2003)[2].

This paper reports initial comparison measurements of the viscosity of two Newtonian syrup solutions using three different techniques. Measurements using a batch concentric-cylinder viscometer, a commercial on-line rotational viscometer and a pipeline viscometer are compared. A pilot plant unit was constructed to enable us to conduct these studies.

The aim of these preliminary experiments was to determine whether we were able to obtain comparable viscosity values using the three different techniques.

Many food products have some elasticity, and also are shear-thinning rather than Newtonian. However, to avoid these complications in our initial experiments, we used a Newtonian syrup. The base syrup was 81 % by weight dry matter, composed of 33 % w/w fructose and 48 % w/w glucose syrup (Skaelskoer Frugt Lys Sirup, Scandic Food Slagelse, Denmark). The working fluid was made by diluting the base syrup with warm deionized water to prepare syrups of 63% w/w and 69% w/w dry matter, with viscosities of about 170 mPas and 500 mPas, respectively, at 20^{o}C. A Stress-Tech rheometer (Reologica AB, Sweden) was used for off-line measurements, all conducted at 20^{o}C. The on-line rotational viscometer used in the study was a PV100-DM64(DN40) from Rheotec Messtechnik GmbH, Ottendorf-Okrilla, Germany, using rotational measuring head MH16 and continuous flow cup MS-ZP2. The inner cylinder was stationary while the outer cup rotated. The gap that defined the shear rate was 2.25 mm for the arrangement. The stated measuring range was 0.02 to 100 Pas, which was suitable for the syrup we were using.

The viscosity was also measured using a pipeline viscometer that could be fitted with one of three exchangeable pipe diameters. The pipes used for pressure drop measurement were stainless steel for dairy usage with surface roughness of at most 0.8 microns for the smooth pipe and 1.6 microns for welds. The differential pressure transducer (Moore 340 XTC Transmitter Controller, Siemens, Somerset, UK) measured pressure differences in the range 0.025 to 1.12 bars. The measurement required connecting flexible rubber tubing (6 mm inner diameter) from the two outlets on the exchangeable tube to the transducer; these lines were completely filled with the syrup during the experiments.

The signal from the rotational viscometer was stable for volumetric flow rates of product in the available range of between 360 and 1800 litres/hour. The signal was slightly lower when the viscometer was filled with product but with no flow through the viscometer. The instrument had eight different speed level settings to choose among, depending on the viscosity of the product. The output signal did depend on these settings; the highest signal was measured for the same product when using the fastest rotational speed. Our further results will be presented at the conference.

ACKNOWLEDGMENTS
The authors are thankful to Nancy Kjøbæk, Peter Stubbe, Preben Bøye Hansen, René Thrane, Peter Meinke, and Søren Linke for sharing their expertise in the design, construction, instrumentation, and operation of the pilot plant rig and for assistance with the off-line experiments. We thank Mogens Nybing from Sentek (Glostrup, Denmark) for arranging for us to borrow the rotational viscometer. This study was funded by LMC, the Center for Advanced Food Studies, Denmark.

REFERENCES

1. Zimmer, L.A. Haley, T.A. and Campanella O.H. (2001), "A comparative study of the performance of selected in-line viscometers on Newtonian and shear-thinning fluids", *Journal of Texture Studies,* **32**, 75-103.

2. Wiklund, J. (2003), "Rheological in-line techniques based on ultrasound Doppler methods for the food industry - a literature survey", SIK - the Swedish Institute for Food and Biotechnology, SIK-Report SR-710, 142 pages.