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ROUGHNESS & TEXTURE OF POLYMER BELTS USING 3D PROFILOMETRY

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INTRODUCTION

A belt is a loop of flexible material that links rotating shafts for relative movement and power transmission. The combination of simplicity, low price and easy shaft alignment makes the belt drive an ideal option in farming, mining, and logging applications, such as bucksaws, sawmills, threshers, silo blowers, conveyors. There are several forms of belts, including flat belts, rope belts, round belts, V belts, multi-groove belts, etc. Depending on the specific requirements of the applications, desired belt shape is selected.

IMPORTANCE OF SURFACE TEXTURE FOR BELTS

Surface finish of the belt is critical for its product quality and performance. The surface texture and uniformity play a critical role on the friction and service lifetime of the belt drive during operation. Sufficient friction ensures effective power transmission without slipping, but excessive friction may rapidly wear the belt. An accurate surface roughness and texture measurement of the belt is important for reliable product inspection and quality control.

MEASUREMENT OBJECTIVE

The roughness and texture of two belts were measured and compared using Nanovea ST400 optical profilometer to showcase the capability of Nanovea optical profilometer in providing comprehensive and user friendly surface analysis of belts with different textures.

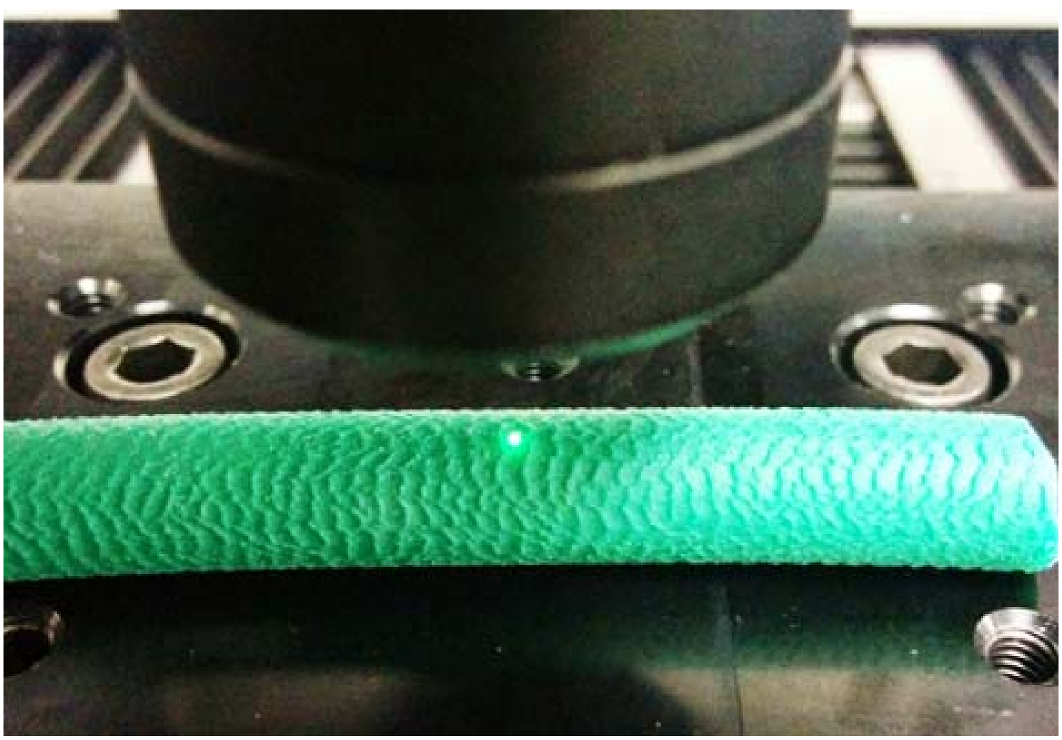
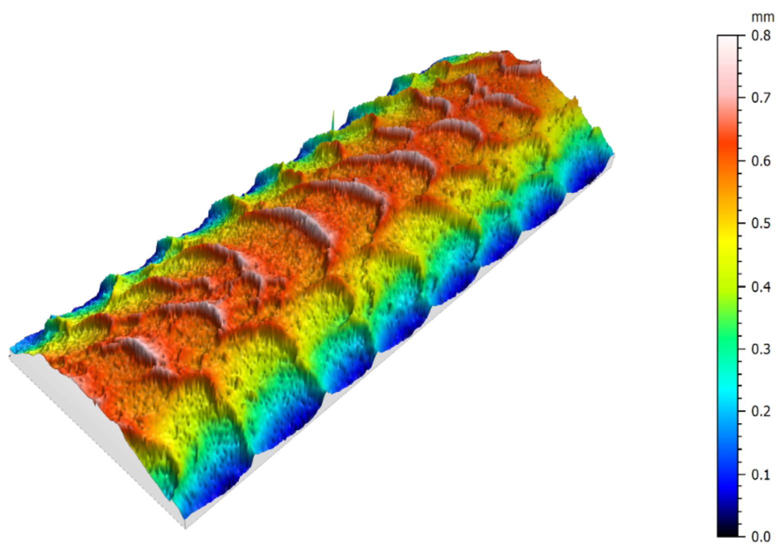


Fig. 1: Non-contact optical pen scanning on the belt.

RESULTS AND DISCUSSION

The 3D view and false color view of the textured and smooth belts are compared in Fig. 2 and Fig. 3, respectively. The textured belt shows a repeated pattern, created by the extrusion process during production. In comparison, the Smooth Belt does not have any texture on the surface. As a result, the textured belt possesses a much higher roughness S_a of 33.53 μm, compared to 8.70 μm for the smooth belt as summarized in Table 1.

(a) 3D View of the belt with a textured surface:



(b) 3D View of the belt with a smooth surface:

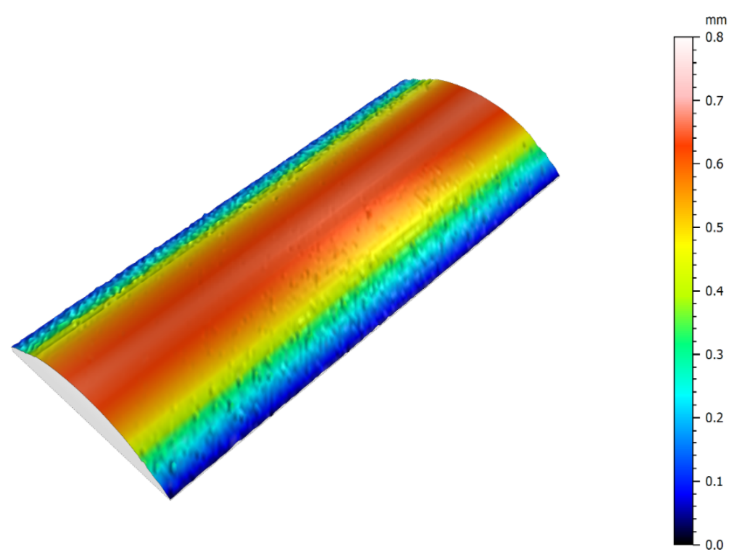


Fig. 2: 3D views of the belts.

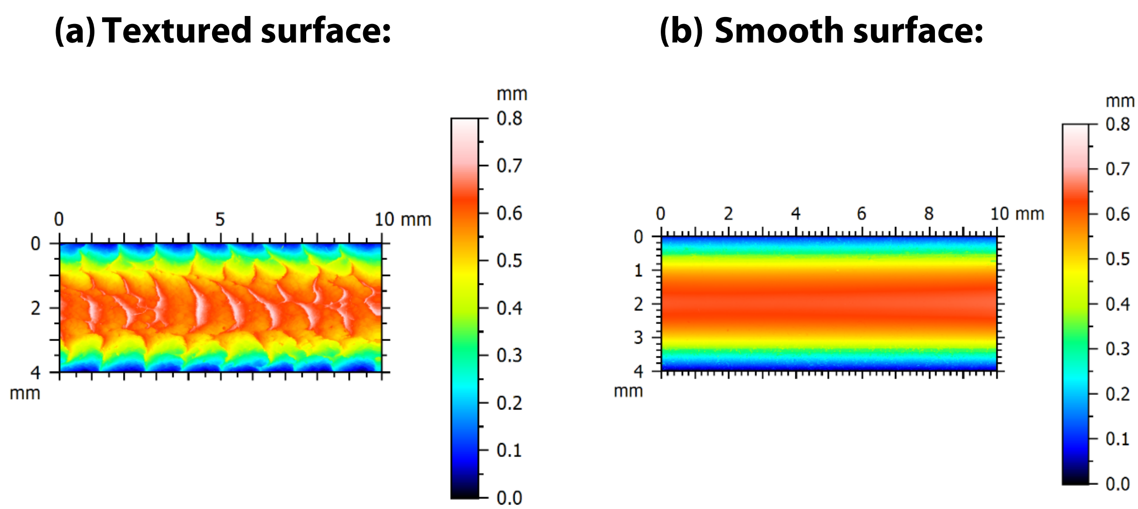
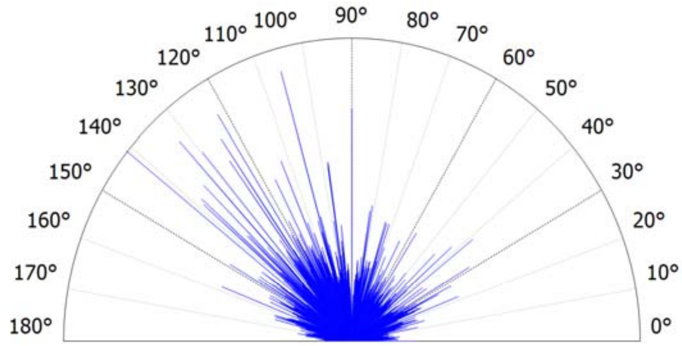


Fig. 3: False color view of the belts with textured and smooth surface.

		Textured surface	Smooth surface	Note
Sq	µm	42.24	11.87	Root-mean-square height
Ssk		1.01	-0.02	Skewness
Sku		3.71	6.90	Kurtosis
Sp	µm	337.26	204.10	Maximum peak height
Sv	µm	139.84	100.94	Maximum pit height
Sz	µm	477.10	305.04	Maximum height
Sa	µm	33.53	8.70	Arithmetic mean height

Table 1: Comparison of roughness of the Textured and Smooth belts.

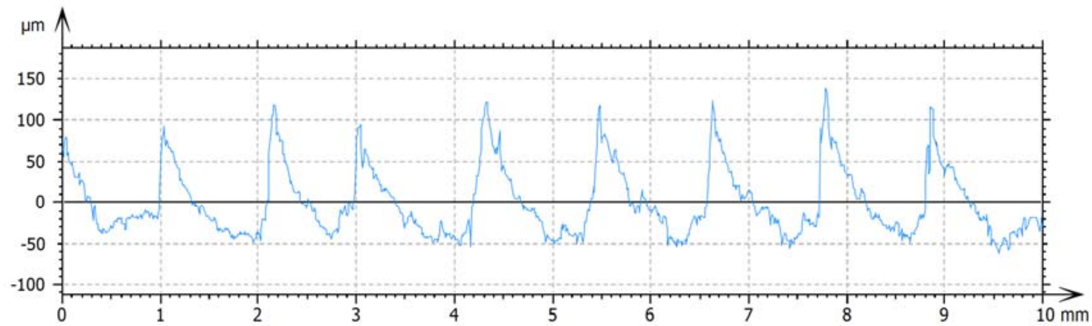
Fig. 4 analyzes the surface texture isotropy of the Textured belt. It can be observed that the belt texture has a preferential direction in the angle ranging from 100 to 150°, leading to a texture isotropy of 43%.



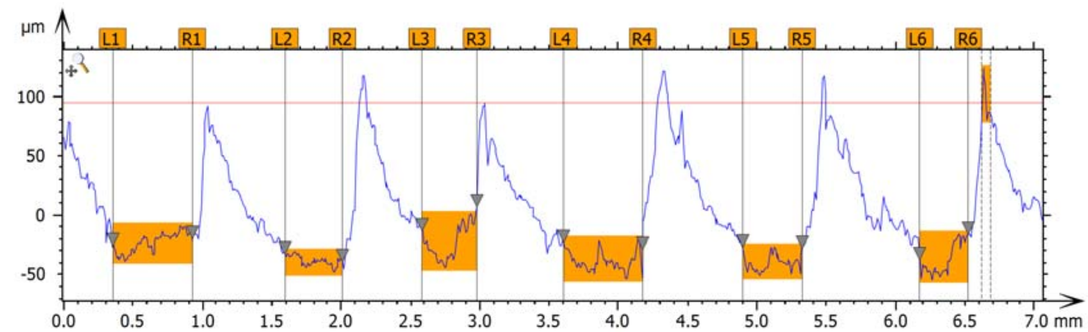
Parameters	Value	Unit
Isotropy	43.0	%
First Direction	141	°
Second Direction	105	°
Third Direction	132	°

Fig. 4: Isotropy of the texture direction of the Textured belt.

The 2D profiles along the axial direction of the textured belt is shown in Fig. 5. The height and distance of the peaks of the surface texture is fairly uniform. The peaks have an average height of ~130 µm.



Parameters	Value	Unit
Length	10.0	mm



Parameters	Unit	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6
Width	mm	0.580	0.420	0.400	0.580	0.440	0.360
Maximum height	µm	133	143	139	149	146	149
Mean height	µm	118	133	118	134	135	132

Fig. 5: 2D profile analysis of the Textured belt.

Fig. 6 displays the two belts after wear tests. The textured belt exhibits a smaller wear track compared to the smooth belt. For the detailed analysis report refer to the application note FRICTION AND WEAR OF BELTS WITH DIFFERENT SURFACE TEXTURE.

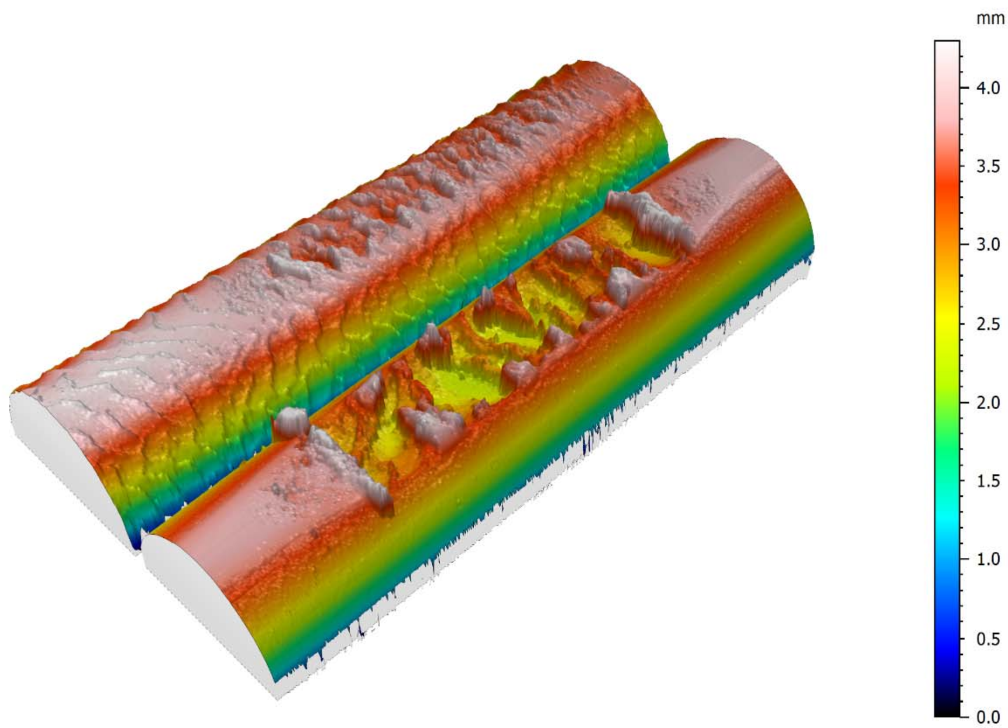


Fig. 6: 3D views of the belts after wear tests.

CONCLUSION

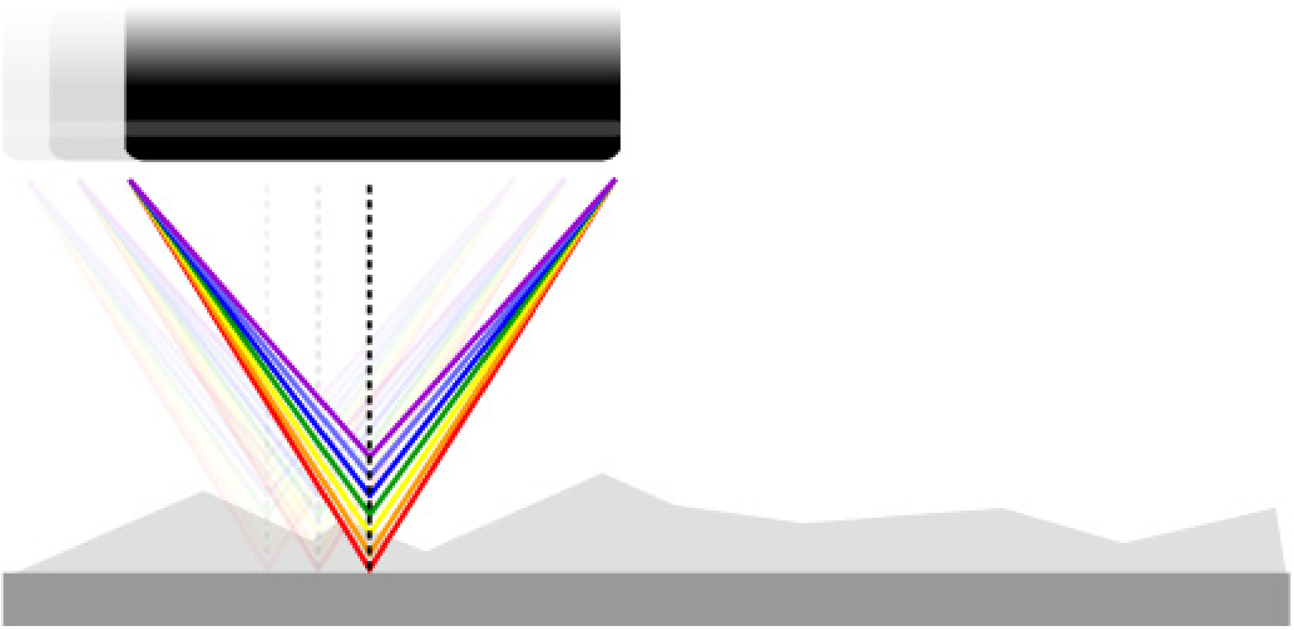
The roughness and texture of two different belts are measured using Nanovea ST400 non-contact profilometer. Such a measurement provides a useful tool in both development phases and quality control of the belts used in a variety of industries, including farming, mining, and logging and many others. The analysis software provides measurements such as uniformity and roughness, texture isotropy and peak and valley profile, enabling users to have a comprehensive understanding of the belt surface texture.

The data shown here represents only a portion of the calculations available in the analysis software. Nanovea Profilometers measure virtually any surface in fields including Semiconductor, Microelectronics, Solar, Fiber Optics, Automotive, Aerospace, Metallurgy, Machining, Coatings, Pharmaceutical, Biomedical, Environmental and many others.

Learn more about the Nanovea Profilometer or Lab Services

MEASUREMENT PRINCIPLE:

The Chromatic Confocal technique uses a white light source, where light passes through an objective lens with a high degree of chromatic aberration. The refractive index of the objective lens will vary in relation to the wavelength of the light. In effect, each separate wavelength of the incident white light will re-focus at a different distance from the lens (different height). When the measured sample is within the range of possible heights, a single monochromatic point will be focalized to form the image. Due to the confocal configuration of the system, only the focused wavelength will pass through the spatial filter with high efficiency, thus causing all other wavelengths to be out of focus. The spectral analysis is done using a diffraction grating. This technique deviates each wavelength at a different position, intercepting a line of CCD, which in turn indicates the position of the maximum intensity and allows direct correspondence to the Z height position.



Unlike the errors caused by probe contact or the manipulative Interferometry technique, Chromatic Confocal technology measures height directly from the detection of the wavelength that hits the surface of the sample in focus. It is a direct measurement with no mathematical software manipulation. This provides unmatched accuracy on the surface measured because a data point is either measured accurately without software interpretation or not at all. The software completes the unmeasured point but the user is fully aware of it and can have confidence that there are no hidden artifacts created by software guessing.

Nanovea optical pens have zero influence from sample reflectivity or absorption. Variations require no sample preparation and have advanced ability to measure high surface angles. Capable of large Z measurement ranges. Measure any material: transparent or opaque, specular or diffusive, polished or rough. Measurement includes: Profile Dimension, Roughness Finish Texture, Shape Form Topography, Flatness Warpage Planarity, Volume Area, Step-Height Depth Thickness and many others.

DEFINITION OF HEIGHT PARAMETERS

	Height Parameter	Definition
Sa	Arithmetical Mean Height	Mean surface roughness. $$Sa = \frac{1}{A} \iint_A \lvert z(x,y) \rvert dxdy$$
Sq	Root Mean Square Height	Standard deviation of the height distribution, or RMS surface roughness. $$Sq = \sqrt{\frac{1}{A} \iint_A z^2(x,y)dxdy}$$ Computes the standard deviation for the amplitudes of the surface (RMS).
Sp	Maximum Peak Height	Height between the highest peak and the mean plane.
Sv	Maximum Pit Height	Depth between the mean plane and the deepest valley.
Sz	Maximum Height	Height between the highest peak and the deepest valley.
Ssk	Skewness	Skewness of the height distribution. $$Ssk = \frac{1}{Sq^3}\left[\frac{1}{A} \iint_A z^3(x,y)dxdy\right]$$ Skewness qualifies the symmetry of the height distribution. A negative Ssk indicates that the surface is composed of mainly one plateau and deep and fine valleys. In this case, the distribution is sloping to the top. A positive Ssk indicates a surface with a lot of peaks on a plane. Therefore, the distribution is sloping to the bottom. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement.
Sku	Kurtosis	Kurtosis of the height distribution. $$Sku = \frac{1}{Sq^4}\left[\frac{1}{A} \iint_A z^4(x,y)dxdy\right]$$ Kurtosis qualifies the flatness of the height distribution. Due to the large exponent used, this parameter is very sensitive to the sampling and noise of the measurement.
Spar	Projected Area	Projected surface area.
Sdar	Developed Area	Developed surface area.