Thermal Transients on a Web Offset Press

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Abstract

The variation of temperatures within a web offset press affects the printing process. Manufacturers include cooling systems in an attempt to minimise these variations. As part of a trial with a Komori UK, the temperatures of the components of the inking train were measured simultaneously using thermal imaging. The results show the build up of thermal energy during the printing run and the effect of different temperature control regimes. The heat transfer affected by the flow of ink and fount solution through the press was found to be highly significant. These tests highlighted the dissipation of heat from within the rolls once the press has stopped. In order to minimise transient effects, there is a need to match the generation of heat within the rollers and the thermal capacity of the press to the cooling system. The potential to obtain thermal stability on start up has been demonstrated.

Introduction

The temperature variations on a web offset press, have previously been shown to have a significant effect on the ink transfer in web offset printing (Bohan et al, 1995). Changes in density of 0.4 have been observed for a 10°C change in temperature. This is approximately equivalent to the density tolerance expected during a typical production run. Increasing temperature causes the viscosity of the ink to reduce and also changes other rheological properties such as surface tension, which in turn affect the ink transfer. The temperature will also influence the mechanical operation of the press, causing changes to the nip settings due to differential thermal expansion, as well as to the properties of blankets. Therefore

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the changing temperatures in the press will not only affect the colour consistency through a print run but could also compromise the ability to match the proof, due to the interrelationship between coverage and the effect of temperature.

The variation in temperature of the press was monitored as part of a series of trials with Komori UK to evaluate the influence of different press temperature control strategies on the quality and consistency of the copy produced by the press. The focus of these tests was short run printing on a web offset press, where good consistent copy has to be achieved with the minimum of waste. The objective was to establish the best temperature control strategy. The main methods can be considered to be no temperature control, a constant supply of cooling water at a fixed temperature or constant press temperature achieved through design of a thermal management system. The cooling system fitted to the press also allowed for the option of independent control of different zones of the press. Having established the temperature control regime, the optimum temperature has then to be established. This paper reports on the temperature variation during start up, constant running and press stop, under three temperature control scenarios.

The temperature measurements were simultaneously taken through the inking train using thermal imaging. These were cross-correlated with measurements derived from strategically located thermocouples. The paper discusses the implications of these measurements for press temperature control.

Experimental Trials

The print trial was held at the Leeds showrooms of Komori UK Ltd on a System 38 heatset, web offset press. This is an 8 unit, 4-colour press with two print units per station. The press has a maximum web width of 965mmm and runs at a maximum speed of 50,000 impressions per hour. The press was fitted with a zoned temperature control system feeding the oscillating copper rollers in the ink train to stabilise the thermal properties of the ink delivery through the roller train. The system enabled independent control of the temperature of three zones (see Figure 1):

1. Ink oscillating rolls and ink duct rollers (A and V1)
2. Dampening water temperature
3. First two rollers in the print chain (F and V2)

In addition the other rollers were connected directly to the chiller unit.

Three operating regimes were investigated:

- Trial 1 - No temperature control of press rolls or ink duct
- Trial 2 - water supplied at 28°C to press rolls, 26°C to ink duct
- Trial 3 - water supplied at 20°C to press rolls, 22°C to ink duct

All other zones of press were supplied with water at a constant temperature. Cooling water at 10°C was supplied to the fount. The flow rates were kept constant through out the trial.

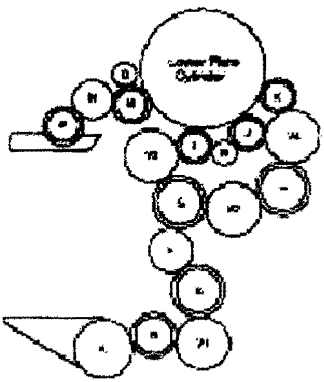


Figure 1. Schematic of Magenta Lower Inking Unit

A thermal imaging camera, NEC Thermo Tracer TH7102, was used to record the thermal behaviour of the rubber and copper inking rollers, the form rollers, the printing plate and the blanket roller on the lower half of the printing unit. The use of the thermal imaging camera enabled the global logging of the temperature for the entire train visible to the camera. The thermal images recorded were colour coded. In order to eliminate image-to-image perturbations, the data was transferred into a spreadsheet and the average temperature calculated for patches on the blanket, plate cylinder, copper cylinder V4 and rubber rolls K & H (see Figure 1).

Thermocouples were also used to monitor the temperature variation in the ink ducts and the fount trays on the lower units for all four colours. Two thermocouples were placed in each ink duct for the cyan, yellow and black and in the fount trays for all four colours. Three thermocouples were used for the ink duct on the magenta unit to enable a more complete record of the temperature variation during the course of the trial. These were also used to cross check the temperatures derived from the thermal imaging camera. This is

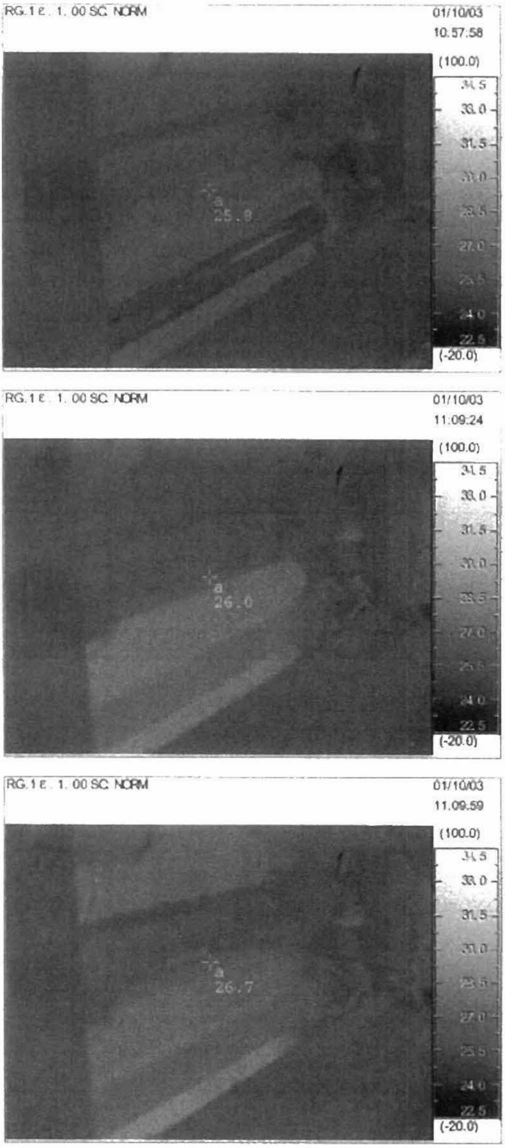


Figure 2. Thermographs of magenta ink train showing flow of ink during start up of trial 1.

essential since the device uses a radiation measurement principle and therefore the temperatures that are recorded are influenced by the surface characteristics of the measured components.

Results

The thermographs during the start of printing are shown in figure 2. This was the first run of the day, so the press was at ambient temperature at the start of the test. The flow of the ink, which was preheated to 25°C, through the press is clearly visible from the images, taking under 1 minute to coat all the inking train. Significant differences are observed between the different components of the inking train. This would suggest that the thermal image camera was effectively measuring the temperature of the components through a thin ink/fount layer.

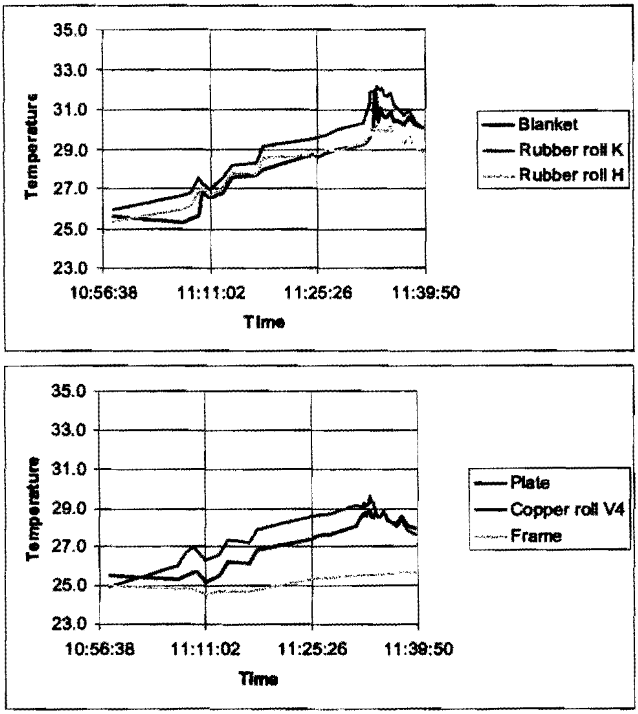


Figure 3. Trial 1- Temperature (C) of press components

The temperatures derived from the thermal images obtained during trial 1 (No temperature control of press rolls or ink duct) are shown in Figure 3. The temperature of all the components of the press rises steadily through out the print run. The highest temperatures occur in the two rubber covered rolls and the blanket roll, with the roll K attaining the highest temperature. When the press stops at 11.33am, the cooling effect of the ink and fount solution stops. The thermal energy stored in the rubber covered rolls then produces a rapid rise of 3°C in approximately 1 minute.

The temperatures of the blanket, the two rubber rolls (K and H) and the plate cylinder are shown relative to the copper roll (V4) in Figure 4. Once the press is running, all of these components maintain a constant temperature relative to the copper roll. This suggests the ink and fount solution plays a major role in maintaining equilibrium throughout the press. Towards the end of the print run the rubber covered rolls and the blanket experience a rapid rise in temperature. This suggests the heat generated by the printing process was initially absorbed by the thermal inertia of the press. Towards the end of the run, the temperatures rise is more in accord with the rate of heat generated. This is reflected in the frame temperature, which remains constant for the first part of the print run and then increases by 0.5°C during the second half of the trial. Once the press stops, then the rubber-covered rolls undertake major excursions to more elevated temperatures as the thermal energy generated in the rubber coverings is no longer convected away by the ink and fount solution.

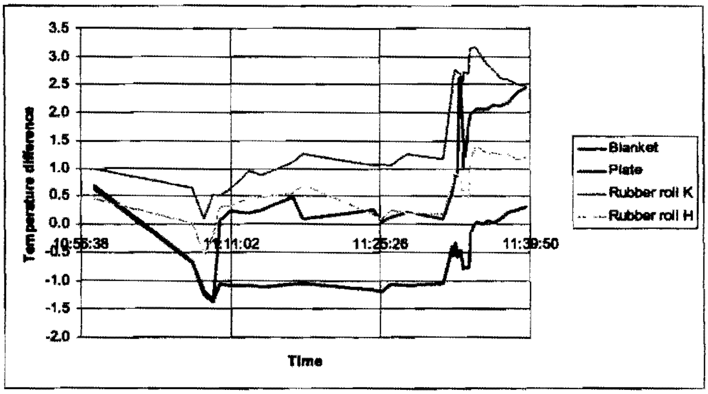


Figure 4. Trial 1 – Temperature (C) of press components relative to Copper roll V4

The high temperatures that occurred in the rubber covered components once printing had stopped and hot spot in non printing area of blanket can be seen in Figure 5, which is of the ink train immediately after it had stopped printing.

Throughout the print run, the edge of the blanket where there was no flow of ink/fount to the substrate experienced a build up to a higher temperature of 32°C (compared to the 29°C of the adjacent part of the blanket where the image was being carried), reaching over 35° C when the press stopped.

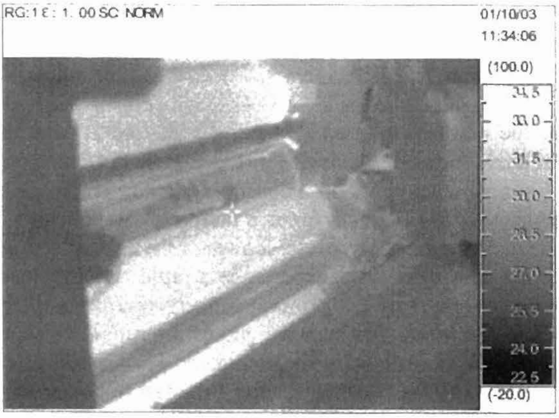


Figure 5. Press immediately after trial 1 had stopped.

The temperature of the ink in the duct rose by 2°C during the run (Figure 6). The temperature is slightly lower in the middle of the duct. This could be the result of feed back through the inking train of the higher temperatures that occur in the non printing area of the blanket or the supply of fresh ink to the duct. The fount rises to a stable 16°C once the press is running, reflecting a balance between the cooling of the fount and the feed back of thermal energy into the fount while printing. Once the press stops, then the fount returns to the temperature of the cooling water.

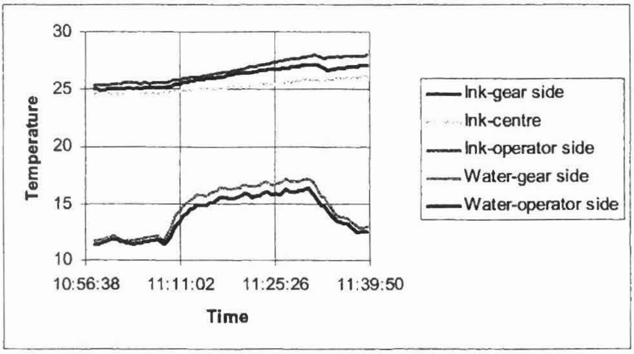
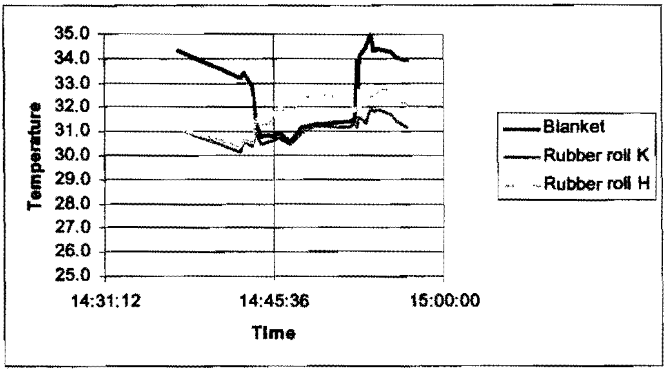


Figure 6. Temperatures (C) of the ink and fount solution

At the start of the second trial, the press was already warm from the previous test (Figure 7). The press cools as it sits idle waiting for the next print run. For trial 2, the water was supplied at 28°C to the press rolls and at 26°C to the ink duct. The effect of the flow of water is seen immediately the press starts. The copper roll, V4, stabilises at 29°C. There is a slight rise in temperature of the copper roll towards the end of the run, suggesting a slight imbalance between the heat generated by the press and the thermal capacity of the cooling system. The flow of ink when the press starts printing drops the surface temperature of all the rolls in 45s. Again when the press stops, the thermal energy stored in the rubber covered rolls causes their temperature to rise rapidly.



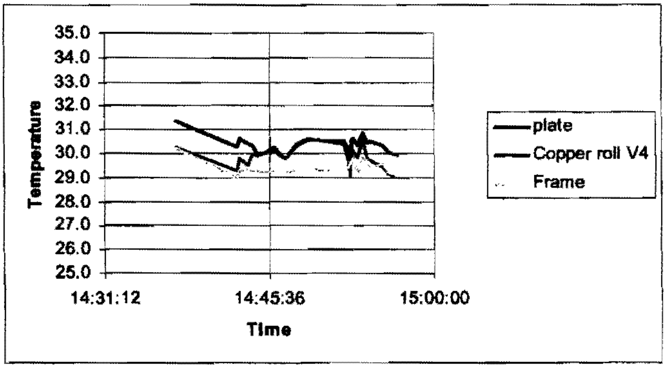


Figure 7. Trial 2- Temperature (C) of press components

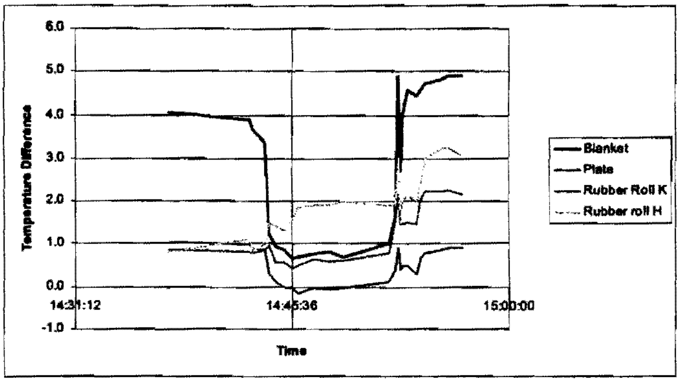


Figure 8. Trial 2 – Temperature (C) of press components relative to Copper roll V4

The thermal transfer effected by the ink and fount solution is evident from the relative temperature of the rubber rolls compared with the copper cylinder (Figure 8). Once the press is printing, the ink train maintains a constant temperature relative to the copper roll. Once the press stops, then the temperature of the ink train rises rapidly relative to the copper roll.

There was little difference in temperature from side to side of the press. The ink duct and fount solution maintained similar temperatures profiles, albeit with the ink at a lower temperatures, reflecting the cooling being supplied to the duct. The fount solution showed an identical profile of rising from 10 to 16 °C, once the press was running and returning to 10°C when the press stopped.

The third trial involved running the press cooling system at a lower temperature (water supplied at 20°C to the press rolls and 22°C to the ink duct). The residual heat stored, particularly in the blanket, is removed by the flow of ink and fount solution once the print trial starts (Figure 9). The temperatures are lower than for the previous trials, reflecting the lower temperatures to which the control had been set. Towards the end of the print run the temperature of the blanket starts to rise, again increasing rapidly once the printing has stopped.

The temperatures appear to follow those of the copper roll. This is borne out by the comparison of the temperatures relative to the copper roll (Figure 10). Once the press is running, these quickly obtain a quazi-stable relationship with respect to the copper roll. Apart from the blanket, which goes up in temperature relative to the copper roll towards the end of the trial. There are indications that the other roll temperatures were also increasing at the end of the print run. This suggests an equilibrium position had not been established between the heat generation in the press and the heat removal by the cooling system.

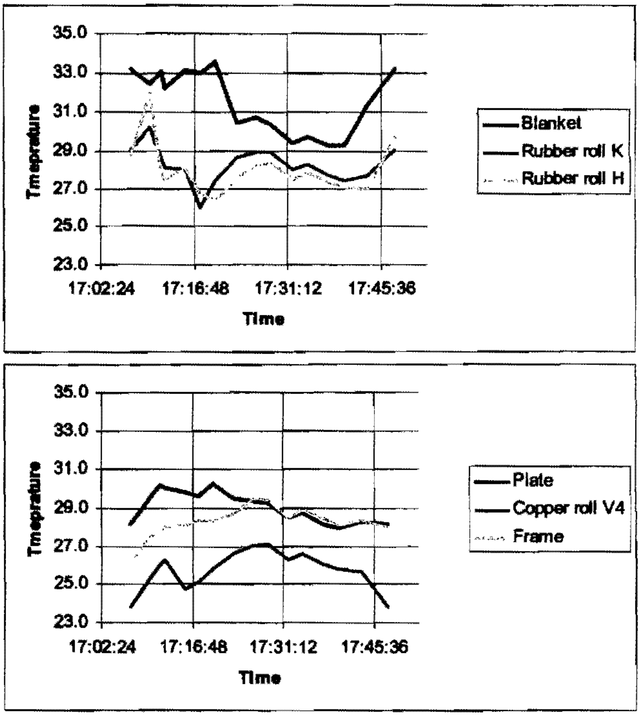


Figure 9. Trial 3 - Temperature (C) of press components

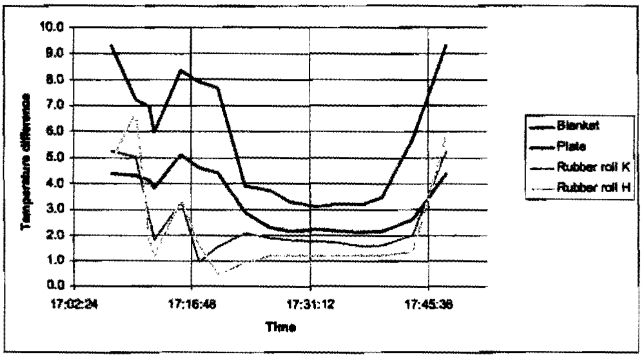


Figure 10. Trial 3 – Temperature (C) of press components relative to Copper roll V4

Discussion

The results with the thermal image camera obtained during the printing trials are summarised in Table 1. This shows the absolute temperature and the temperature relative to the copper roll, V4, at times representing the start of printing, at a mid point and at the end of the print run for each of the components monitored. In addition, the range shows the total amount of fluctuation during the print run. The data on the temperatures of the ink and fount solution are summarised in a similar manner in Table 2.

		Mean Temperature			Relative Temperature		
		Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
Blanket	Start	25.7	30.9	30.5	-1.4	0.9	3.9
	Mid	28.0	31.2	29.4	0.1	0.8	3.1
	End	30.1	31.4	31.4	0.9	1.0	5.7
	Range	5.3	0.9	2.1	2.6	0.6	2.6
Plate Cylinder	Start	25.7	30.0	29.5	-1.4	0.0	2.9
	Mid	26.8	30.3	28.5	-1.0	-0.1	2.2
	End	28.6	30.5	28.3	-0.6	0.1	2.6
	Range	3.7	0.8	1.5	0.9	0.5	0.8
Rubber roll K	Start	27.6	30.6	28.7	0.5	0.6	2.1
	Mid	29.1	31.0	28.1	1.3	0.6	1.8
	End	31.9	31.2	27.7	2.7	0.8	2.0
	Range	5.3	0.8	1.5	2.3	0.5	0.5
Rubber roll H	Start	26.8	31.3	27.5	-0.2	1.3	0.9
	Mid	28.6	32.3	27.5	0.7	1.9	1.2
	End	30.0	31.8	27.0	0.9	1.9	1.3
	Range	3.5	1.3	1.4	0.8	0.7	0.4
Copper roll V5	Start	27.0	30.0	26.6			
	Mid	27.9	30.4	26.3			
	End	29.2	30.4	25.7			
	Range	3.4	0.8	1.5			

Table 1. Summary of temperatures (C) of the inking train during print runs

The role of the ink/fount emulsion as a heat transfer control agent distributing and removing heat is highlighted in the results, particularly by the temperatures of the press components relative to the copper roll. The fount is likely to have a dominant effect as it has a higher thermal capacity than the ink. In trial 1, when there was limited cooling on the press, the temperatures are all similar, although there is a large range of temperatures relative to the copper roll. The temperatures in trial 3, are significantly higher than the copper roll, reflecting the imbalance between the heat removed by the cooling of the copper roll and the heat generated in the press. The range of these relative temperatures is a similar to those of trial 1. In trial 2, the variation across the press and the range of the variation during through print run is far smaller, reflecting the better balance achieved under these operating conditions.

		Mean Temperature		
		Trial 1	Trial 2	Trial 3
Ink Middle	Start	24.7	23.1	25.2
	Mid	25.3	23.7	25.5
	End	25.9	24.2	24.4
	Range	1.2	1.1	1.2
Ink Gear side	Start	25.2	22.8	24.6
	Mid	26.4	23.7	25.2
	End	26.9	24.2	24.1
	Range	1.9	1.5	1.3
Ink Operator side	Start	25.6	22.8	24.5
	Mid	26.8	23.3	24.9
	End	27.7	23.6	24.6
	Range	2.4	1.2	1.1
Water Gear side	Start	12.2	11.9	11.8
	Mid	16.7	17.0	16.8
	End	15.6	16.0	16.0
	Range	5.1	5.4	5.7
Water Operator side	Start	11.7	11.6	11.5
	Mid	15.9	15.7	15.9
	End	14.8	15.2	15.4
	Range	4.7	4.7	5.2

Table 2. Summary of temperatures (C) of the ink and fount solution during print

A major source of heat within the press is the compression and relaxation of the rubber as it passes through nips in the press (Claypole et al 1996, 1997). This has been shown to generate heat in the rubber layer nearest to the steel core in the roll. The flow of fount solution over the surface serves to remove this heat. However, when the press stops, this flow of coolant ceases and the temperature of the surface of the rubber covered rolls rise as the heat built up near the core of the roll conducts to the surface. In regions such as the non printing areas of the blanket beyond the web edge, there is no cooling flow and the temperature increases throughout the print run.

In trial 1, where the majority of the press was not cooled, the temperatures on the press show the largest excursions, with a maximum range on the blanket and roll K of 5.3°C. In the second trial, the rolls were maintained at a temperature of 28° C, most of the main components of the press remain at almost a constant temperature with a range of less than 1°C. The exception is rubber roll H, which has a fluctuation of 1.3°C. However, the rubber roll H is effectively upstream of the copper roll V4 in the ink train and therefore it is likely to be strongly influenced by thermal inputs further upstream in the inking train, e.g. by from copper roll V2 and the temperature of the ink in the duct. The rubber roll H, shows the same range of temperature fluctuations in trial 3, where the temperature of the water to the press was maintained at 20°C. The ranges of temperature for all the other rolls are higher than rubber roll H in trial 3. This is particularly true for the blanket, which first cools through the print run and then warms at the end of the run. This indicates the press was not as stable, with thermal transients passing through the press. Thus, for this particular press under these operating conditions of speed and ambient temperature, then trial 2 would appear to represent an optimum condition, where the heat generated within the rubber components of the press is balanced by the quantity of cooling provided to the press and its distribution. This highlights the benefits of an effective cooling system operated at the correct temperature and extracting an appropriate amount of thermal energy, in that stable conditions are achieved on the press, almost from start up. The optimum operating temperatures will almost certainly vary with print speed, rubber roller engagement and rubber properties. It will also be influenced by the temperature of the supply of the ink and the fount solution. In these trials, the temperature of the ink in the duct varied by a small amount and appeared to only be slightly influenced by the cooling provided to the pan, while the fount solution was delivered at approximately 16°C for all of the trials. This is reflected in the similar range of temperatures obtained for each trial, despite the variations imposed on the cooling water supplied to the rolls.

A further influence on the thermal stability of the press is illustrated by trial 3. The flow of low temperature cooling water through the press chills the rolls and creates in effect a heat sink. The heat generated by the press during the print run has first to overcome this chill, before it can move to its stable operating regime. Thus, just applying intense cooling does not necessarily lead to a more rapid attainment of thermal equilibrium.

Conclusions

The use of a thermal imaging camera has been shown to be a valuable aid to establishing the optimum operating conditions on the press. It enabled the simultaneous evaluation of the temperature of all the components in the inking train.

The flow of fount solution plays a major role in the thermal balance of the press, transferring heat between the rolls of the inking train. Thus when the press is running, the flow of ink and fount tends to equalise the temperatures between the different components in the inking train. However, the different components of the inking train are still operating at subtly different temperatures, which would undoubtedly affect the ink transfer through the train, particularly the film splitting in the nip. This reduces the effectiveness of separate zone control. However, the residual thermal energy that builds up in rubber covered rolls and the blanket that causes the temperature rise during printing, produces rapid temperature excursions on shut down. It is in the thermal preparation of the press for printing, that most benefit is likely to accrue from separate zone control.

Stable printing conditions can be achieved from start up by balancing the thermal production with the cooling at appropriate points in the press. However, it has also shown that the press is a complex interaction of heat sources and sinks. In order to minimise transient conditions, there is a need to develop a thorough understanding of the press behaviour. The optimum cooling temperatures obtained in this trial are a result of the complex interrelationship between temperature, water flow rate, press speed ambient conditions, substrate and coverage.

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