MEDIÇÃO AXIAL E CIRCUNFERENCIAL PARA ROLOS – A CHAVE PARA UMA CORRETA MANUTENÇÃO DE ROLOS

AXIAL AND CIRCUMFERENTIAL ROLL MEASUREMENT – ONE KEY TO PROPER ROLL MAINTENANCE

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ABSTRACT: This paper describes a roll measurement system designed to measure the axial and circumferential surface profiles of rolls used in paper machines. It includes a brief description of roll grinding problems, measuring techniques, data analysis and mathematical procedures. This new, low cost system is unique in that it measures and mathematically separates: Roll Motion, Eccentricity (Run-out) and Roundness The paper also presents field and experimental results to confirm this system's technical approach.

RESUMO: Esta apresentação descreve um sistema duplo de medições projetado para medir axial e circunferencialmente o perfil dos rolos usados em máquinas de papel. Ele inclui uma breve descrição dos problemas de retíficas, técnicas de medição, análise dos dados e procedimentos matemáticos. Uma nova técnica de baixo custo foi desenvolvida para medir o movimento dos rolos, e o verdadeiro perfil circular obtido com o resultado do movimento dos rolos. Este apresentação também inclui resultados de campo e experiências para apoiar este novo sistema.

Introduction and Background

Maintenance of a paper machine is at best, an enormous, never ending task, involving a wide range of engineering principals and practices. Critical to this task is Roll Maintenance, with roll grinding being perhaps its most important function. The move toward the use of wider and faster paper machines, coupled with a demand for higher quality paper products, has given rise to an even greater demand on the types and quality of the rolls used in the paper making machine. Along with structural integrity and balance, these rolls require a high degree of roundness and surface finish, with minimum radial run-out. The roll grinder operator, faced with the task of grinding the roll to meet these requirements, must have a measuring system capable of supplying him with reliable and accurate information. This paper describes such a system, the RollTrack® roll measuring and display system, and in its design, not only provides the operator with axial and roundness surface profile information, but it supplies diagnostic information so that any necessary adjustments could be made in a timely manner, **before** or at any time during the roll grinding process. This paper also discusses some of the problems encountered by the roll grinder operator.

System Description

The system essentially uses a **single** primary probe to record the roll profile shapes (axially and circumferentially). However, a second probe is installed as a **diagnostic tool** specifically designed to measure roll motion (where the rotating center shifts during rotation) or to determine any deviation in the machine ways. The probes are located horizontally, (front and backside of the roll) as shown in Figure 1.

Both probes are activated and with proper evaluation of the data thus recorded and the use of several mathematical procedures, accurate plots of the roll surface profiles are readily obtainable. While the use of the relatively standard two-probe system seems contrary to a prevailing opinion that two probes produce erroneous results and that three or more probes are necessary to measure roundness accurately, it is simply that the original two-probe system used a direct subtraction method to determine eccentricity. Multiple probe systems compound the problem of measuring roundness and complicate an otherwise simple measuring procedure. In other industries, where cylindrical products are routinely measured for roundness, a single stylus type probe is all that is used. All of these industries apparently subscribe and test to the **ISO** "Methods for the Assessment of Departure From

Roundness" (ISO TS 12181-1), a comprehensive document, which does not suggest multiple probes for measuring roundness. It does however suggest (as we do) that the probe be relocated to a point 180 degrees to detect the presence of spindle motion! Most often, cylindrical parts to be inspected are accurately centered and mounted on a precision rotating table, hence one probe is usually sufficient However, with roll grinders, the design and condition of the machine and the manner in which very large roll are supported and rotated, can affect both the grinding procedure and the profile data recorded.

Figure 1. PWT machine mounted roll caliper with two measuring probes.

Of the two measurements required during roll grinding, the crown (or axial profile) and the roundness profile, the crown is more easily measured. Here the methods and procedures are well established, and part of any measuring system. Measuring roundness is more demanding, primarily because the roll must be rotated while the probes are fixed, unlike the crown measurements, where the reverse is true. The single, most important factor in the measurement of roundness is the possible existence of roll motion. This is where the center of rotation shifts during rotation. Were it not for such occurrence, a single probe is all that would be required to measure both eccentricity and surface irregularities (roundness). However, by simply using the same two-probe arrangement normally used to measure the axial profile and by recording the profiles separately and comparing their data, roll motion is readily detectable and measurable.

Figure 2. The RollTrack® computer system which was used during field trial.

Total Indicator Reading (T.I.R.)

Out-of-roundness is defined as the degree of waviness or irregularity as measured from the surface of a perfectly round roll and is normally the result of uneven roll wear occurring during its operation. Run-out, or eccentricity, is the surface motion of this round roll when it is not rotated about its center and results when the roll circumference is not concentric with its journal or its support bearings. Both of these conditions can be corrected by regrinding the roll. T.I.R. (Total Indicator Reading) is the sum of these two conditions added together and is readily measured unless roll shifting occurs during rotation. If this shifting or rocking motion is present, it is superimposed on to the roundness profile, resulting in a recorded profile error. If the roll grinder operator is unaware of this, he will grind the roll to this superimposed shape.

Roll Grinding

Important to a meaningful and accurate analysis of the roll surface profile data recorded is an understanding of the roll grinding set up and procedure, and the number of problems that can be encountered.

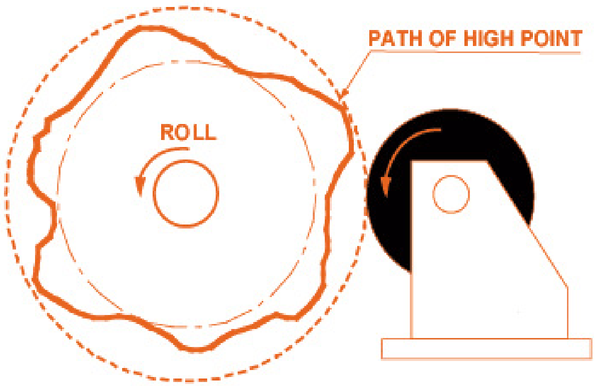


Figure 3-A. Roll grinding principle – a single wheel roll grinder.

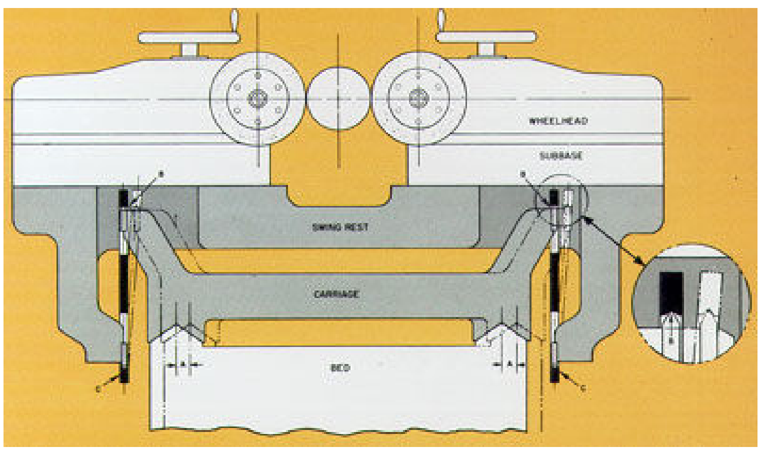


Figure 3-B. A two-wheel roll grinder.

Figure 3-A shows the basic set-up of a roll and the grinding wheel. Note the wheel and the roll are located on the same horizontal centerline to prevent any vertical misalignment or motion from affecting the profile being ground. However, it is susceptible to any horizontal motion generated by movement of the wheelhead or the roll center. In the absence of any extraneous motion, the high speed grinding wheel is fed into the slowly rotating roll where it grinds down the irregular surface shown until it becomes a relatively perfect circle. However, if the roll is not supported properly or is supported with faulty or loose bearings, it may cause the roll center to oscillate during rotation, resulting in poor roll grinding performance and roll roundness measuring errors.

Figure 3-B shows a two wheel roll grinder with a swing rest principle. This still is the best principle to grind long paper mill rolls straight and round.

Figures 4 and 5 show the effect produced when the roll center is shifting, as it is being ground. The figures show a round roll being ground with center motion and how the roll shape changes, conforming to the period of oscillation. Note that with a period of one oscillation per rotation an oval shape develops. Note also in Figure 4 that the probe at the wheel head (A) records an improvement in the roundness of the roll it recorded initially; an apparent out-of-roundness developed by roll motion.

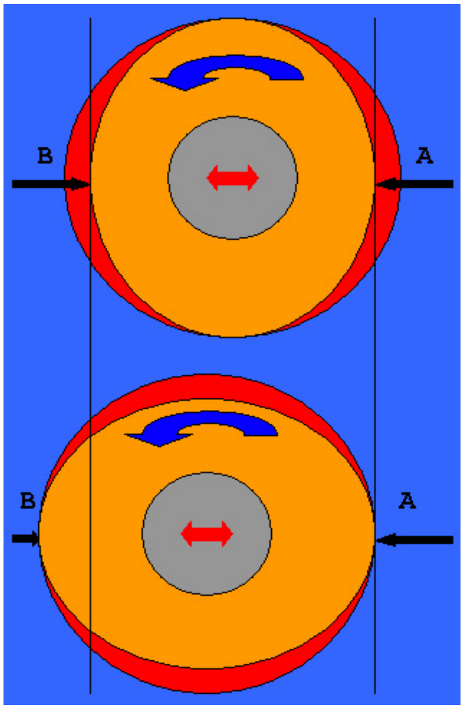


Figure 4. Roll motion is ground to the roll making it oval shape. Red color represents the part which has been ground off.

See animation:
http://fmt-equipment.com/round_motion.htm

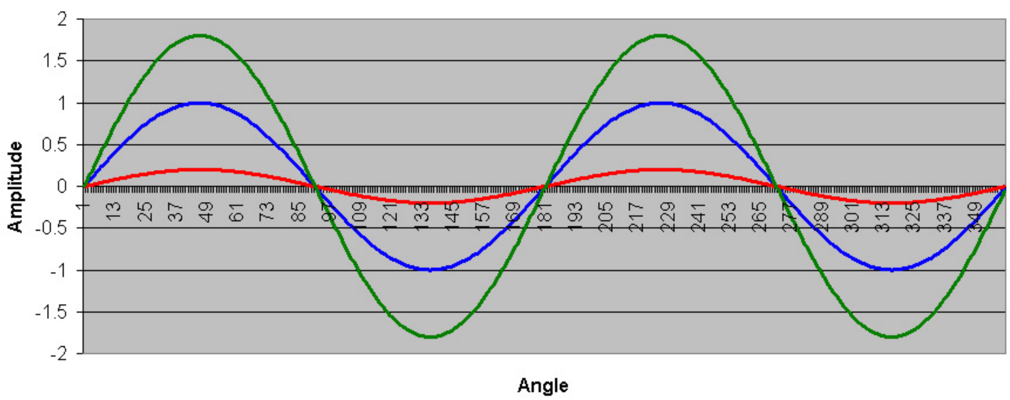


Figure 5. Linear plot of surface movement
Blue line: Initial reading of roll motion by both gauges.
After 80% of roll motion has been ground to the roll.
Red line: Measurement at wheel side.
Green line: Measurement at back side.

However, the diagnostic probe (B) records a negative change. If the roll rotates on center with no shifting, both probes then record the true roll roundness.

Note however, that the blue line in Figure 5 read by both gauges can be mistaken by the operator to be simply eccentric motion which can be ground out. On grinding however, he will note eventually the differences between the two measurements. The two probe system uses a simple and effective mathematical technique to determine if any motion exists and will display the magnitude and pattern of this motion, at any time during the grinding cycle, but more importantly, **before any grinding takes place.** Note that readings should be taken before grinding on both ends of the roll so that corrective action can be taken. In those cases where no action can be taken, then the information developed in this manner might be used to control the wheel head in-feed to compensate for this shifting motion. It is interesting to note that the swing-rest concept of the Farrel two-wheel roll grinder may be effective in compensating for any horizontal motion. Finally, it is recommended that roundness measurements be taken at the same roll speed selected for grinding.

<u>Bearings</u>

Bearings are an important factor in the process of roll grinding, or in the operation of the roll. While there may be valid reasons for grinding rolls with their bearings attached, some of the problems encountered during this process can be directly related to the condition of the bearings. Figure 6 illustrates various bearing conditions related to these problems. Rotation about center is fixed with zero clearance. The roll is free to oscillate with standard or excess clearance. Run-out error on the inner race is ground to the roll. Run-out error on the outer race causes the rotational axis to be relocated but the roll run-out is zero. Damage or waviness on either race or rollers causes the roll "bounce" up and down. Grinding and measuring at 90° eliminates or minimizes the effect.

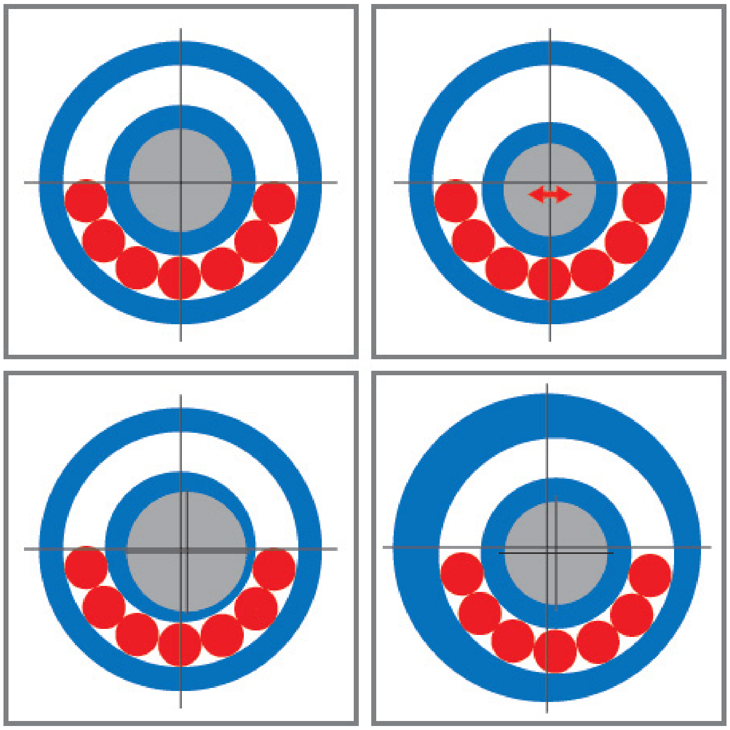


Figure 6.
Top: Bearings with zero and standard clearances.

Bottom: Run-out errors on the inner and outer races.

There are many aspects to the question as to whether to grind the roll supported by its journals, resting in gibs, or to grind the roll supported with its bearing housing. The obvious disadvantage of grinding on journals, of course, is the need to remove the bearing housing and bearings but, in some cases, this is prohibitively time consuming. (Such as with suction press rolls and notably variable crown rolls). However, grinding on bearings can be a problem for the operator. Perhaps the biggest problem he faces is when there are large bearing clearances, and the turning force on the roll causes the roll to rock in its roller bearing cradle, producing center shift. A solution to this problem is to take up the bearing clearance, as is normally done with variable crown rolls. If it is not possible to reduce the bearing clearance, the operator may be able to change the speed of roll rotation and, through measurement of the roll motion, as discussed previously he may be able to reduce this shifting action to an acceptable level.

Another action that may prove beneficial is to make sure the bearings are well lubricated. This will reduce any tendency to "climb" out of its cradle and initiate a rocking motion. However, if the disturbance is caused by worn or damaged rollers or inner or outer race, then the bearings should be replaced.

Also noted in the referenced figures is the existence of bearing run-out. It has been the practice of roll manufacturers to match the high point of a bearing to the low point of the roll. In any event, a roll ground with bearings will be ground relative to the bearing inner race (or outer race, if the roll has a rotating shell) and not to the roll journals. On the other hand, if the roll is ground supported by the journals, then, after bearing assembly, if the roll is not operating in an intermediate position in the calender stack and is supported by the bearings during operation, it will have a run-out equal to the bearing run-out.

Some Corrective Actions which may reduce roll center motion

- Take up bearing clearance(s) if possible.
- Replace bearing(s).
- Grind on babbitt bearings, and make sure they are in good condition and the journals are rotating freely on them.
- Use two grinding wheels with hard surface rolls (steel, chilled iron, bone hard rubber).
- Use teflon block or steady rest on the opposite side of the grinding wheel with hard surface rolls, if one wheel of a two-wheel roll grinder is used.
- Use a single wheel and a contact wheel on the opposite side with soft surface rolls, if one wheel of a two-wheel roll grinder is used.

Circular Roll Measurement Principles

While a single probe is all that is required to measure run-out and roundness of a cylinder if its center of rotation is fixed, the two probe system is required to insure that rotating center is not subject to horizontal, periodic disturbances. The important point to be made here is that once the roll motion is detected and eliminated or minimized, the output from the primary probe is all that is needed!

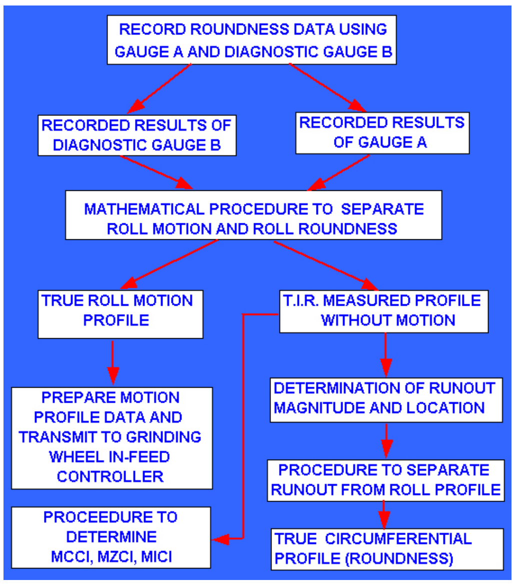


Figure 7. Data recording and calculating procedure to determine roll roundness.
MCCI (Minimum circumscribed circle center)
MICI (Maximum inscribed circle center)
MZCI (Minimum zone center)

The chart in Figure 7 shows the procedure and the analysis used to determine Roundness, Run-Out and Roll Motion. The chart also shows that the outputs of gauges A and B are treated as previously described, and that the roll motion and roll roundness are stored separately. At this point either can be plotted in cylindrical co-ordinates. Now however, in order to determine the true circumferential profile (roundness), the eccentricity portion of the recorded profile is determined, i.e. roll center, and subtracted from the corrected data. However, the actual location of roll center is of little value to the operator, as in the process of roll grinding any eccentric is eliminated so that the roll body center is shifted to match the rotating center. The purpose of measuring system is to analyze and separate the various components of the measured roll roundness and to display their values.

Analysis and Mathematics

While of little interest to the roll grinder operator or the inspector, it is important that this paper support the results of its studies and findings by presenting a brief description of the mathematics and analysis used in processing the recorded data.

From a study of many recorded cylindrical profiles, some of which are presented in this paper, surface irregularities are made up of a number of periodic frequencies (undulations). As such, these periodic undulations are readily evaluated by use of Fourier Transform, a mathematical procedure that unfortunately, produces a lot of data, more useful for sophisticated engineering analysis. Our approach is more direct. Recognizing that all we are interested in is the first frequency, which is really one lobe per revolution (eccentricity) and usually the dominate frequency, it was determined that we could use the Fourier series equations, made up of sine and cosine functions, and create a manageable matrix by limiting the number of frequencies to be included in this series.

In order for a frequency to exist it must complete its number of cycles in exactly 360 degrees of rotation. However, the start position (where its amplitude is zero) may occur at any point. The equations used, when evaluated, provide both the start position and amplitude of any frequency.

The general equation is as follows:

$$Y = A * \sin [(N) X + Ø];$$

Where Y = the value measured at a point
N = frequency
A = amplitude
Ø = angular start position
X = angular position of the data point (0-360 degrees)

For each value of Y, an expanded version of this equation is required, resulting in a number of these equations to be solved simultaneously.

In order to evaluate this expression for the frequencies selected, and reduce the complexity of the calculations involved, a coefficient matrix was created, based on a fixed number of angular increments (X) and a selected number of frequencies (N). As these fixed coefficients were predetermined and are permanently stored in the system computer, matrix algebra is all that is required for the final calculations. Values of Y are obtained from the recorded data at the selected angular increments and matrix multiplication is used to determine the location of the roll center and the magnitude of the eccentric. With this information, the eccentric then can be subtracted from the T.I.R. data at each point. The result when plotted displays the true out-of-roundness profile (Fig. 8).

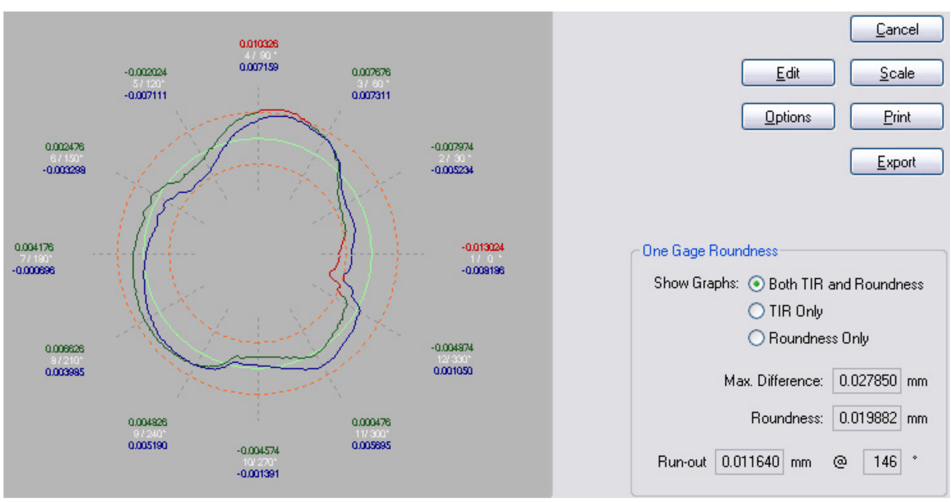
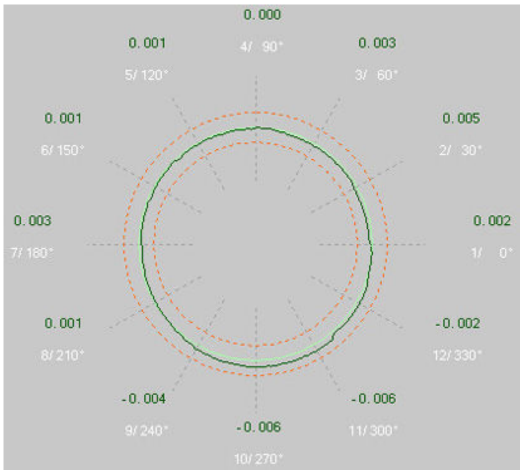


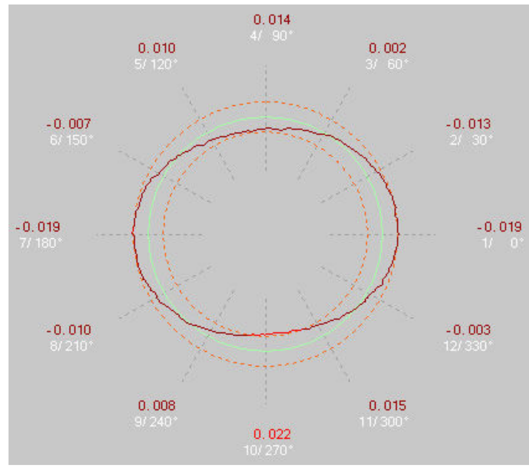
Figure 8. Example of T.I.R. measurement with a Roundness graph after the mathematical procedure was applied.

Case Study

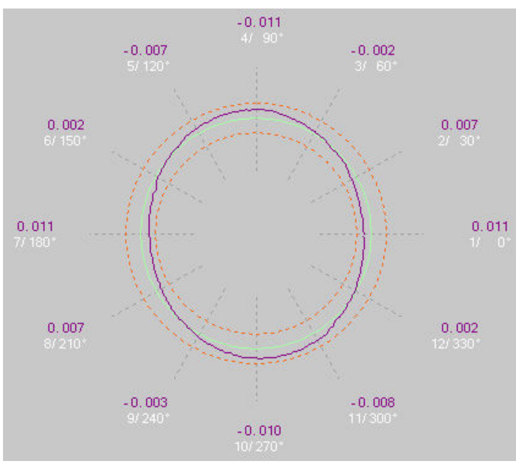
The cylindrical profiles shown in Figures 9-A and 9-B, taken from field trials during the development of the new procedure using two individual probes, illustrate the effect of roll motion. Note that the front probe (A) on the operator or wheel side records a relatively round profile, while the back probe (B), shows a high degree of out-of-roundness, and that neither is correct. Figure 9-C is measured Motion and Figure 9-D is True Roundness after adjusting for Run-out and Motion.



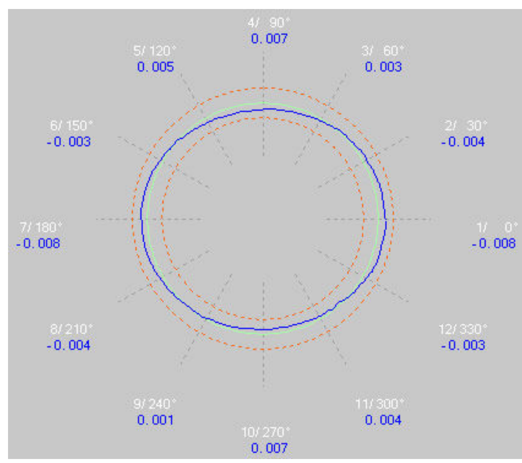
9-A



9-B



9-C



9-D

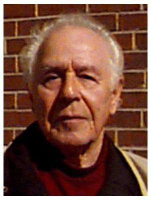
Figure 9. An example of measurements after motion has been ground to the roll.
9-A. Max difference at wheel side: 0,012 mm (.0005") (- Error).
9-B. Max difference at back side: 0,048 mm (.0019") (+ Error).
9-C. Horizontal machine motion: 0,023 mm (0.009") (Correct).
9-D. True Roundness: 0,017 mm (.0007") (Correct).

A more complete profile study is to be found in the attached Appendix.

Observations and Conclusions

It appears that the industry's demand for tighter profile and roundness finishing specifications presents a difficult task for the roll grinder operator. This has given rise to a number of multi-probe measuring systems, and while such systems may accomplish the task with some degree of accuracy, it is believed they are expensive and much more complicated than the simple, two probe system described in this report. We believe that the comprehensive case study shown in the appendix clearly indicates the effectiveness of this measuring system.

Throughout the system development, the objective was to keep it simple so as to reduce the burden on the operator by providing him with not only a simple reliable measuring device, but a diagnostic tool as well.



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Mr. D'Amato has a degree in Mechanical Engineering with advanced studies in machine design and has been involved in the Research and Development of rolls and calenders for a number of years and served as Engineering Manager for Calenders at Farrel Company and Sulzer Corporation. A member of TAPPI, he wrote and presented a number of papers on rolls and calenders.

E. Juhani Jaske, President, FMT Equipment Corporation

Mr. Jaske has a degree in Mechanical Engineering. He worked for the roll and roll grinder divisions of Farrel Company as Sales/Application Engineer for several years. He founded FMT Equipment Corporation 1985 and has given papers on roll measurement and tolerances at several paper industry conferences in the USA, Canada, and Europe.

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Appendix

The attached measurements were taken with the RollTrack system designed and made for a two-wheel roll grinder. The measuring heads are mounted to the wheel guards of the wheelheads, which are kept at a fixed distance from each other by the carriage design, so the measurement gauges are at 180° from each other at 3:00 and 9:00 o'clock positions. The appendices show both an axial profile, T.I.R and motion/roundness measurements.

The test roll was a variable crown, zone controlled, soft calender roll. The roll was rotating on its internal bearings when it was ground using one grinding wheel on the operator side, so the shifting motion was ground to the roll surface. A single measurement pass was taken during one revolution (360°). Roll speed was approximately 4 RPM.

1. Axial profile measurement. The intermediate profile is within 0,037 mm (.0015") across the roll face.

2. T.I.R. measurement graphs at the tending end of the roll:
   Green line is by the gauge on the grinding wheel side with
   Max. Difference of 0,036 mm (.0014")
   Brown (red indicates out-of-tolerance) line is by the gauge on the back side with
   Max. Difference of 0,129 mm (.0051")

3. Motion and Roundness measurement graphs at the tending end of the roll:
   Purple line is computed motion with
   Max. Difference of 0,065 mm (.0026")
   Blue line is computed true roundness with
   Max. Difference of 0,067 mm (.0026")

4. T.I.R. measurement graphs at the roll center:
   Green line is by the gauge on the grinding wheel side with
   Max. Difference of 0,081 mm (.0032")
   Brown (red indicates out-of-tolerance) line is by the gauge on the back side with
   Max. Difference of 0,138 mm (.0055")

5. Motion and Roundness measurement graphs at the roll center:
   Purple line is computed motion with
   Max. Difference of 0,051 mm (.0020")
   Blue line is computed true roundness with
   Max. Difference of 0,064 mm (.0025")

6. T.I.R. measurement graphs at the drive end of the roll:
   Green line is by the gauge on the grinding wheel side with
   Max. Difference of 0,052 mm (.0021")
   Brown (red indicates out-of-tolerance) line is by the gauge on the back side with
   Max. Difference of 0,144 mm (.0057")

7. Motion and Roundness measurement graphs at drive end of the roll:
   Purple line is computed motion with
   Max. Difference of 0,060 mm (.0024")
   Blue line is computed true roundness with
   Max. Difference of 0,088 mm (.0035")

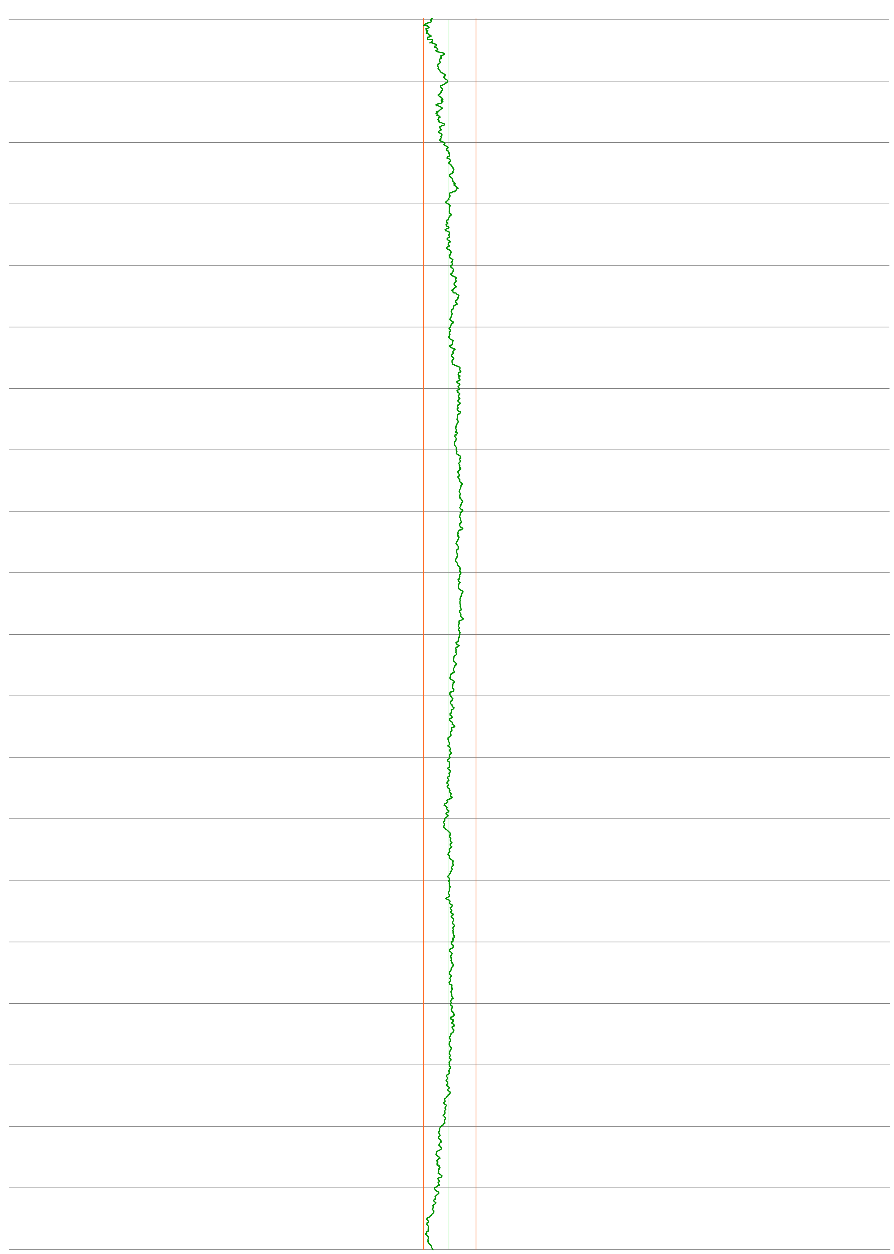
PROFILE REPORT

RollTrack (R) V9.18

Roll Number ...		Job Number	**12345**
Operator		Roll Name	**Soft Cal**
Customer	**PM 1**	Face Length ...	**7787** mm
Measured on ...	**Fri Aug 31 14:15:04 2007**	Diameter	**998.98** mm
Printed on	**Fri Oct 05 14:53:08 2007**	Hardness	
Report Data 1:.		Roll Data 1:...	
Report Data 2:.		Roll Data 2:...	
Report Data 3:.		Roll Data 3:...	
Measured	**INTERMEDIATE**	Roll Data 4:...	
Configuration .	**BOTH GAUGE HEADS**	Roll Data 5:...	
Meas. Length ..	**7787** mm	Roll Data 6:...	
Tolerance Band. ±	**0.0250** mm	Centering	**USE MEAN VALUE**
Scale	**0.5000** mm	Filtering	**3**
Taper Correct .	**-0.065** mm	Recording Mode.	**AUTOMATIC**

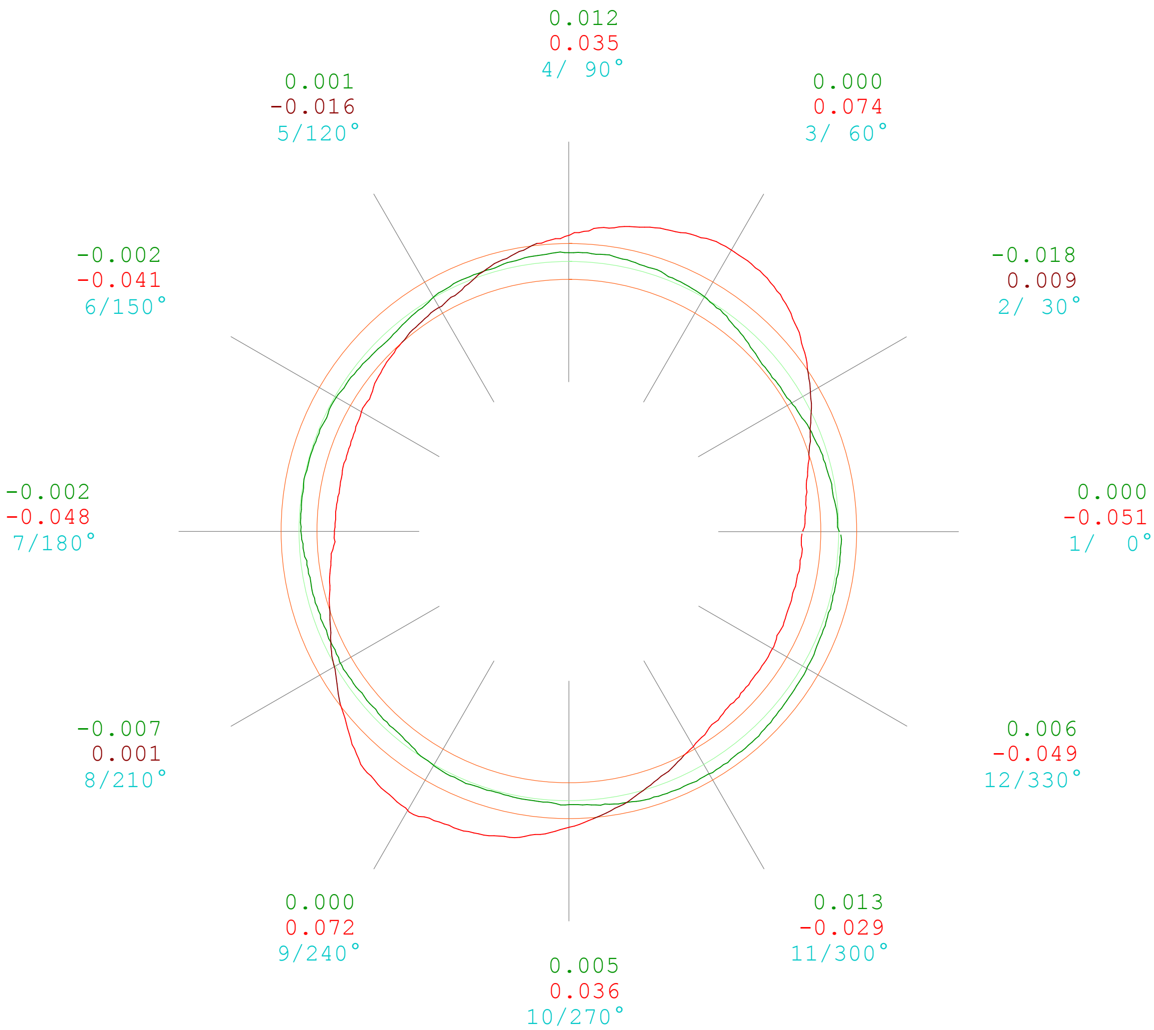
TENDING END

0	0 mm	-0.016 mm
1	389 mm	-0.002 mm
2	778 mm	-0.007 mm
3	1168 mm	-0.003 mm
4	1557 mm	0.002 mm
5	1946 mm	0.000 mm
6	2336 mm	0.008 mm
7	2725 mm	0.006 mm
8	3115 mm	0.012 mm
9	3504 mm	0.010 mm
10	3893 mm	0.009 mm
9	4283 mm	0.001 mm
8	4672 mm	0.000 mm
7	5061 mm	-0.005 mm
6	5451 mm	0.000 mm
5	5840 mm	0.002 mm
4	6230 mm	0.001 mm
3	6619 mm	0.000 mm
2	7008 mm	-0.008 mm
1	7398 mm	-0.014 mm
0	7787 mm	-0.015 mm



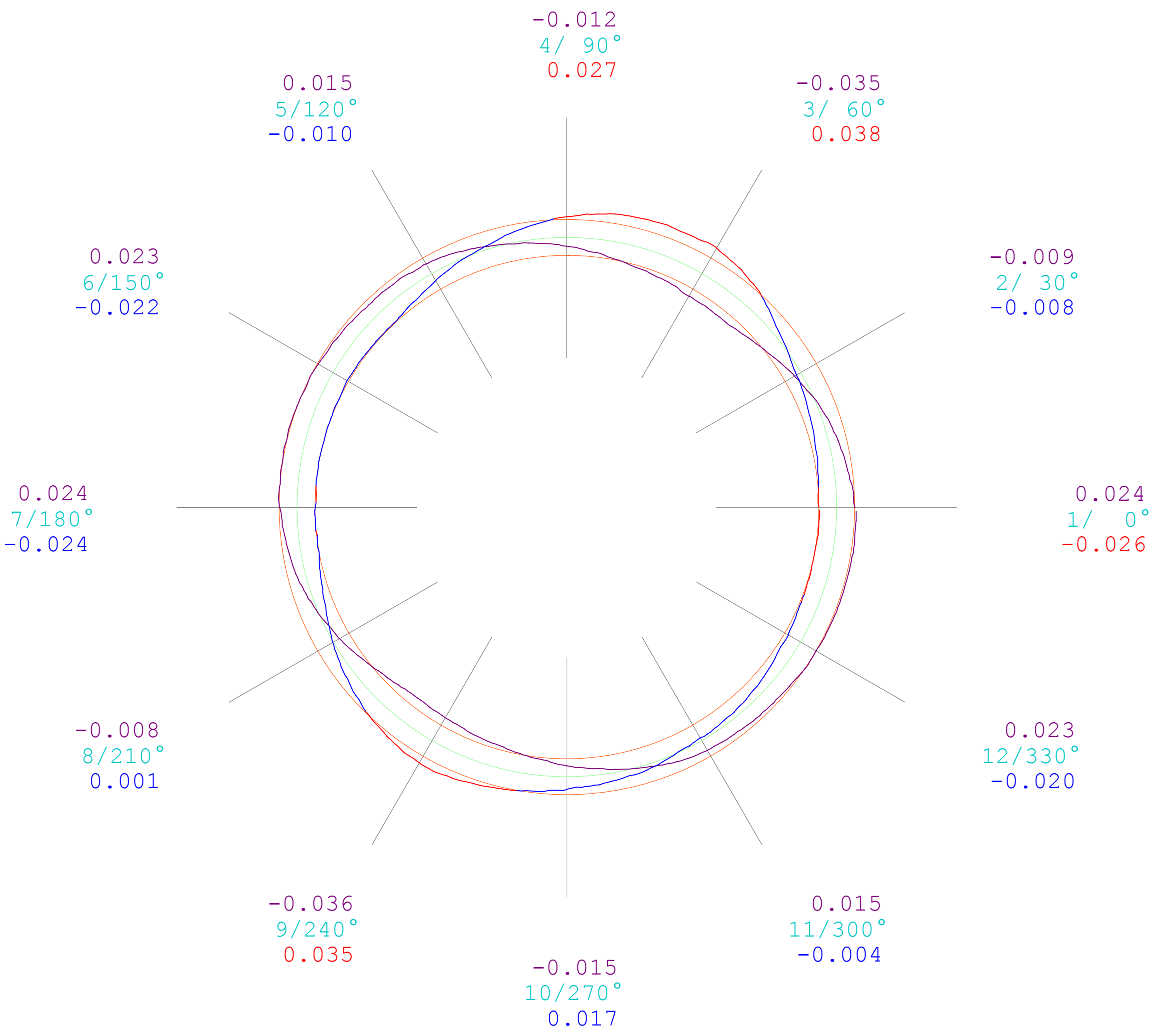
Max. Deviation.	**0.013** mm @ **3797** mm	Max. Difference	**0.037** mm
Min. Deviation.	**-0.024** mm @ **43** mm	Measured Taper.	**0.000** mm

Roll Number ...		Job Number	**12345**
Operator	**FMT**	Roll Name	**Soft Cal**
Customer	**PM 1**	Face Length ...	**7787** mm
Measured on ...	**Fri Aug 31 14:47:16 2007**	Diameter	**998.98** mm
Printed on	**Fri Oct 05 14:55:25 2007**	Hardness	
Report Data 1:.		Roll Data 1:...	
Report Data 2:.		Roll Data 2:...	
Report Data 3:.		Roll Data 3:...	
Measured	**AFTER GRINDING**	Roll Data 4:...	
Measuring ..... Location	**TENDING END**	Roll Data 5:...	
		Roll Data 6:...	
Gauge Head .... Position	**OPERATOR SIDE**	Centering	**USE MEAN VALUE**
		Filtering	**1**
Tolerance Band. ±	**0.0250** mm		
Scale	**0.1250** mm		



First Gauge TIR Max. Difference	**0.036**	mm
Second Gauge TIR Max. Difference	**0.129**	mm

Roll Number ...		Job Number	**12345**
Operator	**FMT**	Roll Name	**Soft Cal**
Customer	**PM 1**	Face Length ...	**7787** mm
Measured on ...	**Fri Aug 31 14:47:16 2007**	Diameter	**998.98** mm
Printed on	**Fri Oct 05 14:56:23 2007**	Hardness	
Report Data 1:.		Roll Data 1:...	
Report Data 2:.		Roll Data 2:...	
Report Data 3:.		Roll Data 3:...	
Measured	**AFTER GRINDING**	Roll Data 4:...	
Measuring ..... Location	**TENDING END**	Roll Data 5:...	
		Roll Data 6:...	
Gauge Head .... Position	**OPERATOR SIDE**	Centering	**USE MEAN VALUE**
Tolerance Band. ±	**0.0250** mm	Filtering	**1**
Scale	**0.1250** mm		

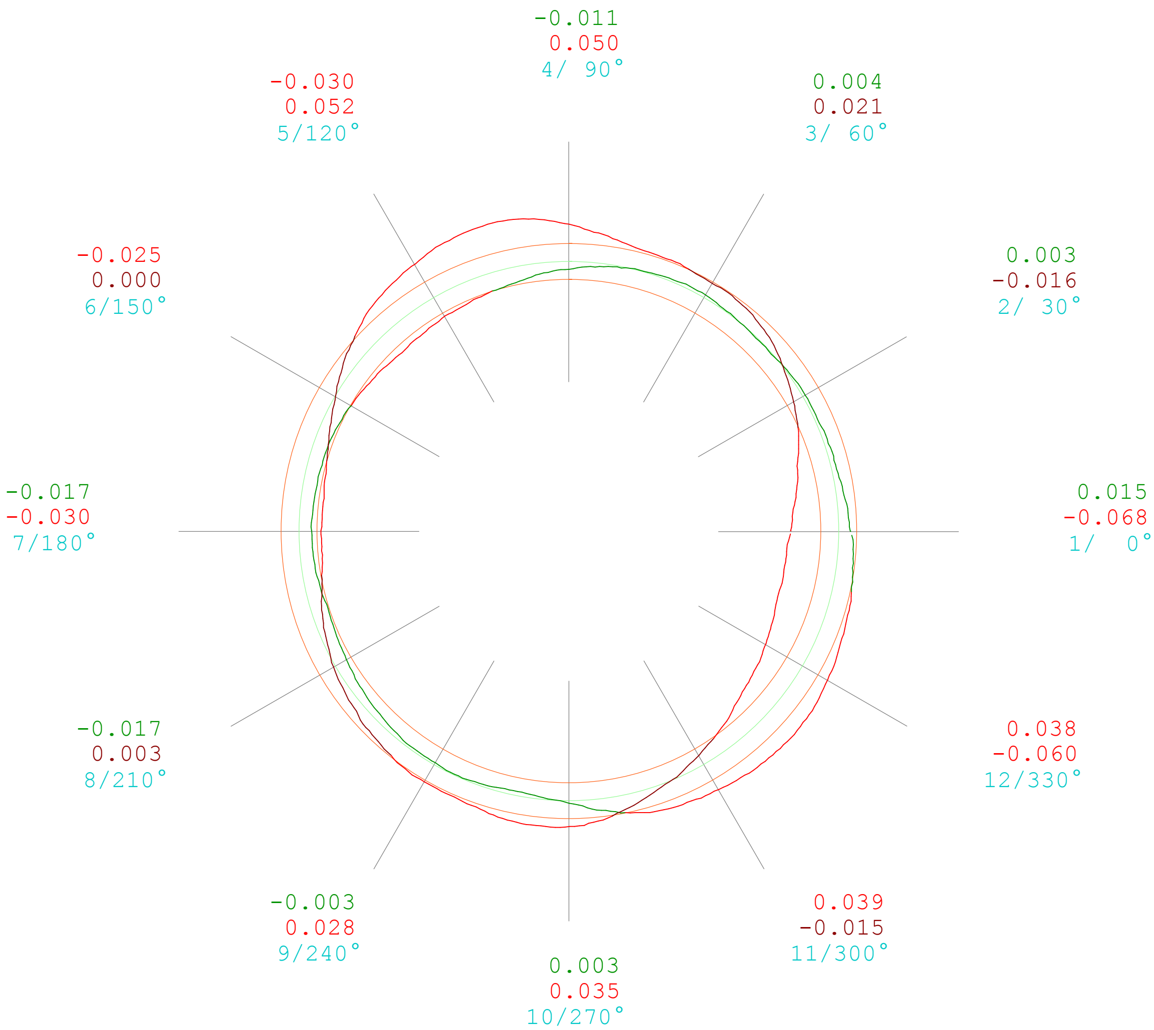


True Roundness
Roundness. **0.067** mm
Run-out. **0.007** mm @ **299** °

Motion
Max. Difference **0.065** mm

Roll Number ...
Operator ......
Customer ...... **PM 1**
Measured on ... **Fri Aug 31 14:57:44 2007**
Printed on .... **Fri Oct 05 14:56:53 2007**
Report Data 1:.
Report Data 2:.
Report Data 3:.
Measured ...... **INTERMEDIATE**
Measuring ..... **CENTER**
Location
Gauge Head .... **OPERATOR SIDE**
Position
Tolerance Band. ± **0.0250** mm
Scale .... **0.1250** mm

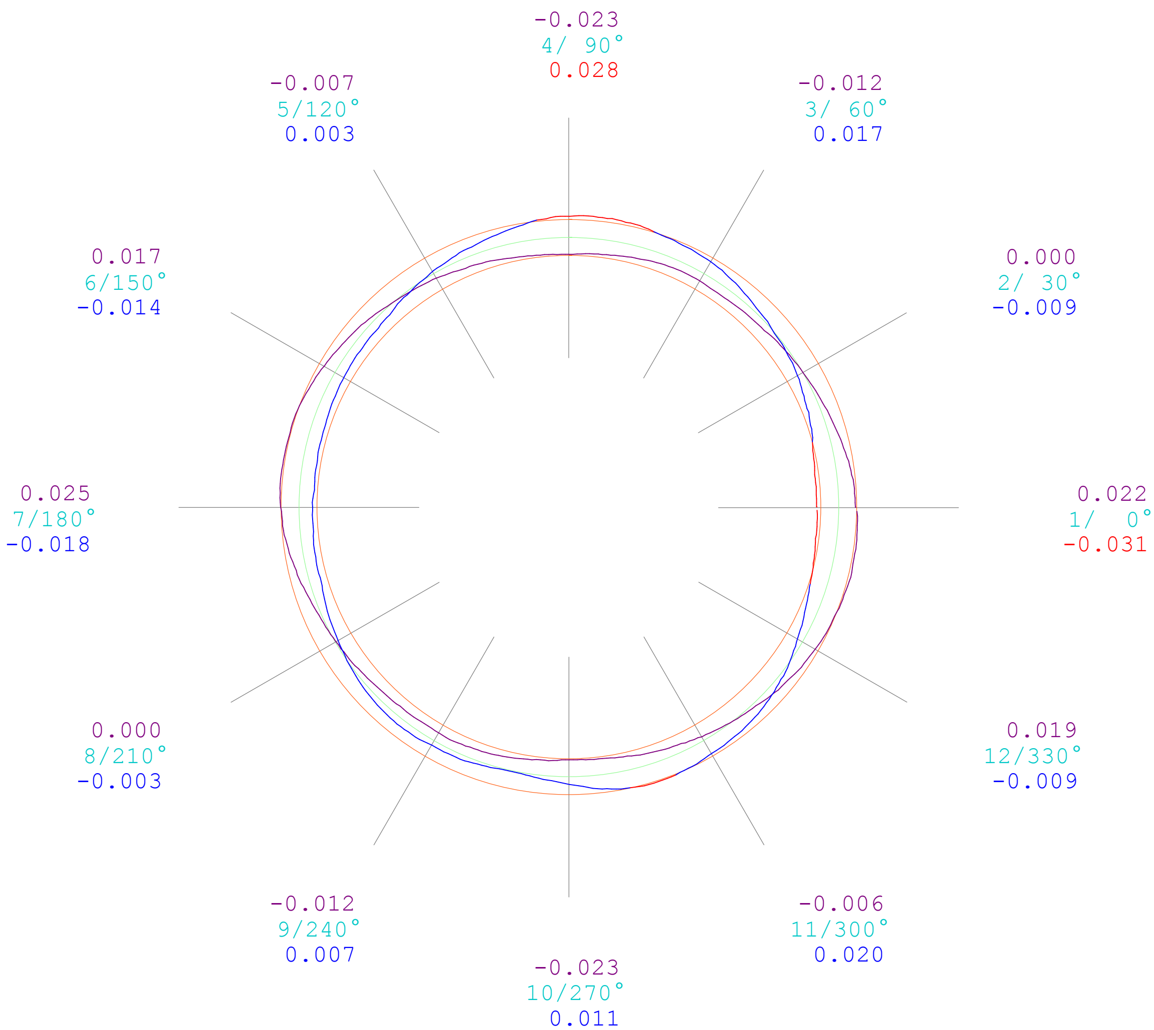
Job Number **12345**
Roll Name ..... **Soft Cal**
Face Length ... **7787** mm
Diameter ...... **998.98** mm
Hardness ......
Roll Data 1:...
Roll Data 2:...
Roll Data 3:...
Roll Data 4:...
Roll Data 5:...
Roll Data 6:...
Centering ..... **USE MEAN VALUE**
Filtering **1**



First Gauge TIR
Max. Difference **0.081** mm

Second Gauge TIR
Max. Difference **0.138** mm

Roll Number ...		Job Number	**12345**
Operator		Roll Name	**Soft Cal**
Customer	**PM 1**	Face Length ...	**7787** mm
Measured on ...	**Fri Aug 31 14:57:44 2007**	Diameter	**998.98** mm
Printed on	**Fri Oct 05 14:57:36 2007**	Hardness	
Report Data 1:.		Roll Data 1:...	
Report Data 2:.		Roll Data 2:...	
Report Data 3:.		Roll Data 3:...	
Measured	**INTERMEDIATE**	Roll Data 4:...	
Measuring ..... Location	**CENTER**	Roll Data 5:...	
		Roll Data 6:...	
Gauge Head .... Position	**OPERATOR SIDE**	Centering	**USE MEAN VALUE**
		Filtering	**1**
Tolerance Band. ±	**0.0250** mm		
Scale	**0.1250** mm		



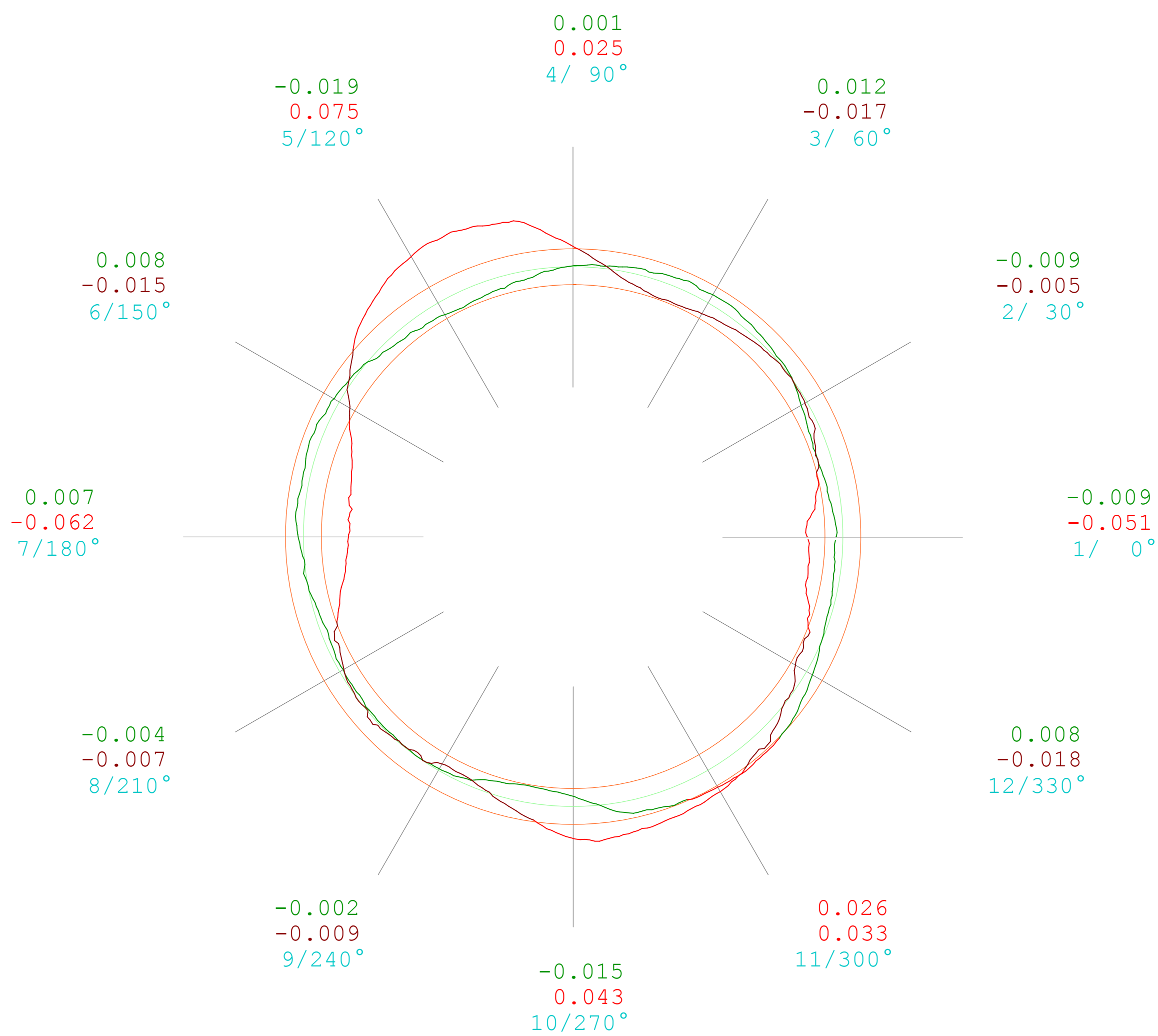
True Roundness
Roundness. **0.061** mm
Run-out. **0.058** mm @ **326** °

Motion
Max. Difference **0.051** mm

TIR AND TWO GAUGE ROUNDNESS REPORT

RollTrack (R) V9.18

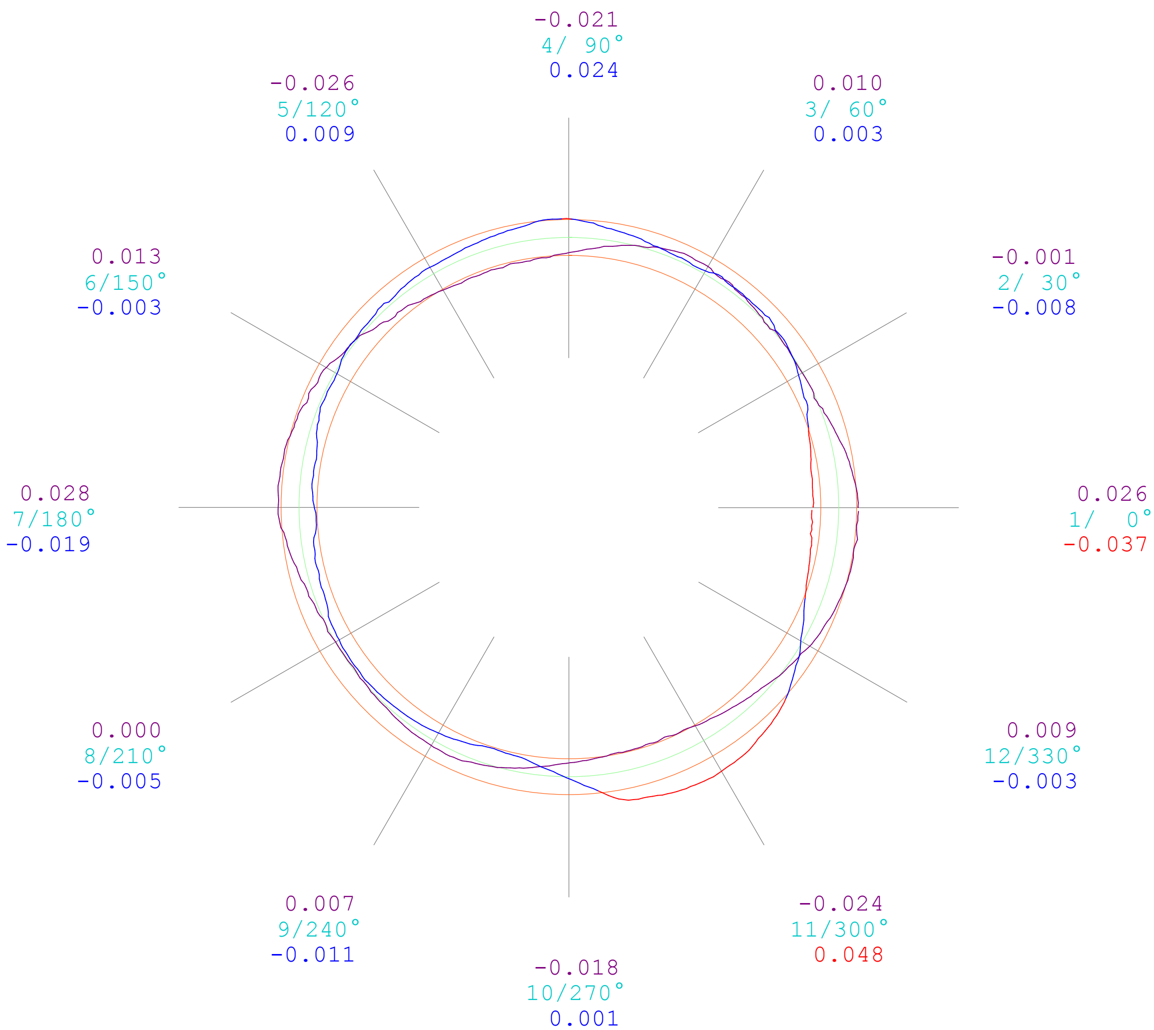
Roll Number ...		Job Number	**12345**
Operator		Roll Name	**Soft Cal**
Customer	**PM 1**	Face Length ...	**7787** mm
Measured on ...	**Fri Aug 31 15:04:11 2007**	Diameter	**998.98** mm
Printed on	**Fri Oct 05 14:58:26 2007**	Hardness	
Report Data 1:.		Roll Data 1:...	
Report Data 2:.		Roll Data 2:...	
Report Data 3:.		Roll Data 3:...	
Measured	**INTERMEDIATE**	Roll Data 4:...	
Measuring ..... Location	**DRIVE END**	Roll Data 5:...	
		Roll Data 6:...	
Gauge Head .... Position	**OPERATOR SIDE**	Centering	**USE MEAN VALUE**
Tolerance Band. ±	**0.0250** mm	Filtering	**1**
Scale	**0.1250** mm		



First Gauge TIR
Max. Difference **0.052** mm

Second Gauge TIR
Max. Difference **0.144** mm

Roll Number ...		Job Number	12345
Operator		Roll Name	Soft Cal
Customer	PM 1	Face Length ...	7787 mm
Measured on ...	Fri Aug 31 15:04:11 2007	Diameter	998.98 mm
Printed on	Fri Oct 05 14:59:11 2007	Hardness	
Report Data 1:.		Roll Data 1:...	
Report Data 2:.		Roll Data 2:...	
Report Data 3:.		Roll Data 3:...	
Measured	INTERMEDIATE	Roll Data 4:...	
Measuring ..... Location	DRIVE END	Roll Data 5:...	
Gauge Head .... Position	OPERATOR SIDE	Roll Data 6:...	
		Centering	USE MEAN VALUE
		Filtering	1
Tolerance Band. ±	0.0250 mm		
Scale	0.1250 mm		



True Roundness
Roundness. 0.089 mm
Run-out. 0.004 mm @ 297 °

Motion
Max. Difference 0.060 mm