Anilox rolls – what is a build up and why is it necessary?

By Art Ehrenberg

Typically when a customer is given a quotation for the cost of reconditioning an anilox roll it is based on the total square inches of the engraved surface and the line screen of the engraving. This is common among most anilox manufacturers. This cost includes incoming inspection of the roll, all machining services, application of a super alloy bond and corrosion barrier coating, application of the ceramic coating, grinding and polishing of the ceramic, laser engraving and a final inspection, and administration fees. The cost does not include what is typically referred to as «build up» or repairs to bearing surfaces and other areas of the rolls journals.

To explain let us start with an anilox roll manufactured from new which was supplied with the new press. This roll would typically have a ceramic coating applied directly over the steel roll to a thickness of between five to ten thousandths (0.005”–0.010”) per side on the diameter.

After the engraving has worn out or in the unfortunate event of damage, the roll is returned to the anilox roll provider for reconditioning. The ceramic layer is stripped from the core of the roll to prepare it for a new coating. When this is done a small amount of the core is also removed. After multiple reconditioning procedures the core diameter will be decreased to a point where ceramic alone could not be used to restore the lost diameter. Therefore it becomes necessary to apply metal (a «build up») to the roll prior to the new ceramic covering and thus additional charges for the additional work and raw materials are imposed.

The reason for ceramic not being used in excess thicknesses is two fold and very important to understand. First of all, the cost of the ceramic process and raw materials is high compared to metallic coatings. Secondly, and most importantly, ceramics are not ductile materials and are prone to micro cracking when thicknesses exceed certain limits which is due to tension stresses which are set up in the coating during its application. The ceramic coating is created from ceramic powder which is melted in a plasma heat source and applied to the roll. As the melted particles impact the surface of the roll they solidify and tension stresses begin to build up. To produce high quality laser engraved ceramic, the particles of the raw ceramic material must be very small and controlled. The physics involved in ceramic spraying with regards to tension stress will dictate the thickness of the ceramic coating based on the particle size of the raw material. The smaller the particles in the powder, the greater the tension stresses in the coating and the greater the risk of micro cracking.

Usually micro cracking in a ceramic coating is difficult to detect with the naked eye if not impossible. If the ceramic coating is micro cracked it will produce cells walls which are very prone to fracture and the roll will have a shorter working life. Micro cracks will also create an conduit for inks and cleaners to reach the base of the roll and possibly corrode it.

The metallic build up materials and the way in which they are applied is a critical element in the quality of the anilox roll and the long-term costs.

There are two basic methods used to apply the metals necessary to rebuild the lost diameter of the roll core. One is welding and the other is thermal spray.

With welding, the metals that are applied are metallurgically bonded to the core and are 100 percent dense. This means that the weld-applied metals cannot delaminate from the original core and inks and cleaners cannot penetrate them. This makes the weld build up reusable for
the next reconditioning of the roll and possibly for two or three additional reconditioning procedures depending on the diameter tolerance. This will save hundreds and even thousands of dollars on future re-engraves.

Eventually after multiple reconditioning the core diameter will again fall to a point which will require more welding however it would never again be necessary to add or pay for the original amount of build up that was applied in the first reconditioning.

In contrast, the thermal spray methods of applying metals are only mechanically bonded to the roll core. With most conventional thermal spray methods the metallic coatings are between 70–90 percent dense, leaving them 10–30 percent porous. Therefore inks and cleaners will migrate into the porosity especially at the ends of the roll which will contaminate the coating making it non-reusable. Some anilox roll manufacturers will try to salvage this old coating. But be careful, these rolls are highly susceptible to what is called "blistering". This is where the ceramic did not adhere properly to the contaminated build up and the ceramic delaminates from the surface. Or it could be that the contamination worked its way to the roll core and corroded it pushing the metal build up and the ceramic coating up in a lump or a blister. Thermal spraying is a very acceptable method of restoring diameters to anilox rolls and repairing bearing surfaces but again, it is not a reusable material.

For example a roll needs a build up of fifty thousandths of an inch and the build up is thermally sprayed. The next time the roll is reconditioned all the old thermal spray metal will have to be removed (because of the contamination) along with a small amount of the core and again there will be a cost for a build up. But now 60 thousandths of an inch may be needed because the core metal was removed during the stripping of the ceramic. With this roll, over time, the core will continue to shrink during subsequent reconditionings and build up costs will continue to rise.

Now you might ask, "why then aren’t all rolls welded to save money on the next reconditionings?" The answer has to do with the wall thickness of the core of the roll. The majority of wide web and corrugated anilox rolls are hollow tubes with welded end journals. If the wall thickness of the original tube is not thick enough the weld process can distort or warp the tube due to the heat input of the welding process. If this happens there is a real problem. Therefore rolls constructed of thin walled tubing are not welding candidates.

As stated earlier, bearing surfaces are also built up to restore their original size and condition by both the welding and thermal spray methods. Most of the same mechanics used in the reconditioning of the roll core apply to the bearing surfaces so, it is best to weld the bearing surfaces if possible for the same reasons for welding the roll core. There are however, just as with the roll core, some limitations which are sprayed. In both cases, if done incorrectly the journals can break off during use usually at the shoulder of the bearing surface. This is due to two primary factors. Either the weld has case hardened the original journal material making it brittle, or in the event of a thermal sprayed surface, the original diameter of the bearing surface was turned too far undersize and the stability of the journal was compromised.

The anilox manufacturers which have welding capabilities use automated welding fixtures that are specifically made for rollers or shafts. The weld methods used on these fixtures are a form of mig welding, either submerged arc or gas shielded arc.

Thermal spray applications are a different animal and are not widely known to the general public like welding, however they are used widely in a surprisingly large amount of applications around today and have a very interesting history. The earliest forms of thermal spray date back to the early 1900’s when a Dr. M. U. Schoop of Zurich/CH developed a device that fed molten metals into a gas stream. The gas stream propelled the molten metal onto a surface thus creating a metal coating. A few years later he experimented with injecting metal particles into a flame to create the stream and then metal wires. Years later as the process developed it became known as metallising. The first commercial sales of these metallising spray devices can be traced back to the 1920’s. The technology was transferred to the United
States in the early 1930’s and soon U.S. manufacturers of the equipment emerged.

Some of the first applications produced in the U.S. were corrosion protective coatings of Zinc and Aluminium on the insides of railroad cars, coal barges, water tanks etc. By the mid to late 1930’s there were approx. 35 thermal spray shops in the U.S. and North America. By this time applications had expanded to items such a laundry machinery, aeroplane manifolds, shafts, brake drums, castings, etc.

When World War II came industry in the U.S. was put under great pressure to keep up with manufacturing needs. Due to its economical impact, thermal spray became a popular method of replacing damaged and worn parts for the military effort.

Up until the 1950’s, metallic coatings were the only coatings being applied by the thermal spray methods. Then came the spraying of ceramic coatings. Some of the first ceramic coatings were produced by melting ceramic materials in rod form with oxygen/acetylene flames. Later, the application of using super hot plasma’s to melt ceramics in powdered forms was introduced.

Plasma is a super hot ionised vapour which is produced by passing a strong electric current through a gas. The gas molecules are stripped of their electrons and the result is heat. Ceramic powders are then fed into the plasma, melted, and propelled on to a surface to create the coating. In the 1960’s plasma applications really began to take off. The plasma coating methods are preferred to create ceramic coatings because of the high melting temperatures of the ceramic materials however, they are also used to create metallic coatings.

In the early 1970’s the first ceramic coated anilox rolls were introduced to the flexographic printing industry along with other thermal spray methods used to restore old worn anilox rolls to «like new» condition. In fact Harper Corporation was the first anilox roll manufacturer to successfully apply ceramics for anilox rolls used in the corrugated box converting industry.

Today there are many methods used to create thermal spray coatings. One of the more popular applications used to perform the «build up» on an anilox roll is called twin wire arc. This is where two wires are electrically charged and fed into a special gun which gun unites the wires and the resulting electric discharge melts them. The wires continuously feed together and melt while air pressure comes from behind and atomizes the molten wire turning it into an aerosol like state and propels it onto the roll to create the coating.

For very special corrosion resistant coatings an application called HVOF - «high velocity oxygen fuels» can be used. This process is very similar to the operation of a rocket or jet engine. In this process we feed a few thousand cubic feet of oxygen per hour and about five gallons of jet fuel per hour into a chamber and ignite it. The explosion exits a gun barrel and creates a jet stream with a velocity of over 5,000 miles per hour. We then feed powdered metals into the jet and they are propelled onto the surface at about 2,600 miles per hour. The resulting impact creates kinetic energy, which melts the particles onto the surface. This creates a very dense coating of usually less than one percent porosity which provides excellent wear and corrosion resistance. HVOF coatings have rather limited coating thickness compared to other thermal spray methods and are usually used for specialty topcoat applications. Today, for example, hydraulic cylinders on aircraft landing gear and construction equipment are no longer chrome plated but HVOF sprayed and polished tungsten carbide coatings. They are also used for corrosion build up barriers under other coatings such as ceramics. One of the advantages of HVOF for anilox production is the ability to provide a very dense corrosion resistant coating to a roll which, due to the wall thickness of its core, could not be welded and therefore would not stand up very well to corrosion with a conventional thermal sprayed coating. Today thermal spray is used in many applications including:

- Jet engine components,
- landing gear,
Anilox Rolls

- biomedical implants (hip joints, tooth anchors etc.),
- hydraulic cylinders,
- piston rings,
- cylinder bores,
- land based turbine blades and components,
- infrastructure repair such as bridge supports,
- boiler tubes,
- holding tank liners,
- paper making rollers etc.

As the technology continues to grow and develop more applications are being introduced. Whatever the application, much care needs to be taken in order to produce high quality coatings which will provide the necessary attributes for the intended function of the coating.

In order to produce high quality coatings which will perform their function many factors must be understood and addressed:
- the preparation of the surface to be coated;
- the composition of the surface to be coated;
- the ceramic and metals material chemistry;
- the ceramic and metals material physical properties;
- the devices used to melt and apply the materials;
- the gases and compressed air used in the processes;
- the operating parameters of the equipment;
- understanding how to properly metallurgically evaluate the coatings;
- coefficient of expansion of materials;
- proper operational and metallurgical training of operators must be optimised.

Attention must be paid to all the above points especially for the production of anilox roll ceramic coatings for laser engraving, in order for the laser to perform proper engraving. The laser will not compensate for irregularities in the ceramic coating therefore the ceramic coating is by far the main controlling factor of a quality roll. So now we have discussed the infamous «build up», why it is needed and how it is applied on metal rolls.

What about carbon fibre anilox rolls? Do they need build up? Carbon fibre or «light weight» rolls as they are sometimes called are becoming popular in certain industries. This is due to ergonomics, roll deflection, stresses on press drive trains etc. With these rolls the roll core is made of carbon fibre or in some cases a form of fibreglass not metal. So what about a build up? Well, the truth is, all the carbon fibre anilox rolls that the author is aware of are sprayed with a metal using one of the thermal spray methods mentioned. This is due to the fact that ceramics don’t like to adhere to carbon fibres for many reasons. One is the epoxy’s used to hold the carbon fibres together and the fact that the co-efficient of expansion between the carbon fibre and the contraction or tension stresses in the ceramic coating make for a very weak if any bonding strength. Therefore a metal layer is thermally sprayed onto the carbon fibre core. Certain metals adhere well to the fibres and this sets up the base for the ceramic coating to be applied. So these rolls already have a build up on them from the start and will need a build up every time they are reconditioned. How the anilox vendor chooses to address the costs of the build up now and in the future is a question concerning the long term cost of ownership of these rolls.

Summary

- «Build up» or «diameter restoration» is a very important/necessary process that is used on all reconditioned anilox rolls at some time during its life.
- The quality (or lack of it) which includes not only the materials but the methods used to apply them can be a determining factor in the life and cost of anilox rolls.
- Either a weld or thermal spray method applies the build up.
- A welded build up will save money over the life of the roll.
- A welded build up can only be used with a roll with a sufficient core tube wall thickness.
- A carbon fibre roll already has a thermally sprayed build up on it.
- A thermal sprayed build up should not be reused during reconditioning if the roll has been subjected to inks and cleaners because of possible adhesion and corrosion conditions which could lead to blistering of the ceramic covering.

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