# ESTIMATION OF WATERLESS OFFSET PRINTING PLATE SURFACE TEMPERATURE

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Abstract: There are many arguments on advantage and disadvantage of waterless offset printing. One of the most important factors affecting sucessful use is the temperature rise on the plate, since no dampening water is applied to the plate.

In this study, the temperature rise of waterless offset printing operations on various presses was estimated using only observed temperature data on conventional dampening offset printing plates during normal daily operations. Through this procedure, without any time consuming test printing with waterless plates, we can select presses which can be used for waterless plate printing as far as temperature rising is concerned.

Studies have been done on four sheet-fed presses and three web-offset presses(two Satellite and one Blanket-to-Blanket). It was found that only two of the sheet-fed presses could be used for waterless printing without any further cooling arrangements to the presses, and the B-B web-offset press was critical depending on the ambient temperature.

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Theory: Motor-driven cylinders of a press with kinematic energy eventually generate heat which makes plate surface temperature higher than the ambient temperature.

For conventional dampening offset plate surface, the generated heat is transfered from the cylinder surface to surrounding atmosphere by following two heat transfer mechanisms as sketched in Fig.1.

A) Convective heat transfer from the rotaing drum surface into atmosphere as

$$Q_1=h_G A(T_s-T_d) \qquad (1)$$

where, $h_G$ is heat transfer coefficient between the rotating cylinder surface and surrounding air(Kcal /hr,sqm,deg C), A is heat transfer area(cylinder surface), $T_s$ is cylinder surface temperature and $T_d$ is dry bulb temperature in the operating room.

B) Heat transfer alonged with water evaporation from the cylinder surface into air,

$$Q_2=k_H AL(H_s-H) \qquad (2)$$

wher $k_H$ is mass transfer coefficient between the rotating cylinder surface and surrounding air(kg-water/hr,sqm,$\Delta$H), $H_s$ is saturated humidity on the wet cylinder surface at temperature $T_s$, H is humidity of the operating room atmosphere(kg-water vap /kg-dry air) and L is latent heat of evaporation of water(Kcal/kg-water).

Thus the total heat flux

$$Q=Q_1+Q_2$$

or

$$Q=h_G A(T_s-T_d)+k_H AL(H_s-H) \qquad (3)$$

The same amount of the heat must be transfered from the waterless plate surface into the environment by convective heat transfer only,as shown in Fig.1-b

$$Q=h_G A(T_D-T_d) \qquad (4)$$

where $T_D$ is the surface temperature of the waterless plate and estimating this temperature is the very objective of this study.

Combining Eqs.(3) and (4) gives

$$h_G A(T_D-T_d)=h_G A(T_s-T_d)+k_H AL(H_s-H) \qquad (5)$$

solving Eq.(5) for $\Delta T_D \equiv T_D-T_d$ gives

$$\Delta T_D=T_s-T_d+(k_H/h_G)L(H_s-H) \qquad (6)$$

There is a well-known empirical relation on heat and mass transfer process in air-water systems; humidity H and temperature T are expressed by following relation(1963)*,

$$H_w-H=(C_H/L)(T-T_w) \qquad (7)$$

where $H_w$ is saturated humidity at wet-bulb temperature $T_w$, $C_H$ is specific heat of wet-air(Kcal /kg-dry air,deg C) and expressed by

$$C_H=0.24+0.45H \qquad (8)$$

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* Details are cited in Appendix

Unknown term in Eq.(6) is $k_H/h_G$ ,which can be estimated by well known Chilton-Colburn(1934) - analogy between heat and mass transfer as

$$h_G/k_H=(Sc/Pr)^{2/3}C_H \tag{9}$$

where Sc is Schmidt Number and Pr is Prandtl Number. For air-water system Lewis(1922) has found the following famous empirical relation

$$h_G/k_H \doteqdot C_H \tag{10}$$

Using Eqs.(6)(7) and (10), the final result is derived as

$$\Delta T_D=T_S-T_W+(L/C_H)(H_S-H_W) \tag{11}$$

Experiments: Observed temperature data of operating presses with conventional offset plates with dampening water are shown in Table 1. Using the observed data, the estimated surface temperatures of waterless plates by Eq.(11) are listed in Table 2.

Conclusions: The highest temperature rise was for Satellite web-offset presses, then for larger sheet-fed presses and blanket-to-blanket web - offset press. Supporse the plate surface temperature must be kept under 45 (deg C), Koni Super-9 and Rolland Record(4C) could be used without any further cooling arrangements on the presses, and the blanket-to-blanket web-offset press(Mitsubishi

Lithopia) is critical depending on the ambient temperature, which must be kept under 20(deg C). The other presses are hopeless to be used for succesful waterless offset printing as long as temperature concerned.

More energy saved presses will be appreciated not only for energy consumption but also for succesful use for waterless plates.

Literatures Cited:


Chilton,T.H. and Colburn,A.P.
Industrial Engineering and Chemistry
26,1183(1934)

Lewis,W.K.,
Mechanical Engineering,44,445(1922)

Perry,J.H.,Ed.,
"Chemical Engineers' Handbook"
15-2(1963)

Appendix: Wet-bulb temperature is the dynamic equilbrium temperature attained by a water surface when the rate of heat transfer to the surface by convection equals the rate of mass transfer away from the surface. At equilibrium, assuming negligible change in the dry-bulb temperature, a heat balance on the surface is

$$k_H L(H_w - H) = h_G (T - T_w) \qquad (1A)$$

assuming the partial pressure or vapor pressure is small relative to the total pressure, thus the wet-bulb equation can be written in term of humidity difference as Eq.(1A).

If a stream of air is intimately mixed with a quantity of water at a temperature $T_a$ in an adiabatic system, the temperature of the air will drop and its humidity will increase. If $T_a$ is such that the air leaving the system is in equilibrium with the water, $T_a$ will be the adiabatic-saturation temperature, and the line relating the temperature and humidity of the air is the adiabatic-saturation line. The equation for the adiabatic-saturation line is

$$H_a - H = (C_H/L)(T - T_a) \qquad (2A)$$

Experimentally it has been shown that for air-water systems the value of $h_G/k_H C_H$, the psychrometric ratio, is approximately equal to one. Under these conditions the wet-bulb temperature and adiabatic saturation temperature are substantially equal and can be used interchangeably. Thus Eq.(7) has been derived.

Table 1 Observed Temperature Data

| Time | Color | Koni Super-9 $T_s$ | Koni Super-9 $T_d$ | Koni Super-9 $T_w$ | Rolland Record-4 $T_s$ | Rolland Record-4 $T_d$ | Rolland Record-4 $T_w$ |
|---|---|---|---|---|---|---|---|
| 9:00 | B | 18 | 21.5 | 16.5 | 18 | 18.5 | 13 |
| | C | 18 | | | 19 | | |
| | M | 18 | | | 19 | | |
| | Y | 17 | | | 20 | | |
| 10:30 | B | 21 | 24 | 18.5 | 19 | 23 | 17 |
| | C | 21 | | | 20 | | |
| | M | 20 | | | 19 | | |
| | Y | 21 | | | 21 | | |
| 13:00 | B | 24 | 25 | 20 | 19 | 21.5 | 15 |
| | C | 24 | | | 20 | | |
| | M | 24 | | | 21 | | |
| | Y | 24 | | | 22 | | |
| 14:30 | B | 24 | 26 | 20.5 | 21 | 24.5 | 18.5 |
| | C | 24 | | | 21 | | |
| | M | 24 | | | 22 | | |
| | Y | 24 | | | 23 | | |
| 15:30 | B | 24 | 27 | 21.5 | 22 | 24.5 | 18.5 |
| | C | 24 | | | 21 | | |
| | M | 25 | | | 24 | | |
| | Y | 25 | | | 25 | | |
| 17:00 | B | 25 | 28.5 | 22.5 | | | |
| | C | 25 | | | | | |
| | M | 26 | | | | | |
| | Y | 26 | | | | | |

| Time | Color | MHI Dia-3 $T_s$ | MHI Dia-3 $T_d$ | MHI Dia-3 $T_w$ | Komori Cosmo $T_s$ | Komori Cosmo $T_d$ | Komori Cosmo $T_w$ |
|---|---|---|---|---|---|---|---|
| 9:00 | B | 17 | 20.5 | 14.5 | 27 | 23 | 17 |
| | C | 17 | | | 25 | | |
| | M | 17 | | | 25 | | |
| | Y | 18 | | | 25 | | |
| 10:30 | B | 20 | 23.5 | 17.5 | 25 | 26.5 | 19 |
| | C | 20 | | | 25 | | |
| | M | 21 | | | 25 | | |
| | Y | 21 | | | 26 | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 12:00 | B | 25 | 26 | 20 | 24 | 27.5 | 19.5 |
| | C | 25 | | | 24 | | |
| | M | 26 | | | 25 | | |
| | Y | 26 | | | 25 | | |
| 13:30 | B | 26 | 25 | 19 | 24 | 26.5 | 19.5 |
| | C | 26 | | | 24 | | |
| | M | 27 | | | 25 | | |
| | Y | 27 | | | 25 | | |
| 15:00 | B | 29 | 28.5 | 22 | 25 | 28.5 | 21.5 |
| | C | 30 | | | 25 | | |
| | M | 30 | | | 26 | | |
| | Y | 30 | | | 26 | | |
| 17:00 | B | 30 | 28.5 | 22 | 25 | 29 | 21.5 |
| | C | 29 | | | 25 | | |
| | M | 30 | | | 26 | | |
| | Y | 30 | | | 27 | | |
| | | Hamada Satellite | | | MHI B-B | | |
| 9:00 | B | 26 | 23 | 16 | 26 | 25 | 19.5 |
| | C | 26 | | | 26 | | |
| | M | 26 | | | 27 | | |
| | Y | 26 | | | 27 | | |
| 11:00 | B | 27 | 26 | 19 | 27 | 26 | 20.5 |
| | C | 27 | | | 27 | | |
| | M | 28 | | | 28 | | |
| | Y | 28 | | | 27 | | |
| 13:00 | B | 29 | 27 | 19 | 27 | 27 | 21 |
| | C | 29 | | | 27 | | |
| | M | 30 | | | 27 | | |
| | Y | 30 | | | 27 | | |
| 16:00 | B | 31 | 28 | 21 | 27 | 28 | 21.5 |
| | C | 32 | | | 27 | | |
| | M | 32 | | | 27 | | |
| | Y | 33 | | | 28 | | |
| 17:00 | B | 32 | 28 | 21 | | | |
| | C | 32 | | | | | |
| | M | 33 | | | | | |
| | Y | 36 | | | | | |

| | | | Mitsubishi Satellite | | | | |
|---|---|---|---|---|---|---|---|
| Time | Color | $T_s$ | $T_d$ | $T_w$ | $T_s$ | $T_d$ | $T_w$ |
| 9:00 | B | 26 | 22.5 | 14.5 | 25 | 23 | 15 |
| | C | 26 | | | 27 | | |
| | M | 25 | | | 26 | | |
| | Y | 25 | | | 26 | | |
| 10:30 | B | 29 | 25.5 | 18 | 27 | 25 | 18 |
| | C | 30 | | | 31 | | |
| | M | 27 | | | 31 | | |
| | Y | 28 | | | 30 | | |
| 12:00 | B | 30 | 27 | 19 | | | |
| | C | 32 | | | | | |
| | M | 29 | | | | | |
| | Y | 29 | | | | | |
| 13:00 | B | 30 | 27.5 | 19.5 | 29 | 27 | 18 |
| | C | 31 | | | 30 | | |
| | M | 29 | | | 31 | | |
| | Y | 30 | | | 30 | | |
| 15:00 | B | 31 | 28.5 | 19.5 | 30 | 28 | 20 |
| | C | 33 | | | 32 | | |
| | M | 31 | | | 32 | | |
| | Y | 31 | | | 31 | | |
| 17:00 | B | 32 | 28.5 | 19.5 | | | |
| | C | 33 | | | | | |
| | M | 31 | | | | | |
| | Y | 31 | | | | | |

Table 2 Estimated Temperature Rise of Waterless Offset Plates

| Type of presses | $\Delta T_w$ | $\Delta T_D$ |
|---|---|---|
| Koni Super-9,sheet-fed | 1.5-2.5 | 4.0-9.4 |
| Rolland Record(4C), " | 5.5-6.5 | 7.5-13.1 |
| MHI Dia-3, " | 2.5-8 | 6.5-32.8 |
| Komori Cosmo, " | 3.5-10 | 13.0-34.6 |
| Hamada(Sate.),web-offset | 10-11 | 33.2-45.8 |
| MHI(Satellite), " | 11.5-12.5 | 37.2-50.9 |
| MHI(B-B), " | 5.5-6.5 | 21.0-23.6 |

* $\Delta T_w = T_s - T_w$ ** $\Delta T_D = T_D - T_d$ (deg.C)

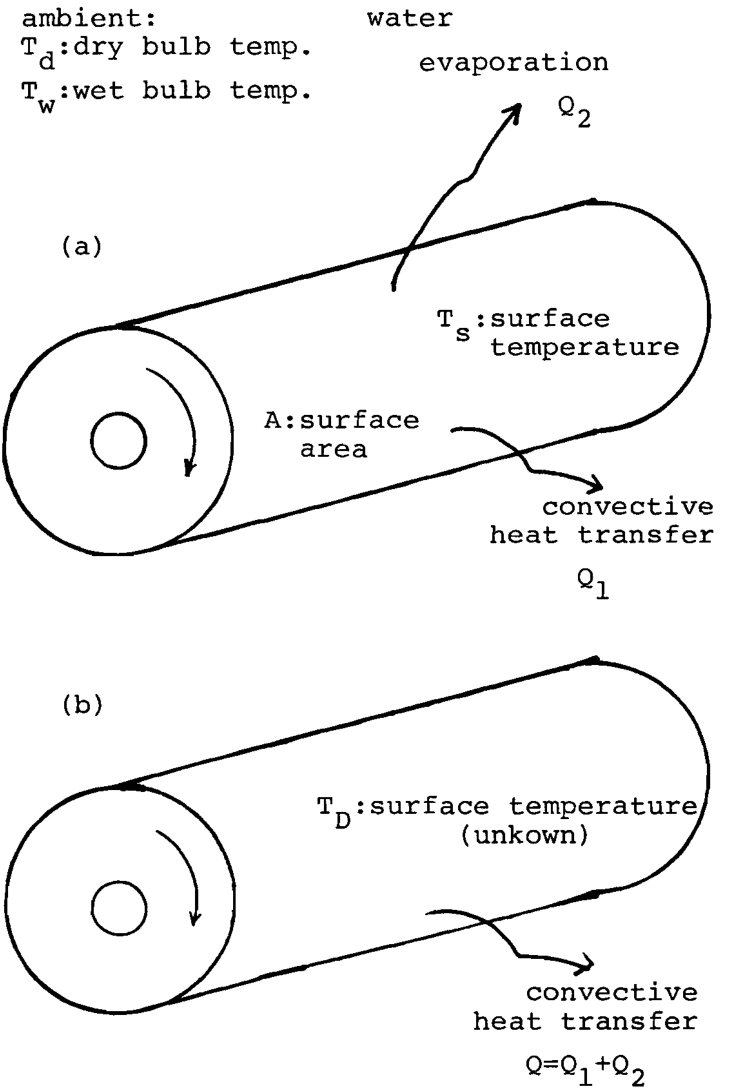


Fig.1 Simplified heat transfer mechanism for conventional dampening plate(a) and waterless plate(b)