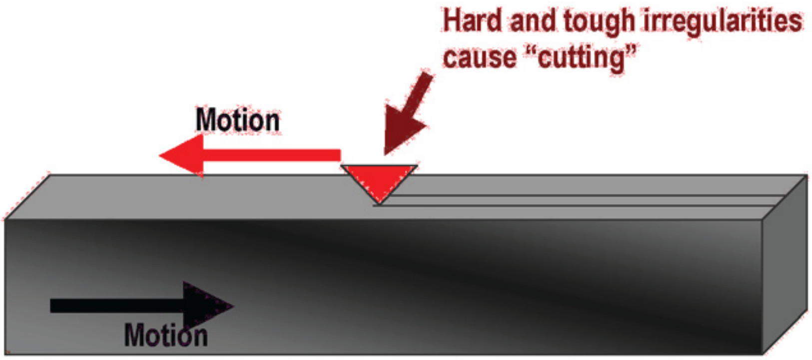

Figure 1

Why is it OK to Use Ceramic Blades on Ceramic Rolls and Cylinders?

By Michael Paczkowski

In recent years, some "exotic" wear-resistant doctor blades have been introduced to the printing industry based on the material behavior of ceramics. There is certainly a great deal of precedent in many industrial processes for the wear-resistant nature of ceramics and the longevity of such components. The tremendous economic benefit of increased productivity that results from more consistent printing quality and less waste has been addressed in previous papers and presentations; but what about the less tangible effect of these blades on the cylinders?

For flexo printing, the longevity and integrity of the laser-engraved anilox cylinder is of critical importance. In this paper we will address the nature of wear and discuss the interaction of the doctor blade with the cylinders to which they are applied.

In the printing process, where a stationary doctor blade is used against a rotating cylinder, there is inevitably a degradation of both the blade and the cylinder surface. We casually call this phenomenon wear. There are, however, two distinct aspects of wear; abrasive wear and friction. Understanding these different mechanisms and the interactions of various materials is the key to understanding observed results when at times these results are almost counterintuitive.

FACT #1

Abrasive Wear Is Dependent Upon

1. Roughness of the two surfaces.
2. Hardness of the materials.
3. Fracture toughness (brittleness).

Remember: Even if material is very hard, and it fractures when contacting an opposing surface, it cannot cause abrasion.

ABRASIVE WEAR

The first type of wear to be addressed is that of abrasion. The component of wear that is due to abrasion can be thought of as the "cutting" of one surface by the other (Figure 1). Particularly with respect to flexo printing and the laser engraved ceramic anilox cylinder, this is the primary wear mechanism.

The degree to which this mechanism occurs is dependent on the roughness of the two surfaces, the hardness of the materials, as well as their "fracture toughness." Hardness is, of course, a concept most of us can relate to; however, fracture toughness is perhaps not so clear. In the field of material sciences; Fracture Toughness = KIC (MPa$\sqrt{m}$). Without going into the mathematics of this term, the easiest way to address this concept is to think of it like brittleness. For example, a fine china cup can be very hard but if it is dropped on the floor it readily shatters; it is not very "tough." So even if a material is very hard, and it fractures when contacting an opposing surface, it cannot cause abrasion. When designing a ceramic doctor blade tip, it is therefore quite important to take into consideration the nature of the cylinder surface it will run against.

In Table 1, several materials are listed along with their hardness and toughness values. The term "ceramic" in the table is being used generically and actually refers to a family of metal oxides. The wide range of hardness reflects this. Being able to select an appropriate ceramic material for the specific application is the key to producing a doctor blade that is safe for the cylinder surface should there be a direct contact or clash of the two surfaces. The safest choice for

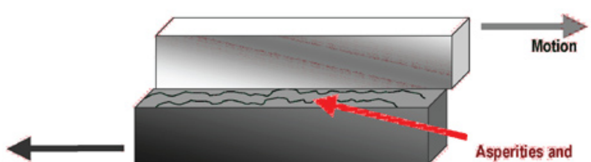

FIGURE 2

	Toughness, KIC [MPa $\sqrt{m}$]	Hardness, HRC (Rockwell)	Hardness, HRC (Vickers)
Hard Chrome plate	6-7	67-70	900-1100
Anilox cylinder (CR2O3)	3-4	74-78	1200-1300
Steel blade	50	50-55	513-594
Tool steel (blade tip)	8	60-64	700-800
Ceramic blade tip	3-5	65-76	800-1300
TiO2 Pigment (white ink)	3-4	67	900

Table 1. Material properties of typical ink train components.

Blade material	Ceramic 1	Ceramic 2	Ceramic 3	Steel
Max temperature reached (°C)	112	133	112	180

Table 2. Maximum blade temperatures achieved under laboratory conditions.

the lower-hardness chrome cylinder would be a ceramic blade tip with its hardness on the lower end of the scale, whereas for a ceramic anilox cylinder a much harder ceramic material can be chosen to take advantage of its greater wear-resistance but yet still be in a safe range for the cylinder surface.

In the actual printing process we do not have a simple system of one dry surface running against another. The ink or coating being used adds a third and very critical component. The ink film that is dragged along the cylinder surface by shear forces at high speed forms a thin film that acts as a barrier between the blade tip and cylinder surface, keeping these two surfaces a very small distance apart. This thin film can be lubricating in nature or, in the opposite extreme, it can be extremely abrasive in itself. Due to the intimate contact of the ink film with the surfaces of both the blade tip and the cylinder it can be said that this is the primary mechanism for abrasive wear for both components. Using the example of white ink, where the primary pigment component is titanium dioxide, and noting its physical properties in the above table, it is easy to see how it can be the most critical factor in wear.

FRICTION (ADHESIVE WEAR)

Contrary to earlier explanations, kinetic friction is now understood not to be caused simply by surface roughness alone but by chemical bonding between the surfaces. The more chemically similar two surfaces are, the greater the mutual solubility of the materials and the greater the bonding. This phenomenon is most prevalent in gravure printing where two metallic surfaces, the steel blade tip and the chrome cylinder surface, come together intimately, particularly in the non-image areas of the cylinder.

On a microscopic scale (Figure 2), there are high spots and low spots on both the blade tip surface and the cylinder surface. Where the high spots meet, there is an extremely high specific pressure generated at this point which causes a bond. As the surfaces momentarily bond and then instantaneously break free, material is transferred and energy released. This is frictional wear. Friction is therefore not a fundamental force and so cannot

FACT #2
Ink or Coating is a Critical Component Because it:

1. Forms a thin film that acts as a barrier between the blade and cylinder.
2. Can be either lubricating or abrasive.

Remember: Due to the intimate contact of the film with the surfaces, ink is the primary mechanism for abrasive wear.

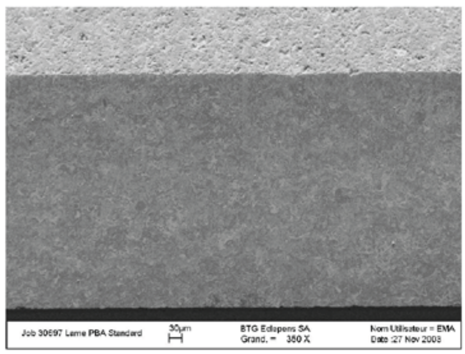

Figure 3a

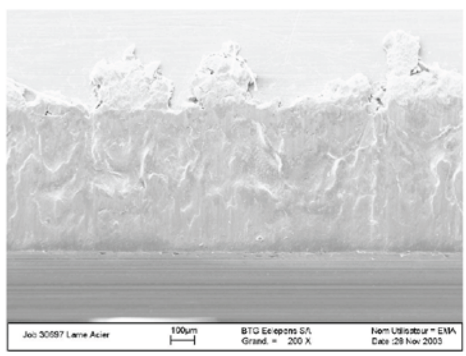

Figure 3b

be calculated from first principles, but instead must be found empirically with tedious attention given to all details of the system studied. There is, however, one very simple and telling indicator of friction and that is heat generation. Ceramic material has little tendency to make such microbonds and therefore exhibits very low frictional properties against metallic surfaces, hence develops less heat.

In Table 2, the operating temperature of various doctor blades were measured in a laboratory test. The blades were run against a non-lubricated hardened steel cylinder to deliberately accelerate results to a failure condition. The various ceramic materials all ran far cooler than the steel blade giving clear evidence of far less friction.

Microscopically examining the worn blade tips from this experiment also reveals very interesting differences in the nature of the material wear. In Figure 3a, the ceramic blade tip contact area is completely unaffected by the harsh conditions, whereas the steel blade tip in Figure 3b exhibits the characteristic plastic deformation and material loss of a typical blade steel. The metal shavings or burs generated in this test—and as seen coming off the blade tip in Figure 3b—are not unlike the tramp metal commonly found in the ink systems on presses and often attributed to the scoring of printing cylinder surfaces.

Friction Facts:

1. Kinetic friction is caused by chemical bonding
2. The more chemically similar surfaces are the greater the bonding
3. A telling indicator of friction is heat generation

Remember: Ceramic material exhibits very low frictional property against metallic surfaces, and thus develops less heat.

CONCLUSION

The need to optimize the practices and materials in the pressroom and to strive for greater productivity is ever increasing. The use of the newly available state-of-the-art doctor blades can be a significant contributor to this goal with their extreme long life and print quality improvement potential. The effect of these doctor blades on the cylinder surface is not only safe but actually healthier in many ways than conventional steel blades. With the proper design and specification of the type of ceramic to match to the cylinder material surface, abrasive wear can be avoided, friction significantly reduced and metal slivers in the ink eliminated. ■

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