Application Note
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Correlation of misting during printing with extensional rheological investigations on offset printing inks with the HAAKE CaBER 1

Key words:

- Coating
- Elongational viscosity
- Misting
- Offset printing ink
- HAAKE CaBER 1

Rheology Application Notes

Dr. Eberhard Pietsch
Thermo Fisher Scientific, Germany

Abstract

The tendency for misting on offset printing inks was examined on two samples using the rotational rheometer HAAKE RheoStress 600 and the extensional rheometer HAAKE CaBER 1.
The results for the amplitude and frequency curve, the creep and recovery test and the flow curve measurement with the rotational rheometer do not correlate with misting during printing.
With the rotational rheometer, it was possible with the aid of the filament break-up time to easily and quickly draw distinctions between different tendencies for misting with offset printing inks.

Introduction

Offset printing is the most widely used method in the printing industry. A thin film of printing ink is applied onto the printing form via a system of rollers. In one hour, it is possible to print approximately 10,000 sheets using this method. Factors that are crucial to printing quality include the printing inks used with regard to their wettability, gradation, sheen and drying.
Offset printing ink consists of the 3 components pigment, binding agent and additives. It is a suspension with complex rheological properties that are influenced by the components used.
In the printing process, it is required that smooth and sharply defined tear-off edges are obtained and that scumming (misting) of the ink is avoided. When the ink is transferred to the printing plate and when the latter is moistened, water droplets are formed in the printing ink. When there are such droplets in an ink string that forms in the gap between the printing roller and the rubber blanket, the ink can spray.
In practice, relative terms such as stickiness (short, long) and rigidity are often used to describe the properties of a printing ink. In addition, besides rheological variables the tack value (stickiness) is defied as a relative value. A forecast regarding the tendency of printing inks to foam and to spray is desirable for ink development and for their use in the printing machine.

Material and methods

Two offset printing inks were examined at a temperature of 40°C with regard to their tendency to mist. The inks were available in their unmodified (sample A) and modified form (sample B). The rotational rheometer HAAKE RheoStress 600 with air bearings permits all the usual rheological examinations such as flow curve measurements, flow limit measurements, creep and recovery, deformation jump and oscillation tests, as well as normal force measurements.

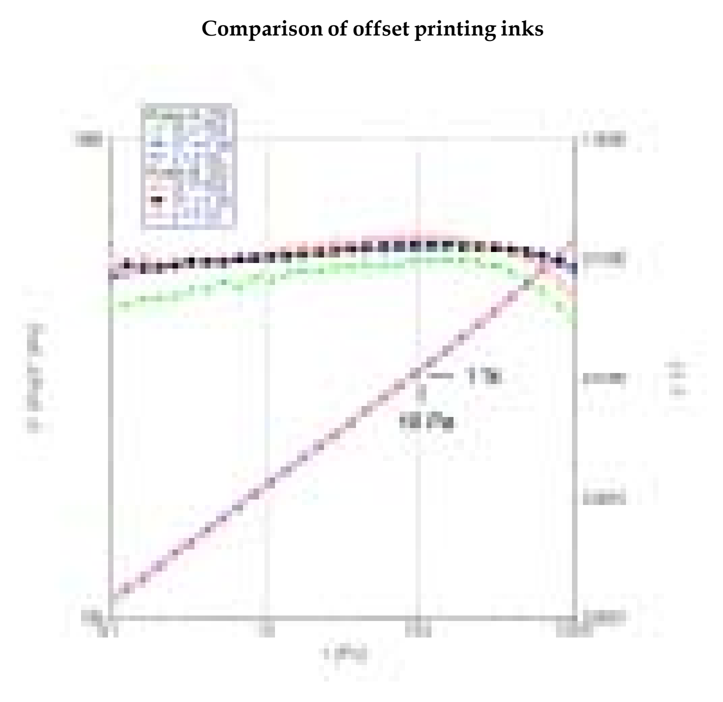

Figure 1: Amplitude curve in CS mode

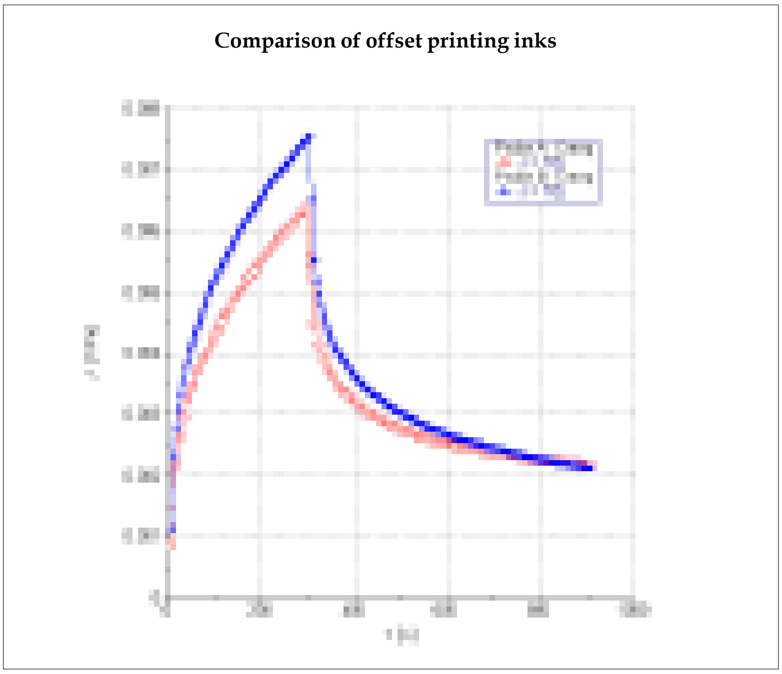

Figure 2: Creep test curve of the compliance J(t) in the creepage phase (t = 1 Pa) and in the recovery phase (t = 0 Pa)

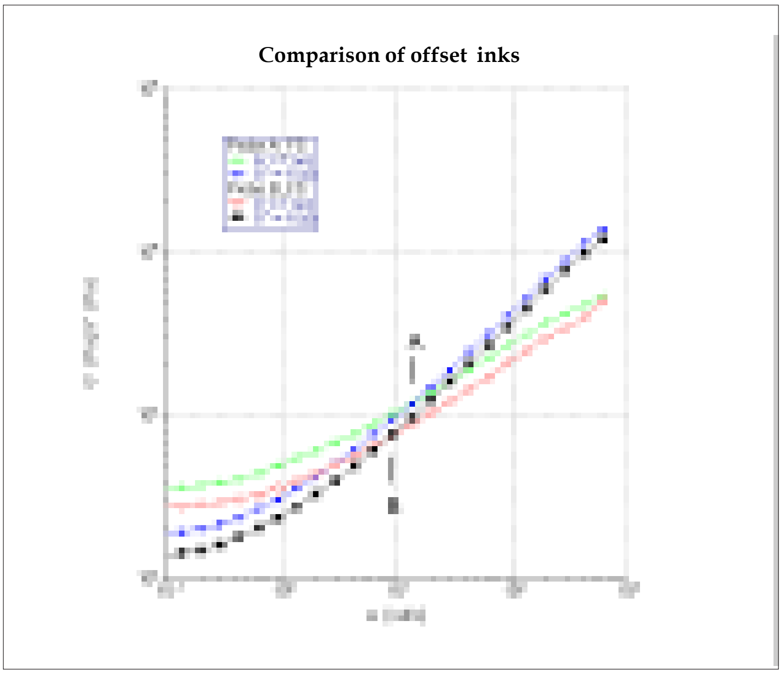

Figure 3: Frequency curves of the storage modulus (open symbols) and loss modulus (closed symbols)

A cone/plate measuring unit consisting of a Peltier temperature control unit and measuring cone C35/1° was used. Rheometer control and evaluation of the measured data were performed with the software HAAKE RheoWin.

Using the extensional rheometer HAAKE CaBER 1, a low sample volume of 6 mm diameter and 3 mm height was extended to a height of 10 mm by way of abrupt extension (50 ms). An extension flow formed for a short time in a liquid. The reduction in the filament diameter up until the point of breakage was measured as a function of the time (1, 2).

Rotational rheometer results

An amplitude sweep measurement was carried out first in the oscillation mode with a defined shear stress (CS) in order to determine the linear-visco-elastic range (LVB). Two minutes was selected as the temperature adjustment time. There was no noticeable difference between the two samples (Figure 1). For measurements within the LVB, a shear stress of 10 Pa and a deformation of 1% should not be exceeded. The slight rise in the storage and loss module indicates that the sample was still relaxing during the measurement.

A creep and recovery test was carried out in the next step. The temperature equilibration time was two minutes. The applied shear stress of 1 Pa was held for a period of 300 s and the recovery was observed. Clear differences were apparent between the two samples (Figure 2; Table 1).

The modified sample B has a greater elastic deformation and recovery at low shear stresses. The zero viscosity η_0 is almost the same on both samples, However, there are different retardation times λ_i. These results are relevant to all stages in the printing process that occur at low shear stresses, for example the gradation of the ink after printing. In addition, the necessary information is obtained about how long it is necessary to wait after the sample filling until the start of the measurement, and also the necessary measurement time for the creepage and recovery phase. Three times the recovery time – in this case approx. 20 to 30 minutes – applies as a rule of thumb.

In another measurement, the reaction to different excitation frequencies was examined with a frequency sweep for both samples. This measurement was performed in the linear visco-elastic range (LVB) with a deformation of 1%.

The curves for both samples are similar (Figure 3). They show the typical pattern for offset printing inks. For slow stresses, the storage modulus G’ is much bigger than the loss modulus G”, and in this range the samples are extremely elastic. The loss modulus G” predominates for rapid stresses, and the viscous component prevails. The intersection point of G’ (w) and G” (w) – also designated as the crossover point – represents a characteristic variable in the frequency curve (Table 1).

For sample B, the crossover point is at a lower cycle frequency w and the module values are lower. The sample is „softer“. This could be an indication of reduced mist formation.

Table 1: Zero viscosity η_0, retardarion time λ_i, crossover modulus and crossover frequency

	Probe A	**Probe B**
η_0 [Pas]	118.000	117.000
λ_i [s]	460	590
$G_C' = G_C''$ [Pa]	1194	731
ω_C [rad/s]	13.8	8.5

However, the deformations occur in the roller gap outside the LVB, while the measurement was made inside this range.

In the rotation test, the flow curves of both samples were measured (Figure 4). Here, problems arose through the gap emptying at high shear speeds and through shear heating at high shear speeds. At a shear speed of 140 s^{-1}, the viscosity curves display only a slight difference. For sample A, the interpolation provides with 14.3 Pas a slightly higher (dynamic) viscosity than for sample B at 12.7 Pas. This means that no clear sample differentiation is possible with regard to the question „misting during printing“.

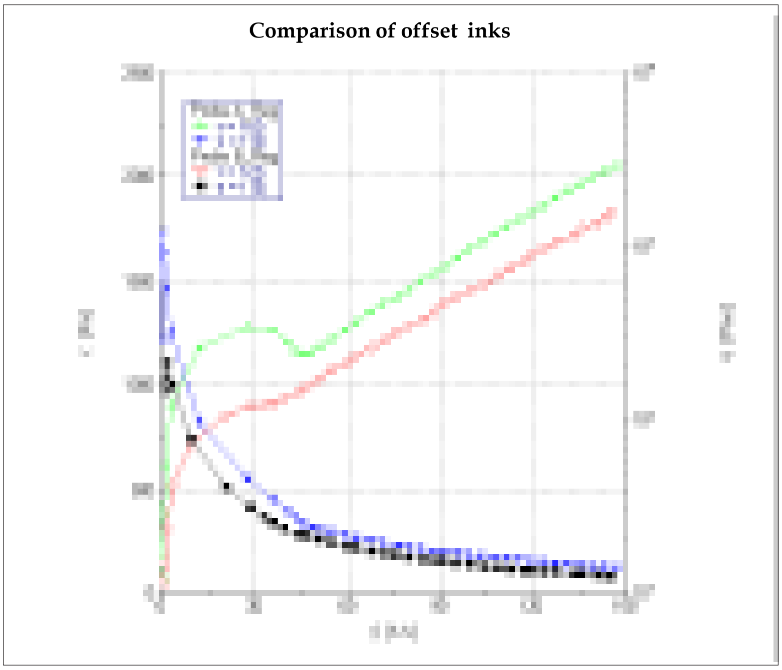

Fig. 4: Rotation test-breakage curve (open symbols) and viscosity curve (closed symbols)

Extensional rheometer results

Figure 5 shows semi-logarithmically the decrease in the thread diameter referred to the starting diameter for sample A and sample B over the period up until breakage. Three repeat measurements were performed in each case, with a slight scatter in the filament break-up times. The reason for this was the type of sample filling and different waiting times up until the measurement. However, great differences can be found in the average thread breakage time between sample A at 148 seconds and sample B at 33 seconds. Due to the significantly longer thread breakage time, sample A tends to mist formation, while sample B displays this tendency less.

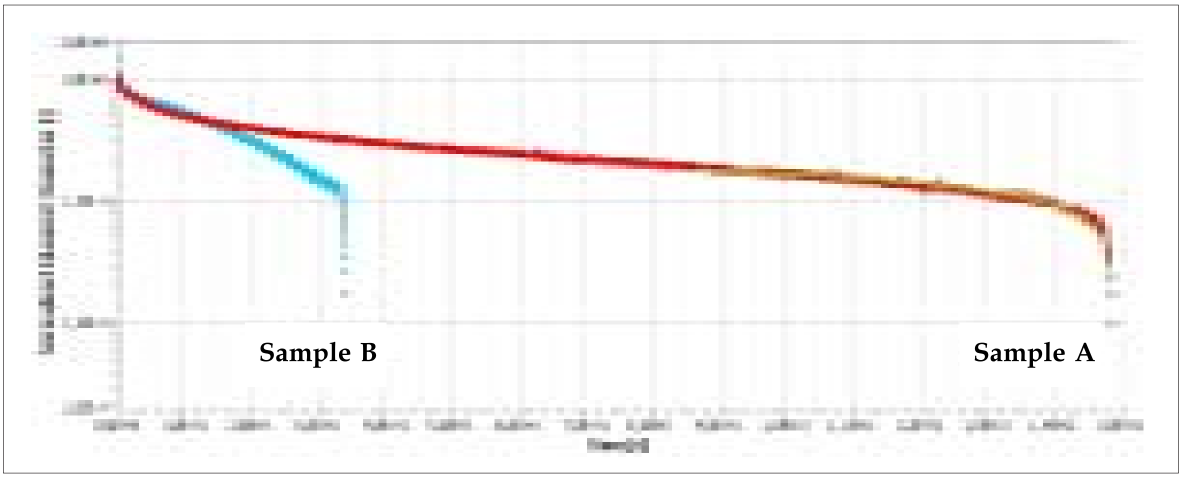

Figure 5: Decrease in the relative filament diameter

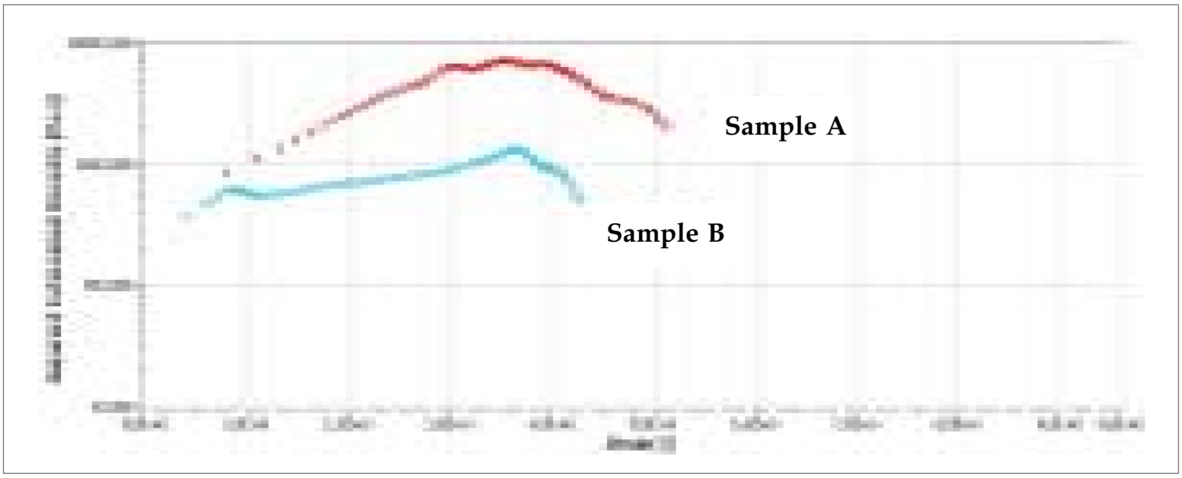

Figure 6: Apparent extensional viscosity as a function of the extension

A great difference between both samples can also be found in the apparent elongational viscosity that can be calculated with the aid of model assumptions (Figure 6)., where sample A displays a value up to 10 times greater than sample B.

Summary

The tendency towards misting with offset printing inks could be differentiated quickly and easily by measuring the filament break-up time on two samples with the extensional rheometer HAAKE CaBER 1. With a high-performance rotational rheometer, a differentiation with regard to this criterion was not possible with any clarity, even with comprehensive rheological measurements.

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Thermo Fisher Scientific
Process Instruments

International/Germany
Dieselstr. 4,
76227 Karlsruhe
Tel. +49(0)721 40 94-444
info.mc.de@thermofisher.com

Benelux
Tel. +31 (0) 76 5 87 98 88
info.mc.nl@thermofisher.com

China
Tel. +86 (21) 68 65 45 88
info.china@thermofisher.com

France
Tel. +33 (0) 1 60 92 48 00
info.mc.fr@thermofisher.com

India
Tel. +91 (22) 27 78 11 01
info.mc.in@thermofisher.com

United Kingdom
Tel. +44 (0) 1785 81 36 48
info.mc.uk@thermofisher.com

USA
Tel. 603 436 9444
info.mc.us@thermofisher.com

www.thermo.com/mc

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