The effect of printing blankets on the rolling condition of printing cylinders

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Abstract: The correct rolling condition is one of the most important aspects in a printing press. Different surface velocities of two unwinding cylinders in the nip lead to slip which causes undesirable effects like sluring or asymmetric power transmission in the case of individual drives. Therefore a experimental setup was developed which mimics a printing couple, consisting of one form and one blanket cylinder, with the diameters of a real printing machine which allows to adjust the indentation of the blanket precisely and measure the revolution frequency of the cylinders with sub-promille resolution. At various impressions the transmission ratio between blanket and plate cylinder was determined for a variety of blankets and the results were compared to the ideal compressible / incompressible case. The results show that a blanket-specific material constant can be defined which describes the effect of printing blankets on the rolling conditions of the cylinders. This semiempirical material constant allows to optimize the rolling conditions of printing cylinders already in the design phase of a webpress construction.

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Introduction

In the litho offset process the pressure that is essential for transmitting the printing ink is produced by the indentation of the blanket in the printing nip. Due to the partial incompressibility this indentation causes a virtual increase of the circumference of the blanket cylinder with respect to its geometric dimension, which depents on the indentation depth and the used blanket. The unwind process of blanket and form or impression cylinder was investigated in several publications. The first "contact rolling experiment" was done by Willer (1960). He investigated the unwinding process of two cylinders of equal diameter one bearing a blanket under pressure. One of those cylinders was external driven and the second cylinder was driven by friction. He measured different numbers of revolution of both cylinders and assumed that the surface of the blanket cylinder is stretched which causes a increased effective diameter of the blanket cylinder (Figure 1).

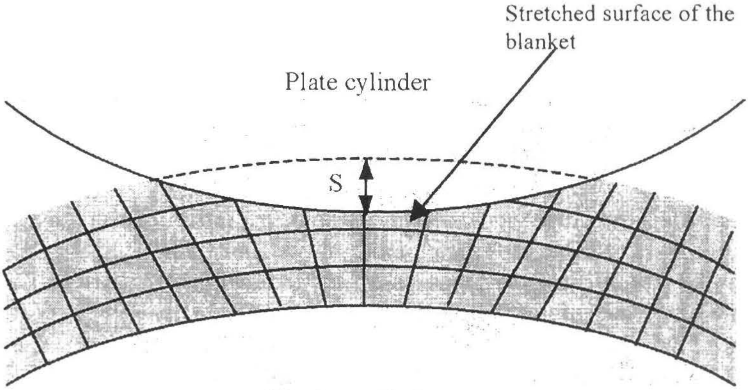

Figure 1: Stretched surface of the printing blanket in the printing nip

Based on his experiments he derived the appropriate diameters of the printing cylinders. Heyne (1978) investigated with a similar test device the rolling condition of blanket cylinders under pressure. He proposed that each printing blanket has his own rolling characteristic which varies with the blankets' indentation. This means that the rolling behaviour of the used printing blanket must be taken into consideration when determining the cylinder diameters or the packing. In his publication he calculated analytically the transmission ratio between rubber and plate cylinder depending on the indentation with the help of the equation of continuity. Based on this equation we define in our investigation two ideal cases for the transmission ratio between form an blanket cylinder, the ideal compressible and an ideal incompressible case. Since a real printing blanket is composed of compressible, e.g. microcellular layer or fabric, and incompressible layers, e.g. the rubber surface, the transmission ratio between form and blanket cylinder is restricted by these two ideal cases. With the comparison of these two ideal cases with the measured transmission ratio for various indentations a semiempirical material constant can be defined which describes the rolling condition of the tested blanket. With this material constant the influence of the blanket can be quantified and so it is possible to take the blanket specific properties regarding rolling condition into consideration when fixing the cylinder diameters of a webpress construction.

Rolling condition of printing cylinders

Depending on the indentation depth of the blanket the deformation in the printing nip causes a effective diameter of the blanket cylinder that is different from its geometric diameter. To calculate the transmission ratio of the cylinders analytically we started out with the considerations of Heyne. Assuming an ideal compressible packing the packing is compressed and the effective radius of the blanket cylinder reduces with increased indentation S (Figure 2).

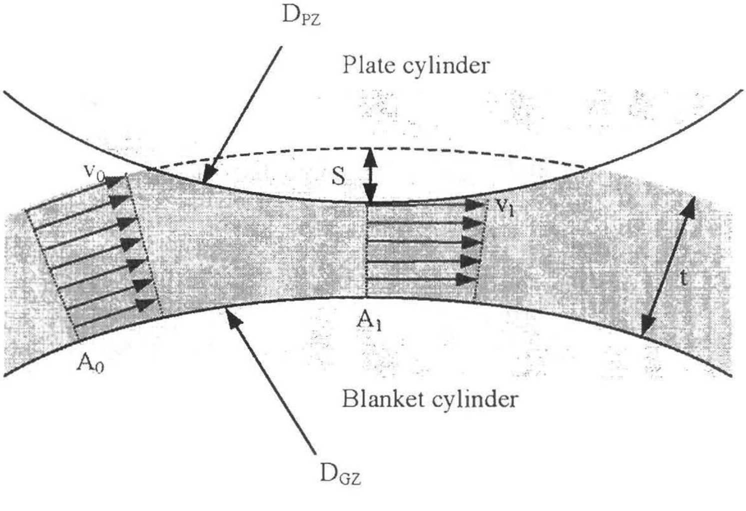

Figure 2: *Ideal compressible medium* passing the printing nip

The effective radius is reduced by the value of the indentation S in the connection line of the centers of blanket and plate cylinder:

$$D_{wGZ} = D_{GZ} + 2 * (t - S) \qquad (1)$$

with,

D_{wGZ}: effective diameter blanket cylinder
D_{GZ}: nominal steel-diameter blanket cylinder
t: thickness of the blanket
S: indentation of the blanket

Defining the transmission ratio between blanket and plate cylinder as

$$I = \frac{n_{GZ}}{n_{PZ}} = \frac{\omega_{GZ}}{\omega_{PZ}} \qquad \text{with} \qquad \omega = \frac{2 * v}{D} \qquad (2, 3)$$

with,

I: transmission ratio
$n_{GZ, PZ}$: number of revolutions blanket / plate cylinder
$\omega_{GZ, PZ}$: angular velocities blanket / plate cylinder
S: indentation of the blanket
v: surface velocity
D: diameter

the transmission ratio in the compressible case can be written as

$$I_{comp} = \frac{2 * v_1 * D_{PZ}}{D_{wGZ} * 2 * v_{PZ}} \qquad (4)$$

with,

I_{comp}: transmission ratio in the compressible case
v_{PZ}: surface velocity plate cylinder
v_1: surface velocity blanket cylinder in the connection line of the centers of blanket and plate cylinder
D_{PZ}: Diameter plate cylinder

In the case of true rolling, which means that there is no slip between both cylinders, the surface velocities of blanket and plate cylinder are equal. So a formular for the transmission ratio in the compressible case can be written as

$$I_{comp} = \frac{\omega_{GZ}}{\omega_{PZ}} = \frac{D_{PZ}}{D_{wGZ}} = \frac{D_{PZ}}{D_{GZ} + 2*(t-S)} \quad (5)$$

On contrary, in the case of an incompressible medium transported through the printing nip, the contraction in the nip leads to a higher transport velocity of the blanket material to reach the same mass transport in the nip than outside (Figure 3).

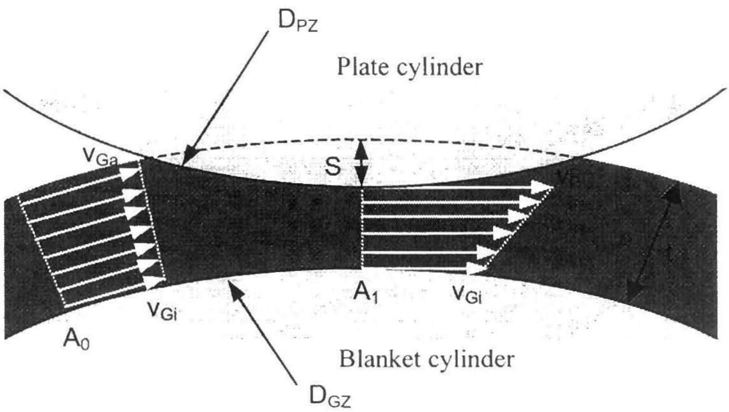

Figure 3: *Ideal incompressible medium* passing the printing nip

Therefore, the continuity equation for mass transport implies that the mass transport before (A_0) and in the printing nip (A_1) must be equal

$$A_0 * v_0 = A_1 * v_1 \quad (6)$$

with,

A_0: blanket cross section before the nip

A_1: blanket cross section in the nip (in the connection-line of the centers)

v_0: average transport velocity of the incompressible medium before the nip

v_1: average transport velocity of the incompressible medium in the nip

The cross sections before and in the printing nip are given through the thickness of the blanket or distance of the two cylinders and the width of the blanket:

$$A_0 = L * t \qquad A_1 = L * (t - S) \tag{7, 8}$$

with,

L: width of the printing blanket

Assuming a linear velocity profile in the nip and taking into account that the boundary velocities of the blanket are equal to the surface velocities of the cylinders, the integration over the velocity profile must yield the average velocitiy. So the equation of continuity (6) can be rewritten as

$$t * \left(\frac{v_{Gi} + v_{Ga}}{2} \right) = (t - S) * \left(\frac{v_{Gi} + v_P}{2} \right) \tag{9}$$

with,

v_{Gi}: Surface velocity of the steel-diameter of the blanket cylinder
v_{Ga}: Surface velocity of the blanket
v_P: Surface velocity of the plate cylinder

With equation (3) for the angular velocity and after several simplifications the transmission ratio in the incompressible case becomes:

$$\boxed{I_{incomp} = \frac{\omega_{GZ}}{\omega_{PZ}} = \frac{D_{PZ} * (t - S)}{D_{GZ} * (t + S) + 2t^2}} \tag{10}$$

Thus two expressions (5, 10) for both ideal cases have been derived in which only geometrical parameters appear. Figure 4 shows the transmission ratios for the ideal compressible and the ideal incompressible case as a function of the indentation (S) of the blanket.

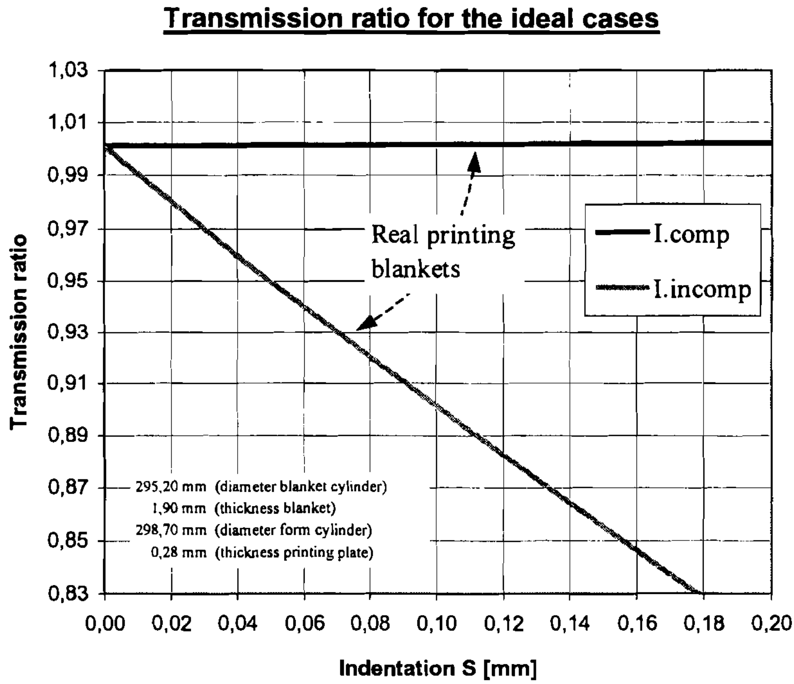

Figure 4: Transmission ratio for the ideal cases as a function of the indentation of the blanket

Experimental setup

The experimental setup was specially designed for this "rolling contact experiments". It mimics a real printing couple, consisting of form and plate cylinder without damping and inking unit. The plate cylinder bears two printing plates and in the blanket cylinder is equipped with two lock up systems for metal blankets as well as fabric back blankets. One of the cylinders is driven by external means while the other one is driven by friction. Thus there is no ideal "true rolling" because of the necessary slip to drive the second cylinder by friction. But this deviation of the ideal true rolling condition is minimized by super precision bearings with small friction to produce errors in the transmission ratio below 0,015 %. The setup was optimized to enable high precision and reproducable indentations of the printing blanket. A special mimic allows to vary the distance between the two cylinders very precisely and to find out the point of no indentation. The angular velocities are measured by opto-electronic angle decoders on the axes of both cylinders. A specially designed subsequent electronic allows to measure the angular speed of the cylinders in sub-promille resolution. Figure 5 shows a schematic drawing of the testing device.

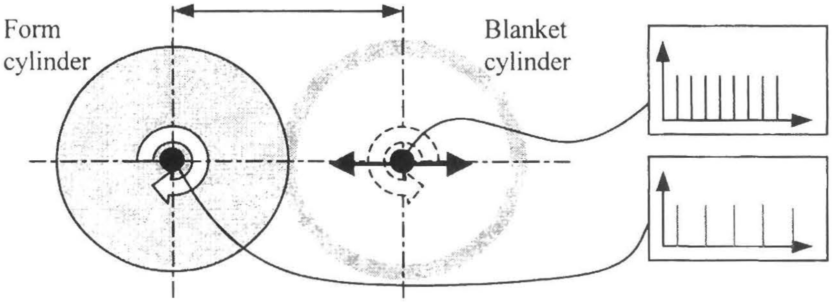

Figure 5: Schematic drawing of the testing device

Table 1 shows some technical datas of the test setup and items regarding the reproducibility of the measured transmission ratio.

Diameter of the cylinders	300 mm
Blanket width	300 mm
Maximum rotation frequency of the cylinders	700 rpm
Reproducibility of a true rolling measurement	< +/- 0,01 %
Reproducibility of the indentation	5 μm

Table 1: Some technical data of the true rolling test device

Experimental Results

So far with this experimental setup we have investigated estimately 20 different fabric blankets straight from the factory from 4 manufacturers regarding their rolling conditions. The transmission ratio was measured for several indentations of the blankets at fixed rotation frequency of the cylinders. These experimental results can also be put into a graph similar to figure 4 as a function of the indentation (see figure 6).

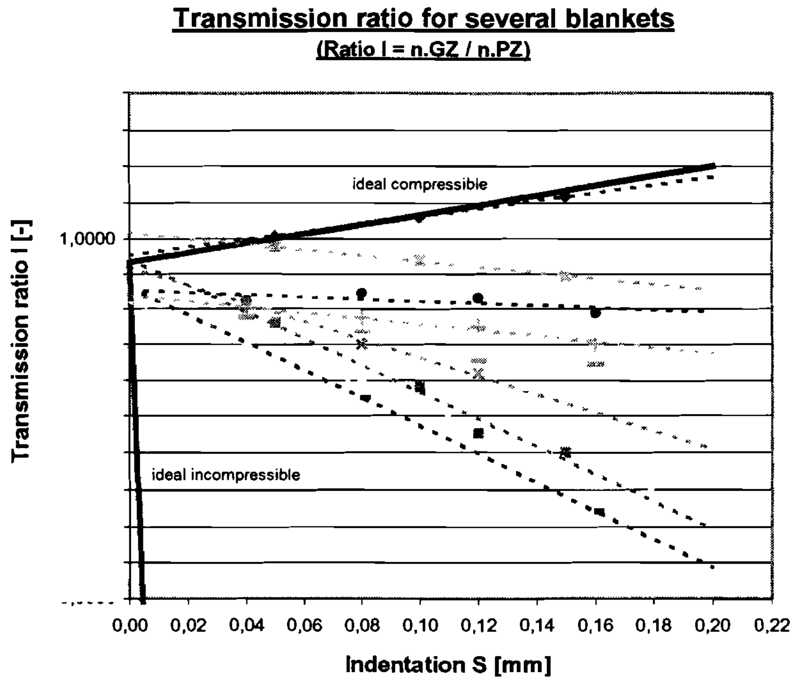

Figure 6: Measured transmission ratio for several indentations and different blankets. There are also shown the ideal cases as a function of indentation

As shown in figure 6 the experimental data can be fitted by a linear polynom. The lines hit in good approximation the intersection of the two lines describing the ideal cases. The visible offsets to the intersection of the ideal cases are caused by different thicknesses of the various blankets. Due to the assumed linear behaviour of the curves, an even more reduced model can be found. This will be explained in figure 7.

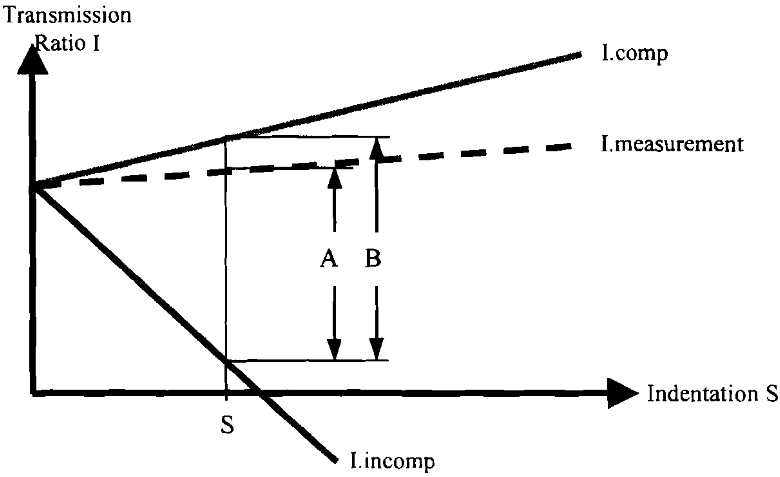

Figure 7: Simplified curves of the transmission ratio as a function of indentation

On the assumption of linear behaviour the ratio between A and B is a constant value, independent of indentation S: We named this material constant α, it describes the rolling condition of the blanket:

$$\alpha = \frac{A}{B} = \frac{I_{real} - I_{incomp}}{I_{comp} - I_{incomp}} \tag{11}$$

with,

α: semiempirical material constant
α=1 → ideal *compressible*
α=0 → ideal *incompressible*

A: Difference between measured and the ideal incompressible transmission ratio for the current indentation

B: Difference between ideal compressible and ideal incompressible transmission ratio for the current indentation

I_{real}: measured transmission ratio as a function of the indentation

I_{comp}: transmission ratio for the *ideal compressible* case

I_{incomp}: transmission ratio for the *ideal incompressible* case

The found material constants of the tested blankets are in a range between 0,97 up to nearly 1,00. This means that the blankets are close to the ideal compressible case, perhaps caused by the microcellular compressible layer presently used by all manufacturers. Most of the investigated blankets showed the assumed linear behaviour. The very few exceptions mainly correlate to new developments aimed to reach a more compressible behaviour. These exceptions will be investigated closer in our series of experiments. There various blankets for heatset, coldset or sheetfed applications from seveal manufacturers will be tested. The defined material constant (α) allows to quantify the rolling conditions of printing blankets independently of a given cylinder-geometry. Indeed several experiments we carried out at web presses showed that this blanket specific constant (α) is transferable to cylinder geometry different from those in the testing setup. This enables the designer to calculate the transmission ratio of blanket and plate cylinder in the phase of design with equation (12) and the help of the equations (5,10).

$$\boxed{I_{real} = \alpha * (I_{comp} - I_{incomp}) + I_{incomp}} \qquad (12)$$

with,

α: material constant of the used blanket

I_{real}: expectable transmission ratio

Conclusions

We have seen that the effective diameter of the blanket cylinder can vary considerably depending on the used blanket and the adjusted indentation depth. In a printing couple the cylinders are forced on the same angular speed by means of gears or single drives. Due to the synchronized angular speed there is more or less slip created in the printing nip between blanket and plate cylinder in the case of different effective diameters. This slip causes worse print quality, e. g. slur or soft dots, and further leads to tangential forces in the nip which increases plate wear. With the material constant α the increase of the effective diameter of the blanket cylinder can be quantified and so the steel-diameters of the cylinders or the packing can be optimized for "true rolling" in web presses.

Further proceeding

In a new series of experiments, which covers estimately 70 blankets, we will investigate the influence of aging, chemicals like ink or washing agent, the difference between production cycles in printing blanket manufacturing and the rolling behaviour of the blanket during their lifetime.

If

- all or at least most of the blanket samples show the assumed linear behaviour (11)
- the effect of mentioned influences is not too high

this material constant could be a new characteristic parameter of printing blankets, beside the present technical information like thickness, elastic modulus, surface roughness etc.
To provide the blanket manufacturers a certain range in tolerance of this material constant the measured range (first number of series α=0,970 ... 0,999) might be divided up into several groups, which are specified when ordering a printing blanket. This would enable an optimal working operation of printing presses for both, the press manufacturer and the final user.

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