# Roller Surface Morphology and its Effects on PQ and on Roller Life.

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## Abstract:

*The surface morphology of the printer roller plays a very important role in creating excellent print quality and enhancing the rollers life. In this paper we tried to present how surface roughness, cof, surface tension and surface resistivity impact print quality at various print test conditions. Also, information is presented on a newly developed super sticky non plasticizer based soft polyurethane roller. The data presented here is for Charge roller, Developer roller, Pinch roller and Cleaning Roller.*

## Introduction:

Surface morphology properties of polyurethane rollers are a very complex phenomenon to understand, specifically in printing applications. Some of the important properties are Surface Tension, Coefficient of Friction & Surface Roughness (Ra & Rz) of rollers & tires. Surface properties of elastomer play a significant role in the total operation, whether it is paper feeding from tray, ink transfer through developer roll, charging OPC drum through charge roll or transferring image on paper through transfer roller. Print Quality is highly dependent upon roller surface characteristics.

Presentation will highlight "How surface properties affect component performance on print quality. Surface tension data, surface finish data & COF data will be correlated to print defects, feed problems…etc. Case study will be presented".

Presentation will also cover " Advancement in new PU materials, from highly slippery (Teflon like) to highly tacky (Sticky tape), used in OEM Printer Platforms provides longer life and superior properties."

## Experiments performed:

Several rollers were prepared using TDI and MDI based polyurethane. Manufactured Rollers were "AS CAST" surface and "cast & ground" surface. Some rollers had a secondary thin coating as well. Roller diameters vary from 0.5" to 2". Length of roller varies from 10" to 30". Polyurethane thickness ranges from 5mm to 20mm.

## Characterization of the Roller Properties:

Surface roughness was measured using Profilameter. Roller surface roughness Ra and Rz ranges from 2 micron to 50 micron. Coefficient of friction ranges from 0.45 to 2.5; measured on recycle paper.

Roller surface topography was also measured. Print quality data was obtained through dry ink toner and liquid ink toner based printer. Surface tension data was generated using Dyne Pen. Microscope was used to get the 100X magnified picture of the surface texture of the rollers and coating. Volume and surface resistivity was measured using Pico Ammeter Kiethly.

## Results and discussion:

### *Developer roll:*

For liquid ink DEP printer, AS CAST roller is the preferable choice. Surface finish Rz (Peak to Valley) & Ra (Peak to Peak) value must be lower than 10 micron and 4 micron respectively. If the surface finish value is higher, then toner particles reside into the valley portion of holes and cleaning blade/roller can not remove toner particles during the cleaning cycle, which causes print quality defects in the subsequent cycle. The surface tension of the roller needs to be optimized so that wetting and de-wetting of ink is accomplished during process cycle. Electrical permittivity of roller should be high enough to achieve a good optical density of ink. For dry toner ink, the Coefficient of friction of roller should be very low for a better release of toner during the cleaning cycle.

### *Charge roller:*

For dry toner ink rollers, bulk and surface resistivity values should be close to each other in order to prevent "snow flake" type print defects, especially under 8%Rh & 60F print test condition. Higher roughness of the roller surface causes grainy print; to prevent this PQ defect, Ra & Rz values should be very low. Permeability (migration) of the unreacted chemical from the bulk of the roller material to the surface of the roller should be very low to none in order to prevent any chemical interaction with OPC drum, which causes a microscopic breakdown of the OPC drum surface, specifically if the migrated chemical is highly oxidizing in nature. This problem leads to print defects such as a dark solid line.

High micro elasticity of the material is desired to prevent any cyclic fatigue. The secondary thin coating needs to have excellent abrasion resistance properties, otherwise roller life shortens dramatically. High coefficient of friction leads to surface contamination and creates a thin layer of toner which reduces the working life of the roller.

Roller run out issue causes improper contact and may lead to the print ghosting print quality problem.

### *Pinch roller:*

Inherently, the pinch roller is a dual durometer configuration part. From a functionality point of view, the surface of the roller should not adhere to ink particles and should have very low cof between the paper and top layer to allow the paper to easily slide out under a given high pull force.

Typically, the underneath layer is a soft elastomer and the top layer is a shrink fit Teflon tube. Dual durometer combination is perfect to create the required nip width and good conformability. The Top layer material being Teflon is a good choice due to its high surface tension properties which prevents ink from adhering to the surface of the roller and its low cof helps to lower drag force. Both properties play a dominant role in their application. Typical life of the above configured roller is less than 5 million cycles. Lower life is attributed to low wear resistance of Teflon and also due to the fact that the bonding of Teflon with any elastomer is not quite strong, even if a bonding agent is used between the Teflon and elastomer. Regardless of the life of the roller, surface finish value of the Ra & Rz should be very low to achieve the required performance.

FP developed a dual durometer polyurethane pinch roller, where the underneath layer is a soft PU and top layer is hard PU. The top layer polyurethane formulation is designed and processed in such a way that it's COF, surface tension and Ra & Rz value is very close to Teflon's surface property. Life of this roller is more than 30 million cycles. Higher life is due to the excellent abrasion resistance of the PU and excellent bond between PU and PU.

### *Sticky roller:*

Historically, the sticky roller is made of a silicon material loaded with mineral oil. Mineral oil tends to leach out from the silicon elastomer to the surface of the roller and therefore the surface becomes slippery/non sticky. Migration of oil towards metal causes bond failure between metal and silicon elastomer. Leaching of oil also results in an increase of silicon hardness over a period of time and thus it losses its conformability. The biggest problem is that it contaminates the entire system and the bond between metal and silicon is very weak. Due to the presence of oil, silicon properties weaken dramatically, especially its tear resistance and hence the life of the roller is very low.

Fenner Precision designed and developed a plasticizer free soft (25SA) & extremely sticky roller for use as a cleaning roll in printer application. Cof on recycle paper and on steel plate is > 5 and 3 respectively. Although PU is very sticky, it does not adhere to matting metal roll under dynamic conditions. The applied polyurethane is hydrophobic in nature, so processing oil build up does not occur easily. Even if it's contaminated, it can be easily cleaned with water and/or IPA. Once it is clean, it regains its stickiness properties. Bond between metal and PU is quite strong. In peel adhesion tests, PU breaks before bond failure occurs between the metal and PU. This roller does not leave any residue or stain. Surface finish can be achieved as per desired requirement via grinding.

## Conclusion:

For roller to perform in its given application, one has to pay serious attention on surface properties of roller. Most important surface properties are; surface tension, surface roughness, surface texture, coefficient of friction, surface resistivity, electrical permittivity, micro elasticity of elastomer, conformability, run out, hardness, abrasion resistance and permeability of material.

## Figures:

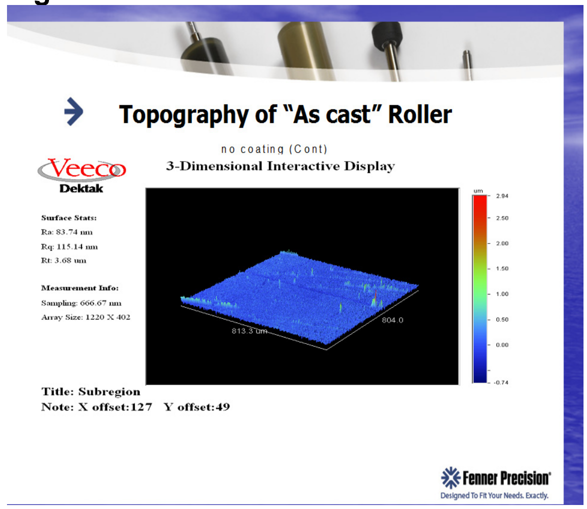


*Figure 1: Surface topography of AS CAST roller, excellent surface finish*

*Figure 2: Surface scan of desirable roller under 200X magnification. No microscopic bubble is observed.*

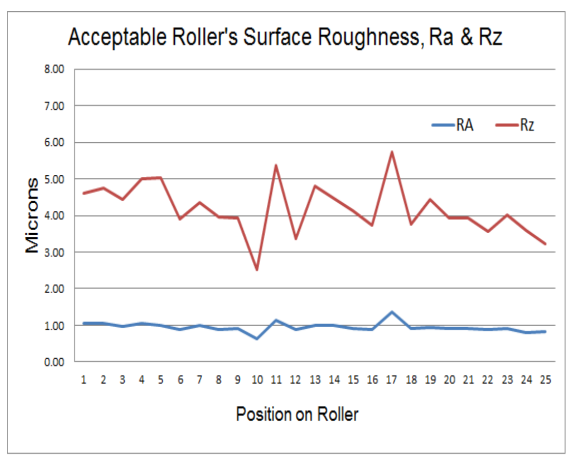


*Figure 3: Acceptable Ra & Rz value of the roller surface roughness.*

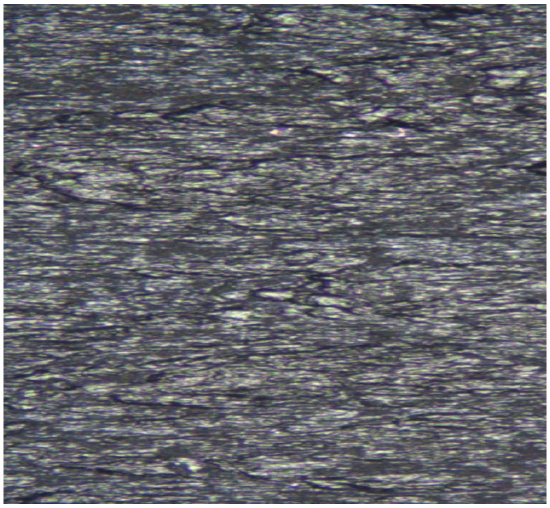

Figure 4: Magnified surface texture of questionable roll which can cause bad print quality.

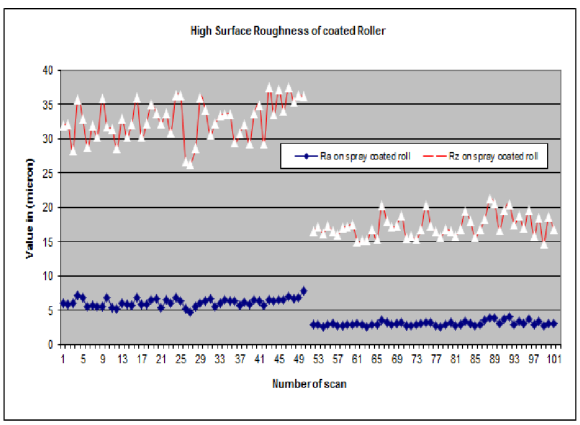


Figure 5: High surface roughness of spray coated roll. Profilameter was used to generate data.

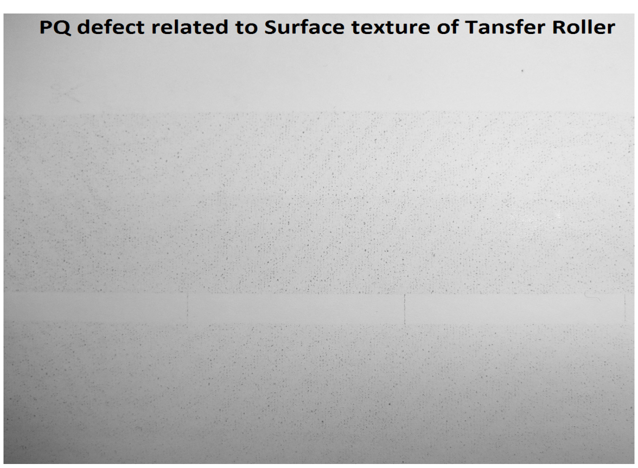


Figure 6: Print quality defect related to surface texture of roller.

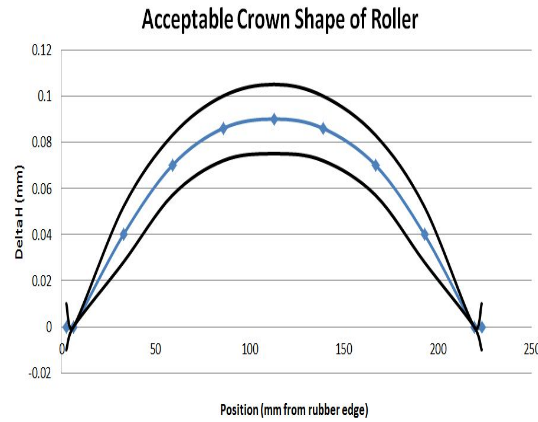


Figure 7: Acceptable crown profile of cast and ground roller to get good PQ.

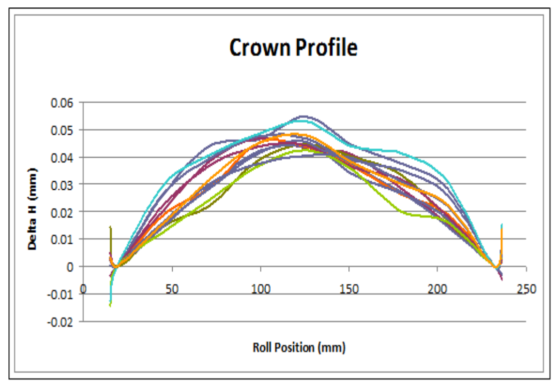


Figure 8: Unacceptable crown profile of ground roller will cause print defects.

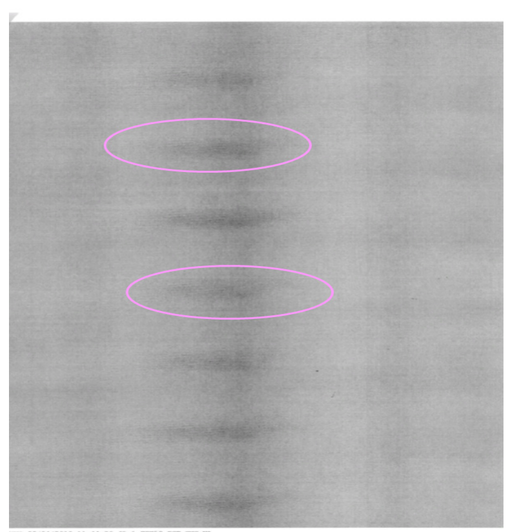

Figure 9: Print quality defects related to bad crown profile.

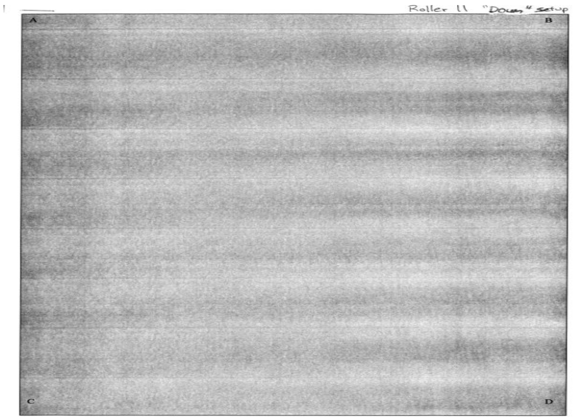


*Figure 10: PQ banding defects if micro elasticity of material is not high enough.*

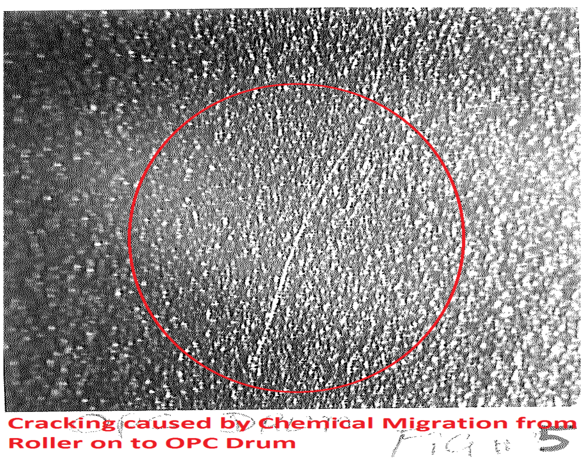


*Figure 11: Chemical attack causes cracking on OPC drum due to migration of un-reacted chemical from the roll.*

*Figure 12" PQ defect as a solid white line related to migration of un-reacted chemicals and caused drum to microscopically crack.*

## Biography:

*Krishna Chaurasia; R&D Manger in Fenner precision, has earned his Bachelor of Science in Chemistry & BE in Chemical Eng (India) & MS in Chemical Eng from University of Detroit. He also completed all Course work & Dissertation for his Doctorate degree in Polymer Eng from University of Detroit.*

*He has published several Technical papers & oral presentations at technical seminars and also recipient of Innovation Awards from American Chemistry Council.*

*Krishna has designed and developed numerous innovative formulations for electrically conductive polyurethane roller, micro-cellular foams, high-performance adhesive systems and surface coatings. His formulations have found applications in a wide variety of markets which include: Digital Imaging and electro photography, Defense, Medical Imaging, glass fiber production, bridge construction and numerous high performance Industrial applications. Krishna maintains a customer focus with customer interaction from the initial R&D phase through product launch, all while supporting the manufacturing departments. He has acquired 15+ years of experiences in polyurethane R&D/TS&D/Processing.*