Application Note #5

Quality of lithographic inks: is it worth to measure physical properties of ink water emulsions?

1. Composition of Litho-inks

Generally lithographic inks exists of a mixture of components with different physical properties, molar masses and chemical reactivity resulting in complex physical-chemical behaviour.

2. A typical litho-ink consists of:

50–60% - Varnish (Resin + Solvent)
10–20% - Pigments
10-20% - Additives

Therefore the varnish mainly determines the physical behaviour of the ink.

3. Conditions for to-day's inks

High running speeds of modern presses require stable physical properties of inks under high temperature and high shear conditions.

Particularly a good transfer on paper and the type of ink drying (coldset, heatset, radiation curing, UV curing) requires special physical properties of modern litho-inks depending on its final use.

4. Origin of misting

At high shear there is a danger of over-emulsification of ink and water resulting in lower structural strength and consequently misting when the centrifugal forces get higher than the internal cohesion strength in the ink.

5. Danger of gloss loss

Physical testing of neat inks is not sufficient to guarantee a good quality print. Stable ink/water emulsion-forming is imperative to maintain good quality and high gloss of the final print.

6. Dot sharpness of print

When the ink/water emulsion touches the paper, it should show instant solidification on the image areas and leave non-image areas clean. Only if the ink/water emulsion forms dots with sharp edges it will result in a high quality print, but over-emulsification may lead to a loss in dot sharpness.

7. Emulsification of litho-inks

Emulsification of a lithographic ink or binder is not a fixed parameter but varies with the operating conditions on the press. Test on a laboratory scale must be carried out near to real conditions, such as high shear rate, controlled temperature, defined water dispension and low evaporation.

8. Testing Emulsification Capacity

For the offset printing process it is important to know how much water can be picked up by the ink under the applied conditions - temperature and shear rate. This property is expressed by the apparent emulsification capacity. Generally higher temperatures and/or lower shear rates reduces the final emulsification capacity of an ink significantly. Low temperatures and/or higher shear rates are causing the opposite. Because of the essential influence of temperature and shear rate these parameter must be controlled exactly for an reproducible water pick up test. The LITHOTRONIC III controls temperature and shear rate in the same ranges as on modern high speed presses – the temperature in a range between 15 to 65°C with an accuracy of 0.2°C and the shear rate in a range from 400 to 6000 s^{-1} with an accuracy of 1 %. The typical resulting torque curve accuracy of one instrument is 1%, the accuracy of measurement results of different instruments is 2%.

The viscosity of emulsions tends to increase slightly compared to the viscosity of the neat ink at low shear rates. At high shear rates both emulsions and neat inks showing a shear-thinning behavior, but emulsions generally present a higher shear-thinning behavior than neat inks. These test have been carried out with headset inks at a rotation speed of 1200 rpm and a temperature of 40°C. At the end of the test, the viscosity decreases rapidly as the emulsion does not absorb the fountain water anymore and the sample rotates on top of a water film. At this point, the emulsion is saturated and the percentage of fountain water compared to the weight of the ink sample is the emulsification capacity EC, so that 100% EC means equal amounts of ink and water in the emulsion.

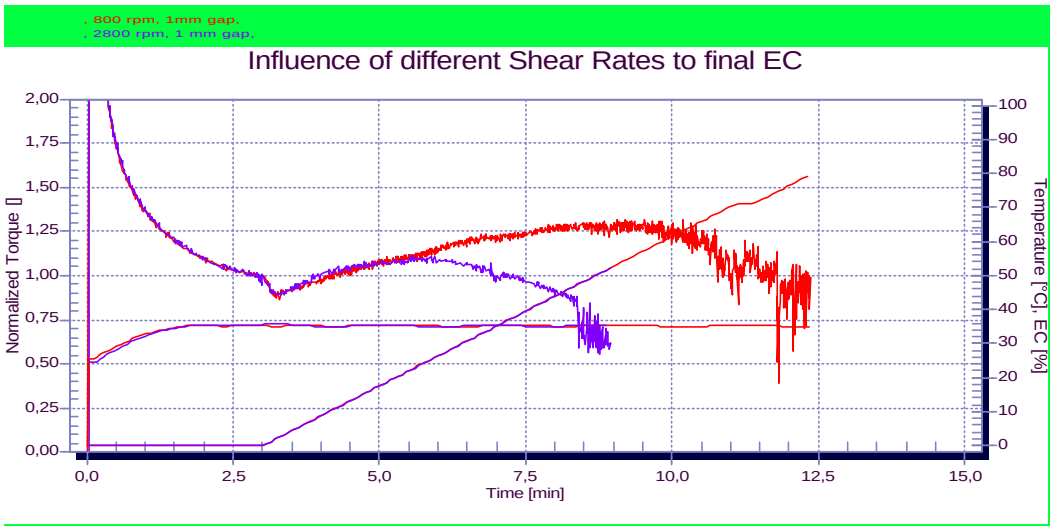

Fig. 1: The same offset ink shows a different emulsification capacity, if the applied shear rate is varied

9. Investigation of Emulsification Stability

In order to determine the droplet size in the emulsion, optical microscopy is not suitable as it is not able to detect submicronic droplets in microemulsions. This also applies to acoustical measurements in which large droplets are causing an audible sound during the test. In the LITHOTRONIC method very fast changes inorque caused by water droplets can be identified. In opposite to a roller driven system the **very small inertia mass of the spindle** and a high speed measuring rate of torque allows the reliable recognition also of minor interfacial effects. These minor changes can be quantified and plotted as standard deviation. Microemulsions with submicronic droplets are showing a low standard deviation and a large standard deviation indicates an instable emulsion with large droplets.

An further point of investigation is the emulsion viscosity versus EC. The measured torque correlates directly with the sample viscosity. The higher torque value is the higher viscosity **under applied high shear** conditions. For optimal process stability a relative independency of viscosity related to EC is desired. The LITHOTRONIC test method offers direct information, how strong the relative change of viscosity is. Unfavourable thickening and diluting effects caused by different fount solution compositions are detected by a strong rising or falling torque slopes.

10. Emulsification Rate Assessment

Higher press speeds imply a shorter time to create a stable ink/water balance on the press, so that it is important to test also the rate of water pick-up of inks. The apparent emulsification rate is one of the most interesting properties of an offset ink. If the pick up rate is too fast problems of water release during the printing process can be expected. If the pick up rate is too low, the emulsification rate doesn't correlates with the printing speed of the high speed presses. In practice a compromise has to be found between these two extremes.

The LITHOTRONIC III offers two methods for emulsification rate assessment. In the linear dispension rate test sudden changes on the curve quantified by the standard deviation are an indication for the rate of water pick up. A higher standard deviation means a slower pick up rate and opposite. By varying the computer controlled fount dosing within a test series the sensitivity of the fount – ink system for this property can be investigated.
The second method is carried out by an automated Surland-test: By dispensing a large amount of water into the cup the torque drops suddenly, because the ink can not emulsify all the water immediately. The time until the torque recovers from this level is an indication for the emulsification rate of the ink under test.

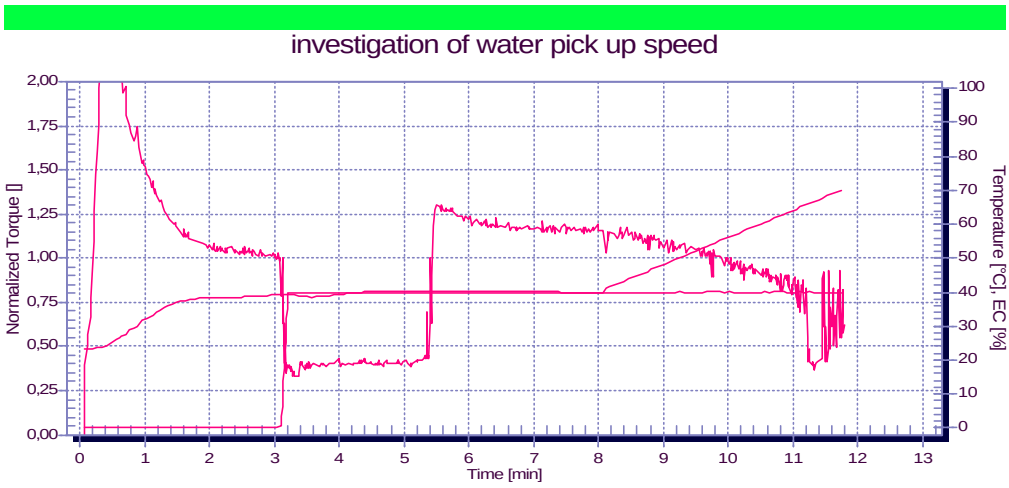

Fig. 2: The water pick up speed can be assessed by "shocking" the ink with fount solution and measuring the recovery time

11. Influence of different fount solutions compositions

The water pick up behavior and emulsification stability is significantly influenced by the quality and composition of the fount solution. On one hand the fount solution may be form a micro-emulsion, which may have a similar behavior like a dispersion. Submicronic droplets behave in the ink system like small solids – the measured torque increases (thickening effect). On the other hand the fount solution may reduce the cohesion forces of ink resulting in a continuously falling torque (diluting effect). In practice both effects may be superposed, so it is up from the respective strength how the torque develops.

The LITHOTRONIC III uses for tests with various fount solutions a new developed ceramic piston pump. This pump operates reliable and is also resistive against more aggressive components in fount solutions. Because of smallest manufacturing tolerances no extra seals are inside – resulting in a maintenance free pump system.

The quasi closed spindle–cup system prevents undesired evaporation and minimizes the effect of the surrounding humidity. Anytime during test it is exactly known how much fount solution is present in the emulsion under test.

12. Measurement System Calibrations

In order to guarantee the specified instrument accuracy over the life time all relevant process parameter, like temperature, shear rate, dosing weight and torque reading must be stable. High precision internal temperature references eliminate the need of any temperature re-calibration. The shear rate depends on rotation speed and gap between spindle and the bottom of the cup. The rotation speed is controlled by a quartz reference, the exact gap distance is set automatically after the ink has been filled into the cup and before the test starts.

The pump system is calibrated by manufacturer but can be proofed and re-calibrated by operator himself. Because of the very stable geometry of the ceramic pump system a re-calibration is only necessary in case of a significant changes in fount solution's density.

The torque reading system has been calibrated by manufacturer and is stable over instrument life time normally. Nevertheless a certified calibration kit is available that allows the operator to proof independently the accuracy of torque reading anytime.

13. Test Efficiency and Cleaning

With the LITHOTRONIC III four to six tests per hour are possible. Results can be saved automatically in indexed designation. Because two identical spindle cup systems are supplied as standard the next test can be prepared during the current one is running. Ink is spoiled only at exchangeable metallic parts. There are no special cautions regarding cleaning solutions and ink compatibility.

14. WinLITHO software and data evaluation

The instrument and the tests are completely controlled by the modern windows software **WinLITHO**. It is intuitive to use, allows a quasi unlimited number of programs and result files. Result curves can be plotted in different manner, multiple curve overlays and cursor functions support the operator evaluating the data. An independent data export function in ASCII format is the interface to special data evaluation programs.

15. Summary

The results of round robin tests by various ink manufacturers have been presented on the EUROCOMMIT session on February 16th 2000 in Frankfurt – Germany. The working group has awarded the high-speed LITHOTRONIC being the preferred instrument for ink emulsification testing as it is precise and flexible in use.

