AN INDUSTRIAL APPLICATION OF THE CONTACT RECOGNITION BETWEEN GRINDING WHEEL AND WORKPIECE

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Nowadays the competition between manufacturing processes companies require intelligent solutions to reduce cost- and time-spending operations. New strategies have to be implemented for a reliable productivity and for customer satisfaction. Among the current processes, grinding is one the most used process on daily manufacturing activities, being used usually to produce parts with high surface quality and close tolerances. As grinding is generally situated at the end of the production chain unexpected errors have to be avoided, otherwise it results in increasing production costs and even wasted parts. A possibility to enhance the capability of a grinding process consists in using monitoring systems integrated in the grinding machine. The monitoring systems which use the acoustic emission of the grinding process to generate informations permit to interfer directly on the control of the machine tool, allowing the process optimization. Based on the knowlege that the acoustic emission signal is recognised in the moment of contact between the grinding wheel and the workpiece in plunge grinding, in this work the acoustic emission (AE) signals have been used to reference the grinding wheel in relation to the position of an oblique workpiece.

Keywords: *Grinding, Process monitoring, Acoustic emission*

1. INTRODUCTION

In periods of crisis, the need for economical and efficient processes becomes specially required. In the manufacturing industry, the grinding process is one of the most used processes used when great quality and close tolerances are desirable. An automotive part deliverer employs grinding to manufacture broaching tools with a high variety of shapes, including helical broaches. During the setup of the grinding operations, an activity that demands considerably amount of time by the machine operator consists in determining the referenced position of the grinding wheel in relation to the workpiece axis. Due to the design characteristics of the machine tool (designed and build by the costumer (4 CNC controlled axis, 2 manual positioned axis) as well as the none standardized fixture of the grinding tool on the main spindle and no instrumented support for the operator to find the relative position between grinding tool and workpiece, the operator needs to find the referenced position of the grinding wheel by try and error procedure. This positioning exerts a direct influence on machined geometry and dimensions in respect to the tied required tolerances. The actual visual determination of the relative position of the grinding wheel in relation to the workpiece is done by detecting the contact during the infeed movement of the grinding wheel visually. The produced mark on the workpiece is about 30 µm deep. The produced mark is than used to verify the centered position of the grinding wheel in relation to the workpiece. This procedure leads to high errors regarding to the designed contour of the workpiece, requiring the rework of broaching tools and sometimes to rejected parts. The higher the angular position between grinding wheel and the workpiece axis is, more difficult is the determination of the centralized position. The present work suggests an instrumented way, based on acoustic emission (AE), to find the centralized position of the contact mark on the workpiece and, in consequence to produce a the symmetric desired profile. Therefore, an AE system was integrated into the CNC command of the machine tool in order to allow detecting the first contact between grinding wheel and workpiece. Different strategies to conducting the infeed movement of the grinding wheel against the workpiece have been tested aiming to detect a secure AE_{RMS} signal with reduced values of interference of the grinding wheel and workpiece. In a second strategy the centralized position was found by moving the grinding wheel in a traverse movement in respect to the workpiece. The positions related to the initial contact (spark in) and the final contact (spark out) were stored on the CNC command which computes the average distance and moves the grinding wheel to the centralized position. The strategies have been studied for two different angular positions (18º and 60º) of the grinding wheel in respect to the workpiece. These values correspond to the boundary limits used on daily activities on the machine.

2. STATE OF THE ART OF AE IN GRINDING

Acoustic emission (AE) is defined as the transient elastic wave generated by the rapid release of energy from a localized source or sources within a material when subjected to a state of stress. This energy release is associated with the abrupt redistribution of internal stresses, and as a result of this a stress wave is propagated through the material. The definition of AE given above indicates that processes that are capable of changing the internal structure of a material, such as dislocation motion, directional diffusion, creep, grain boundary sliding and twinning, which result in plastic deformation, phase transformations, vacancy coalescence and decohesion of inclusions and fracture, are sources of acoustic emission; of the processes mentioned above, only plastic deformation and fracture are of significance in metal cutting. Out of the four plastic deformation processes mentioned, generally, dislocation motion is the dominant mechanism in crystalline materials that are widely used in practice. (Ravindra et al. 1997)

The grinding process is characterized by the simultaneous contact of a large amount of cutting edges on the surface of the workpiece. All the individual contacts that are caused by the grits can be considered as a source of pulse deformation or stress on the workpiece. During the grinding process, as the grains wear increases with the time, the individual characteristics also change, leading to different cutting edges and grains distributions on the grinding wheel. The sources of AE in grinding process are mainly the bond and grain fracture, grain cracks and friction between abrasive grain and workpiece, all of them directly connected to chip formation process (Hundt *apud* Hassui) , and wheel wear. Figure 1 exemplifies the major AE sources that can be found in the grinding process (Karpuschewski, 2001)

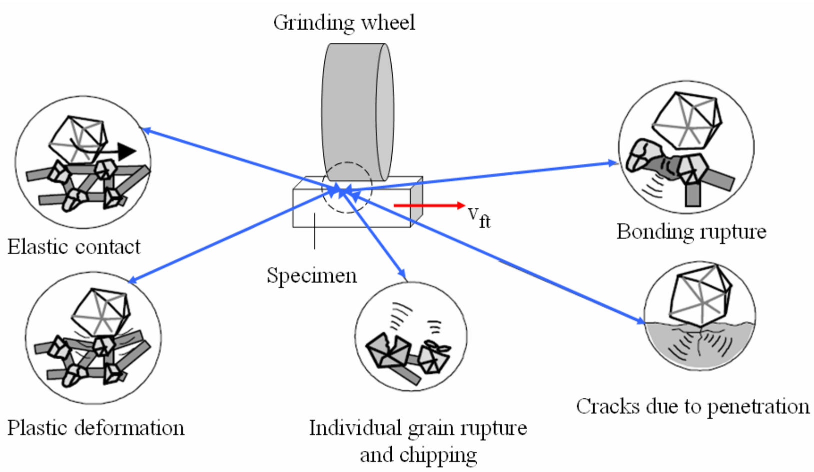


Figure 1. Sources of acoustic emission in the interface between grinding wheel and workpiece. (Karpuschewski, 2001)

2.1. UTILIZATION OF ACOUSTIC EMISSION SIGNALS IN GRINDING PROCESS

The raw acoustic emission signal is fulfilled with different high frequencies, on different levels, difficult to interpret. One of the most employed techniques to extract useful information from the raw acoustic emission signals (AE_{RAW}) consists in the use of the RMS value (root mean square) of the acoustic emission signals "Hwang et al.(2000)". The AE_{RMS} represents a physical dimension of the AE signal intensity and depends directly from the amount and dispersion of stress on the material (Meyen, 1991). According to "Hwang et al.(2000)", the AE_{RMS} signal is defined as:

$$AE_{RMS} = \left[\frac{1}{\Delta T} \int_{0}^{\Delta T} V^2(t)dt \right]^{1/2} \tag{1}$$

Where:
V= RAW acoustic emission signal (AE_{RAW})
ΔT= Integration time constant

The AE_{RMS} (rectified value of AE signal) has been successfully used to monitor several grinding situations however, the spectrum analysis can complement the interpretation in situations where the RMS technique cannot allow satisfactory results (Oliveira, 2001)

3. EXPERIMENTAL SETUP

The experimental setup that has been designed for the tests was implemented in a cylindrical CNC tool grinding machine for broaches (Stauffer/Zen), schematically illustrated on Fig.2. The x, y, z and a (rotation of the workpiece) are CNC controlled. The rotation of the grinding wheel (b) and the additional rotation axis b_1 and c (rotation and tilting of the wheelhead) are operated manually with the indication of the angular position on the screen of the CNC control. The grinding speed and feed rates are controlled by the CNC program. The grinding wheel has a diameter of 100mm. The maximal workpiece length is about 1000 mm. An AE based monitoring system is integrated into the CNC command of the machine to allow the implementation of the automatic recognition of contact between grinding wheel and workpiece. The AE transducer, delivered by the manufacturer of the monitoring system (MS), was screwed on the tailstock. The position on the tailstock showed the lowest interference from the moving components on the machine and a good signal from the process. The MS outputs were delivered to the CNC command of the grinding machine by means of pin-6 of the connector DB-25 present on the MS. This pin is associated to the digital output from the MS and delivers a voltage signal to the input of the CNC of the machine every time the AE_{RMS} signals (from the contact) exceeds the AE-Limit 1 (threshold) previously adjusted by the user. The signals originated from the AE transducer during the event of contact and the information of the traverse movement of the grinding wheel over the specimen are captured and adequately treated. The MS carries out a signal treatment in order to convert the AE_{RAW} signal into AE_{RMS} signal. The AE_{RMS} signals were sent directly to a laptop through a RS-232 interface and could be visualized on the monitor of the laptop by the aid of a specific software which accompanies this MS (Walter Dittel, 2007). This software permits to digitalize the AE_{RAW} signal using a sampling rate of 1000 Samples/s. In parallel, the coordinates associated to the spark in and spark out signals are stored in the CNC command.

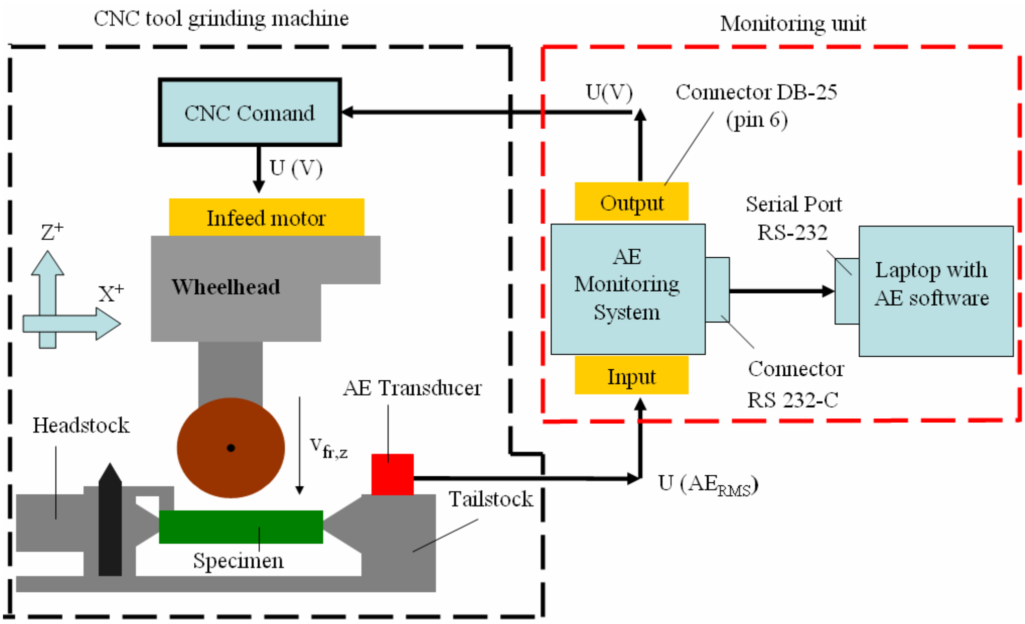


Figure 2. Experimental set up used along the experiments.

4. EXPERIMENTAL PROCEDURE

A grinding wheel is mounted and profiled with a flat top on the grinding machine. A cylindrical specimen (material: M2 steel) is fixed between the headstock and tailstock. With a precision indicating gauge the parallelism between the specimen surface and the X-axis was verified. To certify that the acoustic emission signals were adequately recognized by the monitoring system, the specimen was touched with a metallic bar. The contact recognition and centering experiments have been executed without cutting fluid.

After recognizing the contact with the lowest values of interference between grinding wheel and workpiece, it was possible to implement the strategy to recognize the centralized position of the grinding wheel in respect to the workpiece. The strategy to automatically recognize the centralized position between grinding wheel and specimen is characterized by a traverse movement of the grinding wheel over the specimen with a small interference. The main goal of the experiments consisted in implementing a strategy to automatically determine the centralized position of the grinding wheel in relation to the specimen. The centralized position between grinding wheel and specimen is associated to the Y-axis of the grinding machine. The strategy to center the grinding wheel in respect to the specimen was named as $ZEROY_{AUTO}$. The term “ZERO” refers to the centralized position, whereas the term “$_{AUTO}$” in means the automatic use of the AE_{RMS} signals from the spark in and spark out events. During the experiments to verify the $ZEROY_{AUTO}$ strategy the specimen was kept without revolution (v_w= 0 m/s) and without using cutting fluid. The cutting speed of the grinding wheel was maintained constant along the experiments.

The contact between grinding wheel and the specimen is featured by a physical mark which results from the removal of the material on the surface of the specimen during the time initiated at the first contact between a grit and the specimen until the complete stop of the infeed motion of the grinding wheel. It is always desirable to achieve the smallest mark as possible, in such a way that the dimensional tolerances are not affected.

Even considering that the metal removal on the centering experiments is extremely small, before starting each group of experiments to verify the $ZEROY_{AUTO}$ strategy, the grinding wheel was dressed and the MS turned on. At the beginning of each experiment the grinding wheel was positioned in a secure distance above the surface of the specimen (Z^+= 2mm), visually close to the centralized position of the grinding wheel in respect to the specimen, as showed on Fig. 3**,** position “b” at left. The grinding speed was set to the desired level. Then the grinding wheel is ordered to move to the workpiece (v_{frz}= 10 mm/min) on the Z-axis until the contact with the specimen is recognized by the AE monitoring system and the infeed motion is stopped, (Fig. 3, position “a” at left). The contact position is stored in the CNC for further use. The grinding wheel returns to the safe position “b” and moves along the Y-axis for about 10 mm and more 10 mm on the X-axis, (Fig. 3, position “c and d” respectively). The grinding wheel is ordered to move in Z-axis down to the reference position recognized earlier on point “b” and more 0.01 mm, (a_{e1}) point “e”. The grinding wheel moves along the Y-axis crossing the workpiece completely until point “f”. During this trajectory the grinding wheel touches the workpiece. This contact is recognized by the AE MS and is represented by the smaller mark on the specimen surface. The AE signals in this contact have shown to be not adequate for a centering strategy. The grinding wheel is moved for an increment along the Z-axis, position “g”, (a_{e2}) and than returned to the position “h” on the back side of the specimen. During this movement the spark in position (Y1) and the spark out (Y2) positions are stored into the CNC command and form the reference positions to centering the grinding wheel in respect to the specimen. Than the grinding wheel is lifted to position “i”, moved to “j” and “k” centered over the workpiece and plunged into the specimen until the contact is recognized Fig.3 (position “l”). Figure 3 shows briefly all the stages of movement described by the grinding wheel using the $ZEROY_{AUTO}$ strategy.

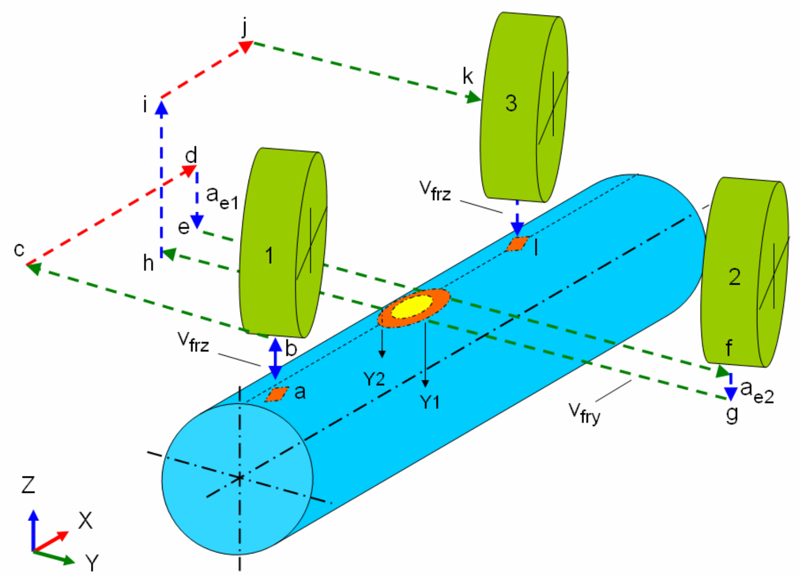


Figure 3 – Phases of movement of the grinding wheel using the $ZEROY_{AUTO}$ strategy.

5. STRUCTURE OF THE EXPERIMENTS

The structure of the experiments was divided into two stages. The first stage has aimed to determine the appropriate conditions in recognizing automatically the centralized position between grinding wheel and specimen by analyzing the major factors which presented influence on the AE_{RMS} signals and thence on the values of $ZEROY_{AUTO}$. During this first stage, the values of the centralized position by using the strategy $ZEROY_{AUTO}$ were compared to the mean value achieved when using the manual strategy. Among the factors that influence the $ZEROY_{AUTO}$ strategy are the cutting speed v_s, the depth of cut a_{e2}, the traverse infeed along the Y-axis v_{fry}, and value of the integration constant time ΔT, selected on the AE MS. Besides these factors, the relative angular position between grinding wheel and specimen λ, has also showed a significant influence on the AE_{RMS} and consequently on the value of center by using the $ZEROY_{AUTO}$ strategy. This position corresponds to the value of the helical angle of the broaching tool. This angle was chosen equal to λ = 18° and λ = - 60°, as being the angular limits of the helical angle of the broaching tools being manufactured by the costumer. Figure 4 shows a schematic top view of the working chamber and the angular positions used during the experiments.

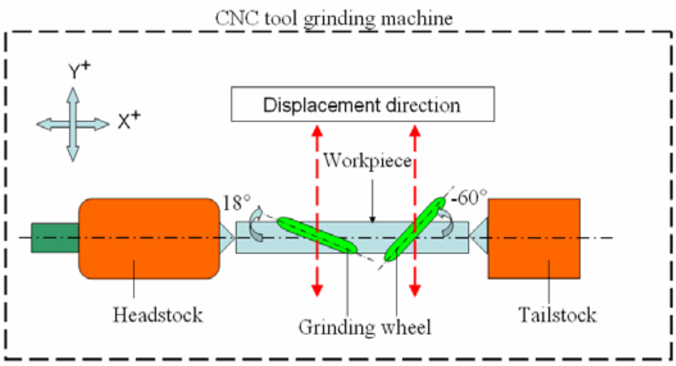


Figure 4 –Schematic representation of both angular positions used during experiments.

The 4 mentioned factors were varied each at 2 levels following the scope of a Factorial Analysis. The combination of the 4 factors and its respective levels of variation have led to a total of 16 experiments, table **xxx.** For each of the 16 experiments, 3 repetitions (R1, R2, R3) have been done in order to achieve a representative mean value and a standard deviation of the centered position, using the $ZEROY_{AUTO}$ strategy. The mean value for each experiment was compared to the mean value of the manual procedure. The levels of variation have been determined by observing the boundary limits to be used without damaging the machine. These values also corresponded to those normally used during the daily jobs on the machine. The levels of variation connected to the factor ΔT, were selected in such a way that the $ZEROY_{AUTO}$ strategy could be implemented. The analysis of the 4 factors have been done by using the critical angular positioning λ= - 60°. The best results for this positioning were compared to the results for λ= 18°. The bests results were close to the mean value obtained with the manual procedure. Table 1 illustrates the combinations of factors with the best achieved results.

Table 1 - Combinations of factors and its respective levels of variation during the first stage of experiments.

Manual procedure (mean value): 180,234 (λ=-60°)									
EXPERIMENTS	FACTORS				REPETITIONS			$ZEROY_{AUTO}$ (Mean)	$ZEROY_{AUTO}$ (Standart Deviation)
	Δt (ms) ↑= 33,33 ↓= 10	V_{fry} (mm/min) ↑= 300 ↓= 200	a_{e2} (mm) ↑= 0,01 ↓=0,05	N (rpm) ↑= 6000 ↓= 5000	R1	R2	R3		
1	↓	↓	↓	↓	180,629	180,806	180,804	180,746	0,082
a	↑	↓	↓	↓	180,395	180,645	180,724	180,588	0,171
b	↑	↓	↓	↓	180,565	180,312	180,423	180,433	0,126
c	↓	↓	↑	↓	181,241	181,37	181,338	181,316	0,067
d	↓	↓	↓	↑	180,833	180,937	180,743	180,837	0,097
ab	↑	↑	↓	↓	180,226	180,245	180,245	180,238	0,010
ac	↑	↓	↑	↓	180,547	180,676	180,93	180,717	0,194
ad	↑	↓	↓	↑	180,607	180,19	180,659	180,485	0,257
bc	↓	↑	↑	↓	180,624	180,978	181,008	180,874	0,213
bd	↓	↑	↓	↑	180,659	180,358	180,451	180,489	0,154
cd	↓	↓	↑	↑	181,126	181,541	181,429	181,365	0,214
abc	↑	↑	↑	↓	180,543	180,092	180,143	1180,259	0,246
abd	↑	↑	↓	↑	180,496	180,201	180,054	180,250	0,225
bcd	↓	↑	↑	↑	180,541	180,684	180,889	180,704	0,174
adc	↑	↓	↑	↑	180,694	181,303	181,482	181,159	0,413
abcd	↑	↑	↑	↑	180,209	180,215	180,139	180,187	0,042

After conducting the 48 experiments regarding to the first stage of the experimental procedure it was possible to verify the experimental conditions which conducted to the nearest mean values between both strategies ($ZEROY_{AUTO}$ and the manual procedure). Among all the 16 experimental conditions just 4 have shown to be useful. The best results were achieved when using the experimental situations, "ab", "abc", "abd", and "abcd" which are detached on table 2. These experimental situations have in common the fact that the factor "ΔT" and "vfry" were set at the highest levels (33.33 ms and 300 mm/min, respectively).

By using the condition "abcd" the angular position of the grinding wheel was then modificated to λ=18° and the strategy $ZEROY_{AUTO}$ was again tested. Table 2 shows the obtained results after 6 repetions on this condition:

Table 2- Achieved results when using the condition "abcd" and an angular position of λ= 18°.

REPETION	$ZEROY_{AUTO}$
R1	47,949
R2	47,952
R3	48,067
R4	48,066
R5	47,903
R6	47,901
MEAN	47,973
STANDART DEVIATION	0,069
$ZEROY_{MANUAL}$	48,122

Despite the difference in about 0.15mm observed in the mean value founded with strategy $ZEROY_{AUTO}$ in comparison to the mean value obtained through the manual procedure, the results have shown this experimental combination could be considered as possible to be used on both angular positions of the grinding wheel (λ=18° and λ=60°) leading to close values between both strategies. Meanwhile, to prove the real efficiency in finding the centralized position with strategy $ZEROY_{AUTO}$, it was necessary to analyze the results obtained along the second phase of the experiments.

The second stage of the experiments consisted in comparing the efficiency of the $ZEROY_{AUTO}$ strategy and the manual procedure in achieving a centralized symmetric groove on a specimen for the angular position of λ= 18°. The comparison was made by measuring the ground groove on the specimen. The groove was measured on a coordinate measuring machine (see Fig. 5) and referenced to the axis of the workpiece and the reference profile. In this procedure the reference profile is independent of the judgment of the grinding machine operator. The machined groove profile was scanned and exported to a specific software allowing the visualization of the actual and the designed profile. The software also permitted to determine the distances between the measured and designed profile on desired positions.

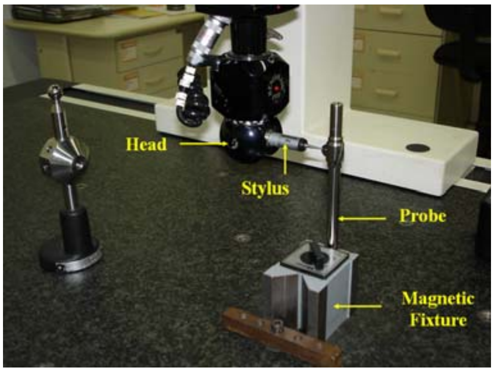


Figure 5 - Measurement of the grooves on a coordinate measuring machine.

6. RESULTS AND ANALYSIS

During the first stage experiments the recorded signal for the different steps of the procedure to automatically detect the centralized position between grinding wheel and specimen shows a repeatable behavior. A characteristic example is shown on Fig. 6. The first peak is consequence of the contact along the Z-axis. The recorded contact position gives the reference for the a_{e1} and a_{e2} cutting depths in the next steps. The second peak is generated due to the contact during the traverse movement from "e" to "f" and the third from the backward movement from "g" to "h". The forth peak is consequence of the infeed motion along the Z-axis at the centralized position between Y1 and Y2.

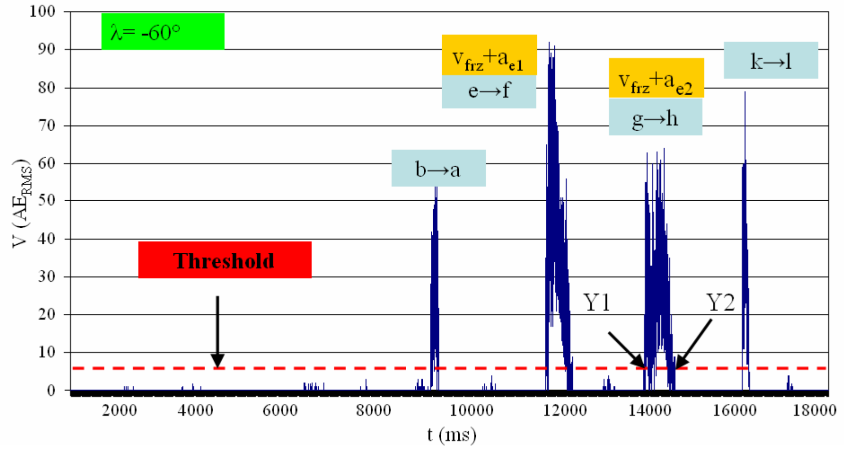


Figure 6 – Characteristic AE_{RMS} signal during the $ZEROY_{AUTO}$ strategy.

The third peak is enhanced on Fig. 7. It shows that the entrance slope is higher than the outgoing slope. This behavior is highlighted through the auxiliary dashed lines in the same figure. The difference noted in both entrance and outgoing slopes is due to the metal removal at the beginning of the contact between the grinding wheel and the specimen. During the traverse movement of the grinding wheel in respect to the specimen, the metal removal stops when the first corner of the grinding wheel starts to lose contact with the specimen. The remaining part of the grinding wheel, which is still in contact with the specimen, continuous to generates an AE signal, but a signal with lower amplitude than the signal at the moment of the entrance of the grinding wheel.

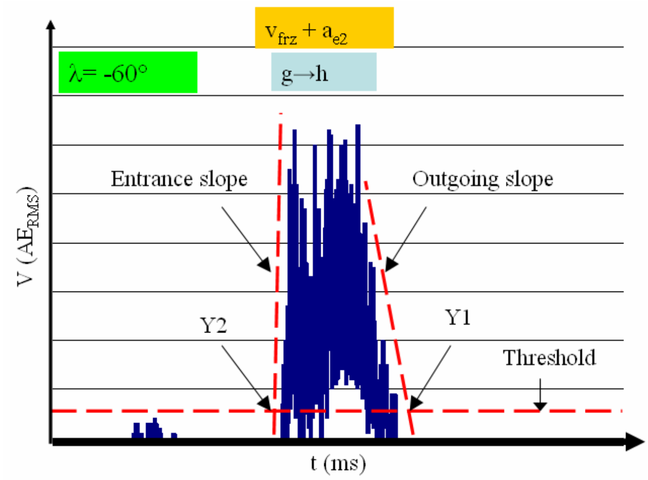


Figure **7**– Characteristic AE_{RMS} signal during displacement g→h by using the $ZEROY_{AUTO}$ strategy.

The results obtained during the second phase of experiments have been achieved with an angular positioning of λ=18° and a grinding wheel presenting an involute lateral profile as well as a concave top profile (corresponding to the corrected root radius of the broach). For a first approach, the grinding wheel was manually centered. The 4 best experimental conditions that have been encountered on the first phase were verified with the strategy $ZEROY_{AUTO}$ in order to guarantee a reliable result. The combination "abd" (Tab. 1) has led to the closest mean value to those obtained manually (54,846 with $ZEROY_{AUTO}$ against 54,834 obtained manually). By using these mean values of center a groove was machined on the specimen for each centralized position. Thereafter the profile of the grooves has been measured. To compare the efficiency of both strategies in reaching a centralized position between grinding wheel and specimen, it was necessary to evaluate the deviations from the designed profile. Figure 8 illustrates an example of the aspect of the measured profile and the overlapping of the designed profile.

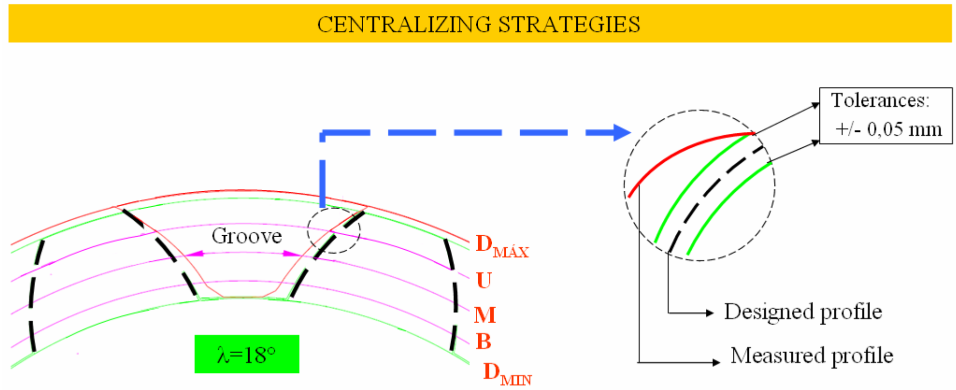


Figure 8 –Designed and measured and profiles achieved by using both strategies

The designed and the scanned profile of the grooves are represented on Fig. 8. The duplicate lines, shown in the enhanced circunference represent the dimensional tolerances of the designed profile. For this profile the tolerances range from +/- 0,05 mm. The scanned profile (measured profile) shows to be extremely out of the desired tolerances. As the main goal of this study was related to the determination of a centralized position amid the grinding wheel and specimen, the correction of the dressed profile is done in a second step, out of the scope of this research. That is why the groove was machined only until the desired depth (D_i), not considering the profile.

The overlapping of the designed profile permits to verify the quality of the centralized position of the grinding wheel in respect to the workpiece. The measurement of the deviations between the designed profile and the measured profile in pre-established radial positions has been done by the aid of a specific software which determinates the linear distance on 3 defined sections in both profiles (defined as Upper U, Middle M, Bottom B). The measured error corresponds to the value between the mean designed profile and the scanned profile. Figure 9 shows the results of the ground grooves with a manual (Fig. 9-a) and with the $ZEROY_{AUTO}$ strategy (Fig. 9-b).

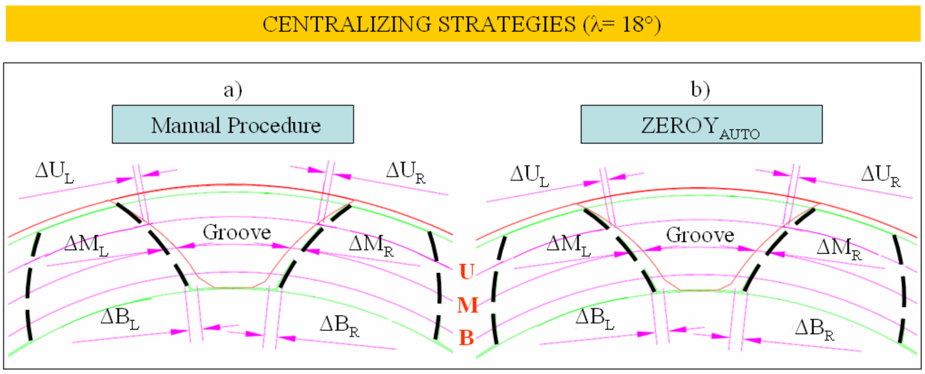


Figure 9- Centralization achieved by using the manual procedure and the strategy $ZEROY_{AUTO}$.

It is possible to verify the achieved centralization by using both strategies presents a good result in terms of the relative position to the design profile. Both strategies lead to machined grooves whose profiles appear to be adequately centralized in reference to the designed profile. The used symbol Δ, corresponds to the gap (error) between the measured and the designed profile. The letters “R” and “L” represents the sides of the groove in which the measurement of the deviations have been done (“right” and “left” side, respectively).

Figure 10 compares the measured values at the upper (U), middle (M) and bottom (B) positions of the ground and designed profile by using both centralizing strategies. The deviation of the centralized position is also shown. The software that superposes the measured and the designed profile considers the best fit at the middle position M. If there is a deviation at the top, it indicates that the centralization of the grinding wheel is not adequate. The centralization that has been done by the operator (manual procedure) shows a deviation at the top of 0,01 mm.

CENTRALIZING STRATEGIES (λ= 18°)

Manual Procedure

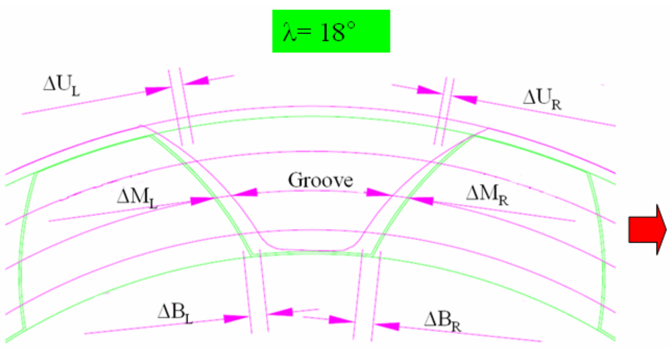
Measuring Position	Deviations		
	Δ_L (mm)	Δ_R (mm)	Δ (mm)
U	0,091	0,101	0,01
M	0,168	0,168	0
B	0,201	0,208	0,007

ZEROY$_{AUTO}$

Measuring Position	Deviations		
	Δ_L (mm)	Δ_R (mm)	Δ (mm)
U	0,088	0,085	0,003
M	0,162	0,162	0
B	0,197	0,204	0,007

Figure 10 – Achieved centralization by using the manual procedure and the ZEROY$_{AUTO}$ strategy. The deviation Δ, means the absolute value of (Δ_L-Δ_R).

Meanwhile, when observing the deviation values obtained in each measuring section (U, M, B) an advantage has been note when using the strategy ZEROY$_{AUTO}$, which has conducted to a lower value than that featured by the manual strategy. As a manner to comprove the achieved values were really the representation of a centralized prolifle a new groove has been machined on the specimen dislocated at 0,2 mm from the centralized value obtained with the ZEROY$_{AUTO}$ strategy. The groove was afterwards measured as the same way done along the experiments and its profile has been compared to the designed profile. Figure 11 demonstrates the results obtained.



Measuring Position	Deviations		
	Δ_L (mm)	Δ_R (mm)	Δ (mm)
U	0,013	0,089	0,041
M	0,169	0,169	0
B	0,191	0,209	0,018

Figure 11- Aspect of the measured profile achieved by machining a groove dislocated 0,2mm (Y-axis).

7. CONCLUSIONS

Based on the results that have been showed in the present article it is possible to verify the proposed strategy (ZEROY$_{AUTO}$) is feasible to be implemented in a practical sense, specially when analyzing the angular position of λ= 18°, which represents the smallest helical angle used to machining the broaching tools inside the costumer. As a first advantage, the ZEROY$_{AUTO}$ strategy has led to an insignificant deviation in relation to the designed profile (0,003 mm at the top measuring section) while the use of the manual strategy conducted to a higher deviation (0,01 mm) at the same measuring section. Such deviation was close to the maximum permitted tolerance designed for the specific profile. The second advantage that was noted when using the ZEROY$_{AUTO}$ strategy has consisted in the considerably reduced time (30s) to recognize the centralized position between grinding wheel and specimen. By using the manual procedure, the average time to find the centralized position has been situated in about 5 min and the necessary verification of the position of the first grove in the metrology laboratory demanding a considerably amount of time (up to several hours).

Additional studies are being made toward the verification of applicability of the strategy ZEROY$_{AUTO}$ by using an angular position of λ= -60°. This positioning consists in a critical situation to recognize the centralized position during the jobs on the machine.

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9. RESPONSIBILITY NOTICE

The authors, Walter Lindolfo Weingaertner, Adriano Boaron, are the only responsible for the printed material included in this paper.

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