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Analysis of Consistency of Printing Blankets using Correlation Technique

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Abstract:

This paper presents the application of an analytical tool to quantify material consistency of offset printing blankets. Printing blankets are essentially viscoelastic rubber composites of several laminas. High levels of material consistency are expected from rubber blankets for quality print and for quick recovery from smash encountered during the printing process. The present study aims at determining objectively the consistency of printing blankets at three specific torque levels of tension under two distinct stages; 1. under normal printing conditions and 2. on recovery after smash. The experiment devised exhibits a variation in tone reproduction properties of each blanket signifying the levels of inconsistency also in thickness direction. Correlation technique was employed on ink density variations obtained from the blanket on paper. Both blankets exhibited good consistency over three torque levels under normal printing conditions. However on smash the recovery of blanket and its consistency was a function of manufacturing and torque levels. This study attempts to provide a new metrics for failure analysis of offset printing blankets. It also underscores the need for optimising the torque for blankets from different manufacturers.

Keywords:

Offset Printing, Printing Blanket, Material Consistency

1. Introduction

Modern offset printing blankets with fabric carcass are viscoelastic rubber composites of several different laminas. They are considered to be the heart of offset printing process and are required to possess good material consistency and quick recovery. They are hence more sophisticated in terms of the method of manufacture and various elastomeric compounds used. However, it is known that elastomeric materials used in practice are usually heterogeneous, rheologically complex and they produce relatively large deformations *(Oman et al., 2009)*, which makes it difficult to predict its behaviour accurately, as the material is vulnerable to stresses and strains during the printing process. Most performance characteristics and material consistency have a direct bearing on the torque to which the blanket itself is tensioned around the cylinder *(Heyne 1977)*. Consequently, the ability of blankets to recover from shocks and smash due to double sheet, paper wrap, spliced material, or crumpled sheets, significantly changes as well. Recovering ability is an important criterion in the selection of a good offset blanket.

Whilst uniform smash recovering ability itself dependents on the consistency of the material and torque levels to which the blankets are tensioned. This is why determining the optimum torque for each type of blanket will be of great help in obtaining improved print quality and run length. Inferior quality blankets or improper blanket handling techniques increase downtime and waste. Motivation for the present work arose from the fact that the behavioural property of offset printing blanket varies depending on the manufacturer and the torque levels to which they are tensioned around the cylinder. Apart from the torque, the chemicals used in washes such as inks, fountain solution, and stock thickness also play a major role in determining the overall service life of the blanket. Material that appears good need not be consistent in terms of its uniform material distribution. There may be voids or pockets beneath the surface layer. During the formative stages of the blanket, the material may not have laid evenly across the length and width. This results in a situation where the material is not perfectly homogeneous, which leads to inadequate performance during its service period. There is hence a definite need to understand the extent to which the blanket is consistent also in thickness direction across the length and width. The aim of the work is to develop a correlation technique to make meaningful and objective determination of blanket's consistency, 1. in thickness direction and 2. in different regions under normal and extreme service conditions for different levels of torque.

2. Experimental Setup

A print test form *Figure 1* was designed for this purpose and was printed using new blankets with the procedure suggested *(Kumar et al., 2007)*. The test was conducted on PO-25, Single colour offset printing machine manufactured by Manugraph. The blanket to be tested was mounted flush with the cylinder bearers using packing gauge and the plate was packed to 0.075 mm above bearer, as per machine specification. The blanket was tensioned to an initial torque of 55Nm. The impression cylinder pressure was adjusted to suit 0.095mm thick 80gsm Maplitho paper of size 450x575mm. Black ink from Lavanya Printing Inks was used. The optimum solid ink density was maintained at 1.05±0.05.

The machine speed was maintained at 3600 sheets per hour throughout.

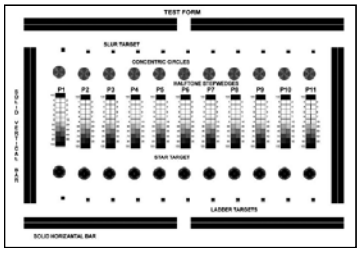

Figure 1. Test form for blanket evaluation

The stack was prepared by keeping 150 sheets, beneath which a smashing sheet *Figure 2* laid with 1mm indenting strips in their respective regions was kept. These indenting strips were prepared by pasting 9 adhesive strips (35x100mm.), each having a thickness of 0.1mm on a sheet of maplitho paper to bring it to a total thickness of 1.0mm.

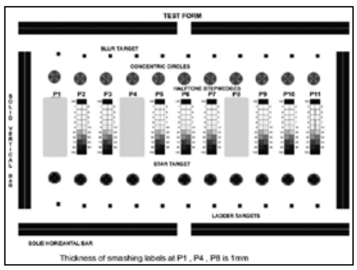

Figure 2 Smashing sheet for 55NmTorque

Table 1. Ink density readings - Blanket 1-55Nm torque

Blanket 1 55Nm torque						
Patch numbers of Test form						
Ď	*P1*	*1sP1*	*P4*	*1sP4*	*P8*	*1sP8*
0.09	*0.08*	*0.08*	*0.09*	*0.08*	*0.09*	*0.09*
0.15	*0.15*	*0.14*	*0.14*	*0.12*	*0.15*	*0.13*
0.22	*0.24*	*0.22*	*0.22*	*0.21*	*0.21*	*0.20*
0.30	*0.33*	*0.29*	*0.29*	*0.26*	*0.28*	*0.27*
0.38	*0.41*	*0.3*	*0.36*	*0.30*	*0.36*	*0.34*
0.46	*0.465*	*0.35*	*0.45*	*0.39*	*0.47*	*0.37*
0.55	*0.585*	*0.43*	*0.54*	*0.45*	*0.54*	*0.42*
0.65	*0.725*	*0.51*	*0.62*	*0.55*	*0.61*	*0.51*
0.78	*0.85*	*0.63*	*0.735*	*0.57*	*0.745*	*0.56*
0.91	*0.97*	*0.73*	*0.865*	*0.69*	*0.88*	*0.63*
1.09	*1.1*	*0.8*	*1.1*	*0.80*	*1.075*	*0.76*
CorlnCoeff	*r(Dav,P1)*	*tr(P1,1sP1)*	*r(Dav,P4)*	*r(P4,1sP4)*	*r(Dav,P8)*	*R(P8,1sP8)*
r	*0.997421865*	*0.997343216*	*0.998826916*	*0.992914096*	*0.99931423*	*0.993353861*
r2	*0.994850376*	*0.99469349*	*0.997655208*	*0.985878401*	*0.99862894*	*0.986751893*

To begin with, the machine was operated under standard conditions to get the optimal ink density in the printed sheet. Once the printing conditions stabilized, the prepared smashing sheet kept inside the stack for 55Nm torque was allowed to pass. After smashing the specific blanket regions, two sheets, one before smash and another after the first second of smash, were collected. Ink density readings of each halftone step before smash were averaged using X-Rite 530 Spectro densitometer to derive normalized ink transferring the ability of the blanket. The same is denoted as Ď in *Table 1*. Density readings from these specific region before smash are denoted as P1, P4 and P8. Similarly, the density readings obtained from the sheets of the regions after the 1st second of smash are denoted as 1SP1, 1SP4 and 1SP8.

Afterwards the blanket was first relaxed and then tensioned again, and the procedure was repeated for the next two torque levels namely 65Nm and 75Nm. The smashing regions of the blanket for each torque levels were changed using respective smashing sheets that were prepared as per *Table 2*. The above test procedure was repeated for the two blankets one after the other.

Table 2. Smashed Regions vs Torque

Torque [Nm]	*Patch*		
55	*P1*	*P4*	*P8*
65	*P2*	*P5*	*P9*
75	*P3*	*P6*	*P10*

4. Data Analysis

The relation between two variables can be analysed using some exploratory data analysis techniques to derive numerical quantity needed to ascribe a characteristic to the blankets consistency as a whole. This could be done by finding if two variables "go together," or

co-vary. If two variables are correlated, the relationship can be used to describe and possibly predict future behaviour. It was therefore decided to take this experimental data one step further by calculating the degree to which the variables are related and from which the coefficient of determination is derived. In this paper ink density readings obtained from the printed sheets at each torque level were analysed using Karl Pearson's, 'Product Moment correlation coefficient' and the coefficient of determination. This statistical tool is used for a better understanding of the blanket in terms of its consistency in thickness direction and homogeneity.

From the data in *Table 1* the coefficients of determination, that is the r^2 values for the three regions before smash, namely r^2(Ď,P1), r^2(Ď,P4), r^2(Ď,P8) and after the first second of smash, namely r^2(P1,1SP1), r^2(P4,1SP4), r^2(P8,1SP8) were derived. To understand the consistency of blanket laterally on the cylinder in normal conditions and in extreme conditions, that is immediately after the 1 second of smash, these r^2 data were analysed by examining their values and their proximity to each other. The above procedure was repeated for 65 and 75Nm torque levels by preparing similar tables to find determination coefficients of the blanket. Where, for 65Nm 'Ď' is the average ink density of region 2, 5, 9 and for 75Nm 'Ď' is the average ink density of region 3, 6, 10 indented. While the notations 1SP2, 1SP5, 1SP9 and 1SP3, 1SP6, 1SP10 refer to the actual ink density readings of each region immediately after the first second of smash for 65 and 75Nm torque respectively. A consolidated table of coefficients of determination, before and after smashing the blanket at three torque levels, was based upon these data and shown in *Table 3*.

5. Results and Discussion

Blanket 1 before smash at varying torque

The pair of coefficient of determination depicted in *Table 3*, obtained for the three regions of Blanket 1 at each torque level before and after smash, was used to plot the curves in *Figure 3*. This figure illustrates the consistency of blanket in thickness direction and magnitude before and after smash. If numerical quantities were close to unity or same, it would give a straight line parallel to X-axis, which is indicative of a high level of consistency in the rectangular region of the blanket under normal printing conditions for a particular torque.

From the experiment coefficient of determination, r^2(Ď P1), r^2(Ď P4), r^2(Ď P8), values were 0.994850376, 0.997655208, 0.99862894 respectively before smashing at 55Nm torque of each region 1, 4, 8. These values are close to unity and nearly the same in every region separately. This shows that the blanket was consistent enough circumferentially before smashing. While joining all these three points in *Figure 2*, resulted in a near straight line indicating the extent to which it was consistent laterally from one region to another. The printed sheet displayed that the slur resulting

Table 3 Coefficient of determination - Blanket 1-55, 65, 75Nm torque

Coefficient of determination of Ink density– Blanket 1								
@ 55 Nm torque			*@ 65Nm torque*			*@ 75Nm torque*		
Patch No	*Before Smash*	*After Smash*	*Patch No*	*Before Smash*	*After Smash*	*Patch No*	*Before Smash*	*After Smash*
P1	*0.9948504*	*0.9946935*	*P2*	*0.9985983*	*0.9211211*	*P3*	*0.9967536*	*0.9019869*
P4	*0.9976552*	*0.9858784*	*P5*	*0.9994393*	*0.9192478*	*P6*	*0.9988882*	*0.8966013*
P8	*0.9986289*	*0.9867519*	*P9*	*0.9989263*	*0.9241326*	*P10*	*0.998772*	*0.8897914*

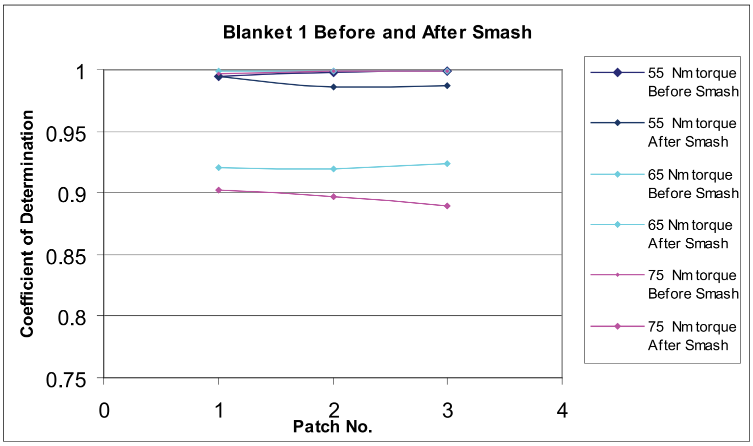

Figure 3. Consistency of Blanket 1 -55, 65, 75Nm torque

from slack blanket when it was tightened to the minimum torque level of 55Nm created dot gain in all three regions during normal printing. It could be said that the tightening should be more than 55Nm.

Coefficient of determination at 65Nm torque for regions 2, 5, 9 namely r^2(ĎP2), r^2(ĎP5), r^2(Ď P9) were 0.99859832, 0.999439314, 0.99892631 respectively. Each of these was much closer to unity, thus implying that the consistency of blanket circumferentially was better than at 55Nm torque. The straightness of the line with reference to different regions indicates that the blanket behaved laterally also in a more uniform manner than at 55Nm torque before smash. This implies that tightening the blanket to 65Nm would retain uniformity and consistency.

Coefficients of determination at 75Nm torque for regions 3, 6, 10 namely r^2(Ď P3), r^2(Ď P6), r^2(Ď P10), were 0.996753569, 0.99888817, 0.99877201 and were better than 55Nm torque in its uniformity in consistency and evenness of tone transfer circumferentially. The near straightness of the line plotted with the given values in *Figure 3* shows that the material was also consistent laterally.

Blanket 1 after smash at varying torque

After the first second of smash at 55Nm, the blanket showed remarkable recovery to normalcy as is evident from the coefficient of determination of regions 1, 4, 8, namely r^2(P1,1SP1), r^2(P4,1SP4), r^2(P8,1SP8) with the values 0.99469349, 0.985878401, 0.986751893 respectively. This implies that at 55Nm torque the blanket exhibited remarkable smash recovery. It exhibited consistency in two regions and in the first region it was tending to be on a par with "unsmashed" condition. This could be the result of low torque levels to which the blanket is tensioned. The reproductions of tones demonstrated a very high order circumferentially as the determinants were closer to unity. With regard to the lateral direction, i.e. from one region to another, material consistency was also proved very good, as could be seen from the value of determinants after smash being plotted horizontally resulting in a near straight line.

The coefficients of determination at 65Nm torque for regions 2, 5, 9 namely r^2(P2,1SP2), r^2(P5,1SP5), r^2(P9,1SP9) are 0.921121131, 0.919247832, 0.924132634 respectively. These values are relatively lower than at 55Nm torque. It is thus clear that while the consistency of material is better at 65Nm torque under normal condition, the material experiences compression due to indentation. However, this compression is uniform over all the three regions, which is evident from the straight line. This implies that the consistency of material is not disturbed at 65Nm. It could also be said that the compression which affected the material due to smash under the strain energy at 65Nm is optimum and ideal. The blanket could therefore be tightened to 65Nm torque for optimum performance.

The coefficients of determination at 75Nm torque for regions 3, 6, 10 namely r^2(P3,1SP3),

r^2(P6,1sP6), r^2(P10,1sP10) are 0.901986906, 0.896601341, 0.889791452 respectively. This clearly indicates that the material had lost its consistency to a greater extent, both circumferentially and laterally, as is evident from the graph in *Figure 3* and *Table 3*.

Blanket 2 before smash at varying torque

The coefficients of determination at 55Nm torque for regions 1, 4, 8 namely r^2(Ď P1), r^2(Ď P4), r^2(Ď P8), as given in *Table 4* are 0.998233321, 0.9995025, 0.99986019. These values are close to unity in every region separately. This shows that the blanket was consistent enough circumferentially before smashing. While joining all these three points in *Figure 4*, resulted in a near straight line indicating very high levels of consistency from one region to another.

The coefficients of determination at 65Nm torque for regions 2, 5, 9 namely r^2(Ď P2), r^2(Ď P5), r^2(Ď P9) are 0.999467064, 0.999265, 0.99967278. These values are nearly the same as depicted by a near straight line in *Figure 5*. This indicates a very high level of material consistency in thickness direction and laterally. This means that the blanket behaves very well in normal conditions and is better than at 55Nm torque.

The coefficients of determination at 75Nm torque for regions 3, 6, 10 namely r^2(Ď P3), r^2(Ď P6), r^2(Ď P10) are 0.997992566, 0.999506, and 0.99843511. The tone transfer was reasonably uniform laterally and circumferentially.

Blanket 2 after smash at varying torque

The coefficients of determination after the first second of smash at 55Nm, of regions namely r^2(P1,1sP1), r^2(P4,1sP4), r^2(P8,1sP8) are 0.93775529, 0.96419949, 0.961812. These values in their respective regions of the blanket prove that the material is consistent only to some extent. In region 1, the material behaves rather poorly in the circumferential and thickness direction indicating

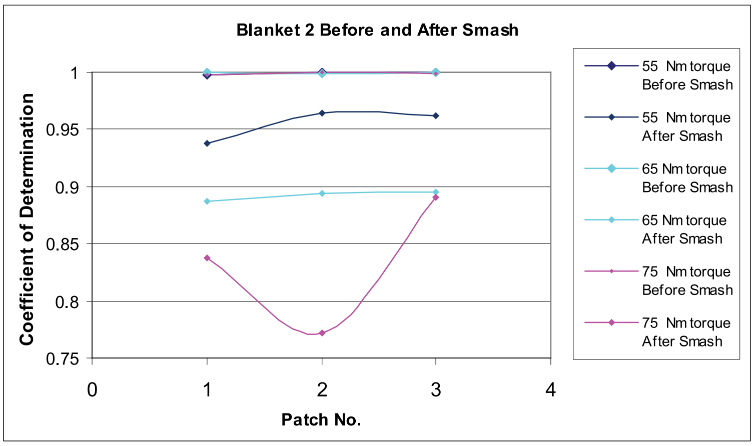

Figure 4 Consistency of Blanket 2 -55, 65, 75Nm torque

Table 4 Coefficient of determination - Blanket 2-55, 65, 75Nm torque

Coefficient of determination of Ink density– Blanket 2								
@ 55 Nm torque			@ 65Nm torque			@ 75Nm torque		
Patch No	Before Smash	After Smash	Patch No	Before Smash	After Smash	Patch No	Before Smash	After Smash
P1	0.9982333	0.9377553	P2	0.9994671	0.887247	P3	0.997993	0.837235
P4	0.9995025	0.9641995	P5	0.9992651	0.8935588	P6	0.999506	0.771773
P8	0.9998602	0.9618119	P9	0.9996728	0.8949108	P10	0.998435	0.889977

major mechanical failure due to material inconsistency when being subjected to high levels of compression. The same is evident from *Figure 4*.

The coefficients of determination at 65Nm torque for regions namely r^2(P2,1SP2), r^2(P5,1SP5), r^2(P9,1SP9) are 0.88724703, 0.893558822, 0.894911. They exhibit very good uniformity of material under extreme compression for 1mm indentation at 65Nm torque. These values in different regions of the blanket indicate that the material behaves consistently in normal conditions, whereas in smashing conditions it behaves in an inconsistent manner regarding thickness direction; however, it is uniform across the regions. The same is depicted in *Figure 5* as a near straight line. Since the degree of resilience is low and is uniform across the blanket, this implies that the blanket is homogeneous to some extent. Therefore blanket could be subjected to a tension of 65Nm torque for optimum performance.

The coefficients of determination at 75Nm torque for regions namely r^2(P3,1SP3), r^2(P6,1SP6), r^2(P10,1SP10) are 0.837235152, 0.771773464, 0.88997 respectively. This indicates that the material had lost its consistency to a very large extent in thickness direction and laterally. In the centre region the blanket almost completely lost its uniformity. It is equally serious in the other two regions. This implies that at higher levels of torque the blanket is unable to withstand the stress due to smash resulting in non-uniformity and low resilience. This could be attributed to the voids and weak spots in the underlying layers of the blanket resulting in heterogeneous behaviour. The same is evident in *Figure 4*.

6. Conclusion

From the above analysis it is clear that at 55Nm torque both blankets had good consistency under normal conditions. In smashing conditions blanket 1 had better resilience than blanket 2.

At 65Nm torque both blankets had very good consistency under normal conditions and tone reproductions were better than those of 55Nm. In smashing conditions, the resilience was better in the case of blanket 1. This implies that optimal tightening of the blanket could be around 55 to 65Nm for blanket 1 and 65Nm for blanket 2.

At 75Nm torque both blankets had good consistency in normal conditions. In smashing conditions blanket 2 behaved in a highly inconsistent manner due to low resilience which was varying in different regions implying poor internal structure ruptured at higher torque. This particular blanket is therefore extremely sensitive to indentations and blanket tightening.

The above phenomenon can be attributed to the tensile or compressive shear strains in the nip *(Bould et al., 2006)*, to which the blankets are subjected at higher torques and indentations resulting in the consistency of the material which is affected in thickness direction, as well as in different regions of the blanket.

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