Automatic System for Thermal Damage Detection in Manufacturing Process with Internet Monitoring

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This work involved the development of a smart system dedicated to surface burning detection in the grinding process through constant monitoring of the process by acoustic emission and electrical power signals. A program in Visual Basic® for Windows® was developed, which collects the signals through an analog-digital converter and further processes them using burning detection algorithms already known. Three other parameters are proposed here and a comparative study carried out. When burning occurs, the newly developed software program sends a control signal warning the operator or interrupting the process, and delivers process information via the Internet. Parallel to this, the user can also interfere in the process via Internet, changing parameters and/or monitoring the grinding process. The findings of a comparative study of the various parameters are also discussed here.

Keywords: *Grinding, burn detection, acoustic emission, electrical power, monitoring, internet.*

Introduction

The grinding process is the last stage of the manufacturing cycle and therefore represents a high added value in the end product. In this context, researchers have sought to control the grinding process through approaches that qualify and quantify it faithfully. Owing to the large number of variables involved in the process, the existing approaches encompass a limited number of situations, many of which are inapplicable in practice.

However, to the new technologies, researchers have been adding tools that can overcome deficiencies heretofore difficult to solve. These new technologies incorporate a great number of advanced digital signals processing functions to process, filter or alter characteristics so that information can be identified in the process, thereby enabling transducer signals to be associated with the processing.

Thus, the implementation of superficial burn monitoring systems in grinding machines may not only improve the reliability of these operations but also increase quality and reduce costs. However, their implementation is still fraught with difficulties due to several factors and a lack of well-defined criteria for their best practical application. These obstacles highlight the need for a computational tool that can overcome these limitations.

The innovative proposal described here was made possible by associating the parameters developed by other researchers with digital signals processing tools.

The objectives of this work are as follows: 1) Development of a computational software program that can process signals and detect burning in the surface grinding process (on-line and off-line); 2) Development of new parameters for burn detection; 3) Definition of burn thresholds (Slight, Medium and Severe), comparing the newly developed parameters with existing ones; and 4) Allow for monitoring and process control via the Internet.

Burn Monitoring in Grinding

One of the most common types of thermal damage in grinding process is the workpiece burn. This phenomenon has been investigated recently by several researchers, still there is no measurements methods that allow the on-line monitoring (Webster et al., 1994; Konig, 1993). The industrial user is forced to rely on destructive tests of the parts that are gotten from a random way. This is time consuming and high cost procedure, conflicting with the current trends of increasing demand by minimum cost (Aguiar, 2003).

The visible burning in steels is characterized by bluish coloration on the surface of the part, which is due to the formation of oxide layer. This coloration generally is removed by the "spark-out" period at the end of the grinding cycle, but this effect is cosmetic, and the absence of coloration on the ground surface does not mean necessarily that the burning of the part did not occur (Malkin, 1989).

Basically, the difficulty in controlling thermal damage in the grinding process is the lack of a reliable method to provide real-time feedback during the process. Webster et al. (1994) demonstrated that the measurement of acoustic emission signals is considerably more sensitive to variations in grinding conditions than the measurement of force and power, thus offering a more promising technique for on-line monitoring of the process.

The predominant parameter studied in previous researches using acoustic emission has been the root mean square (RMS) of the filtered EA signal (EArms) over a carefully selected frequency band. This signal has been a reasonable study parameter, for the grinding process is very rich in sound waves and so contains a great deal of available acoustic information. For this reason, and because of technological limitations, it has been the focus of earlier and current researches (Saravanapriyan et al., 2001; Pathare etal., 1998; Inasaki, 1999; Wang etal., 2001; Soares & Oliveira, 2002).

Aguiar (1997) demonstrated that the RMS acoustic emission signal and the cutting power signal combined can provide significant parameters for indicating burning of the workpiece in surface grinding. This researcher has been using a configuration of a fixed EA sensor coupled close to the workpiece and an electric power sensor from the grinding wheel starting motor to measure the cutting force. The combination of these signals has provided Aguiar (1997) with a parameter to indicate burning of the workpiece, which has been dubbed DPO, and which consists of the relation between the standard deviation of the RMS acoustic emission signal and the maximum cutting force per grinding wheel pass. Expression (1) represents the DPO parameter.

$$DPO = \sigma(EA)Max(P) \qquad (1)$$

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Where $\sigma(EA)$ is the Standard deviation from the acoustic emission; and $Max(P)$ is the maximum power in the pass.

Although the DPO parameter has proved to be a burn indicator in most of the tests that have been conducted, in some cases it has not behaved the same way. Aguiar et al. (2002) developed another important parameter to detect superficial burning in surface grinding, the FKS parameter. This parameter is calculated by dividing the maximum cutting force per grinding wheel pass by the product of the skewness and the kurtosis statistical tools, both applied to the acoustic emission signal obtained in each pass of the grinding wheel. Expression (2) represents the FKS parameter.

$$FKS = \frac{F_{c(Max)}}{S(EA)K(EA)} \qquad (2)$$

Where $F_{c(Max)}$ is the maximum cutting force in the pass; $S(EA)$ is the skewness of the acoustic emission signal in the pass; and $K(EA)$ is the kurtosis of the acoustic emission signal in the pass.

The raw acoustic emission signal has also recently been explored in monitoring of the grinding process. Technical papers have shown that the use of signal processing tools and neural networks are efficient in monitoring grinding (Aguiar, 2003; Wang et al., 2001; Aguiar etal. (1999); Aguiar etal., 2002).

Mokbel & Maksoud (2000) stated that the raw acoustic emission signal can be a very useful tool for monitoring the conditions of the grinding wheel in the grinding process, and that the variations in acoustic emission amplitude and in surface roughness within the frequency spectrum reflect the superficial condition of the grinding wheel.

Due to the changes that have been occurring in the scientific sector with the introduction of dedicated digital signal processor (DSP) and new signal processing routines, the number of papers relating these themes to the grinding process is extremely limited. When one applies an even more restricted approach, such as on-line control of burn detection in surface grinding, not a single paper seems to be available. Thus, the importance of this work in the scientific world is undeniable, clearly contributing toward the development of innovative research in this area.

Meanwhile, the use of the Internet in manufacturing systems has become commonplace over the years. Several articles demonstrate the integration of these systems with the Internet, allowing for the creation of simulation, monitoring and control software. However, when one restricts one's search to the grinding process, it is nigh impossible to find studies using the Internet as a means of communication, again illustrating the importance of this work for the scientific community.

Methodology

For burn detection to be on-line, as we propose here, and taking specific actions, it was necessary to develop a computational software program that could perform such tasks.

Newly Developed Software

The objective of the software developed in Visual Basic® and called Grinding Analysis is to contribute to the monitoring of burning in surface grinding. In other words, a tool, which, associated with other intelligent grinding tools, can add new functions to the control process. Figure 1 shows a block diagram of the newly developed software.

All the functions for configuring the software, i.e., the parameters required for its execution, were implemented in the "General Configurations" block. The definition of the data acquisition channels for storage of the signals, the acquisition time, sampling rate, characteristics of the graphs to be presented, database parameters, etc. are part of this block.

The "Additional Tools" contain all the algorithms for manipulating and treating the signals. Routines for filtering, data acquisition, importation and exportation are included in this block. In this stage, one can transmit and receive data from outside programs, adding portability to the tests. The function of the data acquisition tool incorporated in this block is to capture signals originating from the acquisition board without any processing.

The "Off-line Processing" block contains all the functions for the analysis and processing of off-line parameters. The functionalities of this block are extremely varied, allowing one to view the channels and apply the analytical tools (mean, standard deviation, variance, FFT – Fast Fourier Transform, maximum, minimum, etc.)(Smith, 1999) to any of the channels mapped in the software. This block also includes the off-line calculation of the burn parameters, enabling the user to detect the passes in which burning occurred based on a previously chosen parameter. Moreover, the automatic pass detection functions were implemented so that the entire process for calculating burn parameters is done without the user's interference.

The "On-line Burn Processing" block encompasses the same topics as those of the off-line burn processing, but the functions were adjusted to be executed as the process occurs. In this block, Internet access is available, allowing the user to monitor and alter parameters remotely.

The "Database" block contains the library of tests that have been performed, and allows for inclusions, alterations and exclusions. Access to a remote database is also possible in this block. This database includes characteristics of the grinding wheel, workpiece, fluid and control.

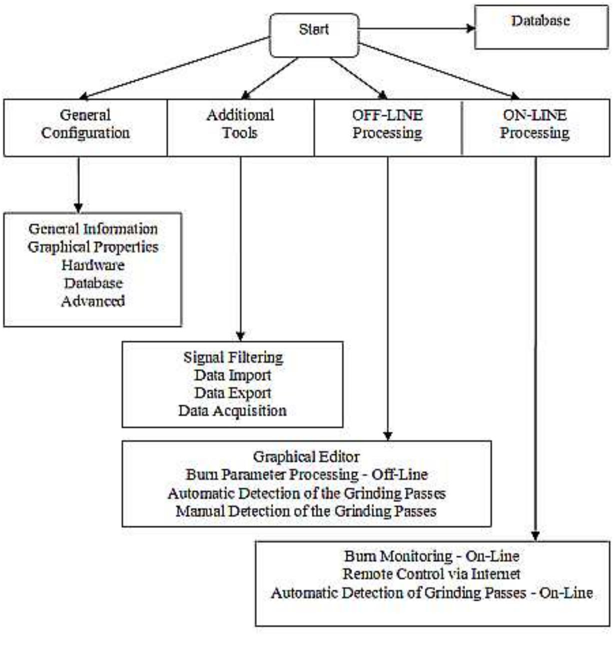


Figure 1. Block diagram of the newly developed software.

Implementation of Computational Routines for Data Acquisition

The computational implementation of routines in Visual Basic® for communication with the National Instruments® acquisition board used here consists basically of the development of algorithms that interface between Visual Basic® and the dynamic library (DLL) of National Instruments®. This dynamic library contains all the routines needed for communication with the acquisition board, allowing for the reading and writing of analogical and digital values on the board's respective output and input ports, as well as other functions that allow for its configuration.

The use of Visual Basic® in this communication eliminated intermediary layers that are normally used by various programs and that cause a significant reduction in the acquisition speed, besides compromising the precise control of the board.

The National Instruments® library contains an enormous number of functions for communicating with the data acquisition board. However, only a few of these functions proved really useful for data acquisition.

Computational Routines for Remote Access in Visual Basic®

To access the Internet with Visual Basic®, one must first develop an application that will communicate with the transport layer of the TCP/IP. The transport layer consists of two fundamental protocols: the UDP (User Datagram Protocol) and the TCP (Transmission Control Protocol).

In fact, it has been decided to create an application of the client-server type in Visual Basic®, for it is considered safer and more versatile for this case. Therefore, in this work the Windows® socket resources have been used, which offer ActiveX control for this type of functionality, called Winsock (or socket for Windows®). The Visual Basic® application should therefore work as a server or client application.

The TCP protocol was chosen in this work, because it offers its own resources for treating errors and controlling flow without requiring any additional code. However, the packages that pass through the network should always arrive, for if any delay occurs, it will be passed on to the system, which needs all the blocks to set up the information again.

A proprietary protocol was developed to make it difficult to invade the system, which will become a remote server (server application) available to users worldwide. This protocol was implemented under the Winsock control, validating users and checking if the connection should be maintained or not, depending on the degree of reliability established between client and server. In other words, all the data entering through the control are checked to assess the reliability of their generating source (client). Currently, the method most commonly employed in communications via the Internet is the one that uses cryptographic keys. In this work, part of the protocol that uses cryptography (encoding data so that it can only be decoded by specific individuals) was implemented.

Although client-server communication allows several clients to connect to the server simultaneously, it has been decided that this remote access system will allow only one connection because, for the data to be sent via the Internet as the grinding process is taking place, the time it takes to capture and send the data must be as short as possible. If simultaneous connections with various clients were permitted, this might cause delays in processing time, thus compromising the on-line burn detection.

Experimental Setup

Figure 2 illustrates the experimental setup used for testing this work. It can be seen in this figure that an induction motor, which is fed by a frequency converter, drives the grinding wheel; an electric power transducer is used to measure the cutting power; a fixed acoustic emission sensor is place close to the workpiece and then amplified accordingly. The electric power and acoustic emission signals are connected to a BNC connector block, which is wired to, the data acquisition board inside the personal computer (PC).

Through the modules of Acoustic Emission and Electrical Power of the Motor, the signals are captured from the sensors and transported to the National Instruments® data acquisition board, where they are converted into digital signals and then processed by the Grinding Analysis software.

The model of the National Instruments® board is a PCI 6035E, with 16 analog 16-bit input channels, 2 analog12-bit output channels, and 8 digital input and output channels. This board was installed in a PC AMD XP 1800 microcomputer with 128MG of RAM memory. The sampling rate used in the tests was 10,000 samples per second.

To measure the electrical power of the 7.5 horse-power three-phase induction motor that activates the grinding wheel's drive shaft, a module was used containing a Hall Effect sensor, model SA-20S, and a piezoelectric transducer, model LV25-P, both manufactured by LEM Components.

The acoustic emission generated in grinding was measured with a piezoelectric sensor, from Sensis, coupled to the support beside the workpiece to ensure the acquisition of signals free of undesirable noise. This sensor is then connected to a signal conditioner module, model BM12, also from Sensis, that calculates the RMS value of this signal (with a 1ms integration time). This calculated RMS signal is passed on to the data acquisition board.

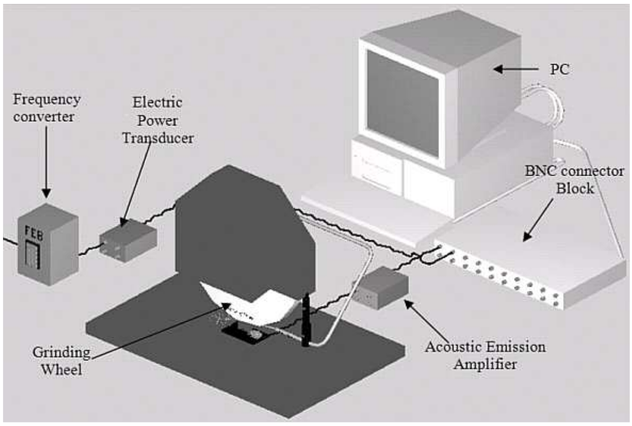


Figure 2. Experimental setup.

An important point, which was considered to remain constant in order not to vary the amplitude of the acoustic emission signal, is the position of the piezoelectric sensor fixed onto the workpiece support, as illustrate in Figure 3.

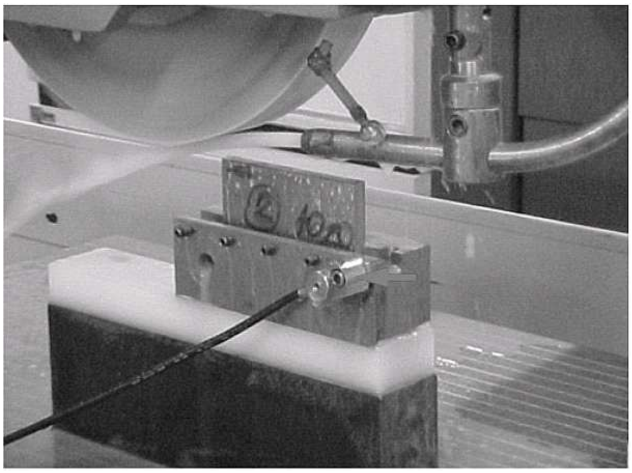


Figure 3. Piezoelectric sensor positioning.

The steel used for the test specimens (workpieces) was ABNT 1045 (ABNT stands for Brazilian Association for Technical Standards), which was tempered to increase its hardness to 32 HRC. The workpieces used in this work were rectangular prism-shaped with dimensions of 98.65 mm length, 48.79 mm height and 8.67 mm width. An aluminum oxide NORTON model AA46M6V grinding wheel was used. The grinding machine used for surface grinding was a model 1055E manufactured by SULMECÂNICA. An emulsion-type (5% concentration) cutting fluid was used in the tests, and a flease-type dresser was used in the dressing operations.

Four test specimens (workpieces) were used during the tests. The cutting depth was increased every 2 to 3 passes to force burning in the tests and thus obtain the respective burn thresholds for each of the parameters under study.

After a grinding process had started, it was only ended when severe burning occurred or when a given number of passes had been made (26th pass). Whichever of the two occurred first caused the end of testing on the workpiece.

The characterization and classification of burns were done visually during the machining. According to the coloring of the workpieces after each pass of the grinding machine, the surface of the workpiece was classified as no burn, slight, medium or severe burn. Table 1 shows photographs of samples of coloring obtained in the tests.

Table 1. Color patterns utilized for burn classification.

	Severe Burn
	Medium Burn
	Slight Burn
	No Burn

New Parameters for Burn Detection in Surface Grinding

The methodology employed in this work enabled us to discover other parameters that offer better results in some situations, or even contribute to confirm the occurrence of burning in cases where the known parameters cause doubts.

DPKS Parameter

The DPKS is calculated by multiplying the standard deviation of acoustic emission by the sum of the power subtracted from its standard deviation elevated to the fourth power. The expression (3) represents the DPKS parameter.

$$DPKS = \left(\sum_{i=1}^{i=m} (POT(i) - \sigma(POT))^4 \right) * \sigma(EA) \qquad (3)$$

where, i is the power index which varies from 1 up to m points in each pass; m is the number of points in the pass; *POT(i)* is the instant value of the power; σ*(POT)* is the standard deviation of the power in the pass; and σ(EA) is the standard deviation of the RMS Acoustic Emission in the pass.

DAREA Parameter

The DAREA parameter is calculated by the sum of the power signal elevated by the sum of the normalized RMS Acoustic Emission signal. Expression (4) represents the DAREA parameter.

$$DAREA = \left(\sum_{i=1}^{i=m} POT(i) \right)^{\sum_{i=1}^{i=m} \left(\frac{EA(i)}{EAMAX} \right)} \qquad (4)$$

where i is the index that varies from 1 up to m points in each pass; m is the number of points in the pass; *POT(i)* is the instant value of the power; *EA(i)* is the instant value of the RMS Acoustic Emission signal; and *EAMAX* is the maximum value of the RMS Acoustic Emission signal in the pass.

DIFP Parameter

The method of extraction of passes from the power signal was used to supply data for the calculation of this new burn parameter. Figure 4 shows the automatic pass definition in a power signal.

During the extraction of passes, triangles are created that define the region of valid passes. In Figure 4, note this triangle formed by the vertices 0, I and II.

The DIFP parameter actually uses the increasing straight line generated in the pass detection as a variation coefficient. The sine of the alpha angle (α) is calculated and multiplied by the average acoustic emission and then multiplied by the maximum power times one hundred. Expression (5) represents the DIFP parameter.

$$DIFP = 100.\sin(\alpha).MAXPOT.MEAN(EA) \qquad (5)$$

where, sin(α) is the sine of the angle formed between the increasing straight line present in the pass extraction of the power signal; MAXPOT is the maximum power in the pass; and MEAN(EA) is the average of the Acoustic Emission signal in the pass.

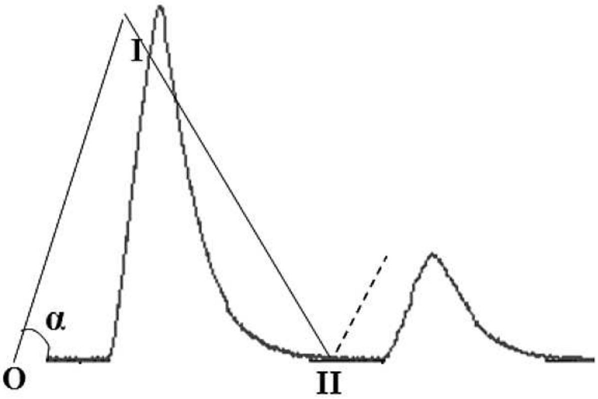


Figure 4. Algorithm of Pass Extraction in the Power signal.

Results and Discussion

Next, the results from the tests as well as the signal processing of the acoustic emission and electrical power will be shown and discussed. The Internet access which was implemented in the developed software will be presented.

Tests Results

Table 2 shows the results obtained visually during the grinding process for each of the four-machined workpieces (ABNT 1045 steel).

After the grinding process had started, it was only ended when severe burn occurred or when a given number of passes had been achieved (26 passes). Whichever the two occurred first caused the end of the test for that workpiece. However, the workpiece # 1 was not considered in this criterion on purpose, that is, without severe burn on it in order to have it as a reference during the analysis.

The definition of slight, medium and severe burn showed variations during the tests, and it was sometimes impossible to characterize the burn exactly according to one of these three categories. Therefore, we have used the prefixes + and – to represent intermediary situations.

Table 2. History of the grinding passes for the ground workpieces– ABNT 1045 steel – NB = No Burn, SLB=Slight Burn; MB=Medium Burn; SV=Severe Burn.

Passes	1	2	2	4	5	6	7	8	9	10	11	12	13
Part 1	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
Part 2	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
Part 3	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB
Part 4	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	NB	SLB	SLB

Passes	14	15	16	17	18	19	20	21	22	23	24	25	26
Part 1	NB	NB	SLB	SLB	MB	MB							
Part 2	NB	NB	NB	NB	NB	MB	MB	MB	MB	SB			
Part 3	NB	NB	NB	MB	MB+	SB							
Part 4	SLB+	SLB	SLB+	SLB+	SLB+	MB-	MB-	MB	MB	MB-	MB	MB	MB+

The acoustic emission and the electric power signals are shown in Figure 5 for just one grinding pass in order to illustrate more clearly the shape of each signal collected in this work. It can be seen in Figure 5(a) a great variation of the acoustic emission during the grinding pass followed by a period of time called spark-out in which the grinding wheel is not fed downward into the workpiece but just touch it instead. The electric power signal for a grinding pass is shown in Figure 5(b) where it can be observed its shape well-behaved and predictable.

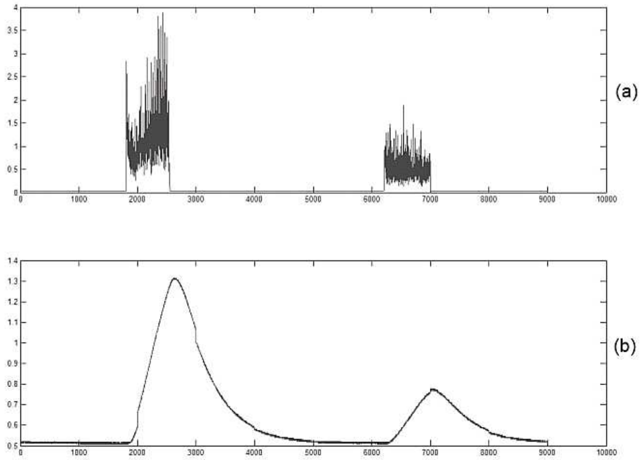


Figure 5. Signals collected in the tests – (a) Acoustic emission; (b) Electric power. The abscissa corresponds the # of samples and the y-axis the level in Volts.

Signal Processing

Figures 6 to 10 illustrate the processing of each of the burn parameters only for workpiece # 2, since it characterizes well the main types of burn that occurred. The upper graph in each figure represents the RMS acoustic emission signal during the test, while the power signal is represented by the graph in the center, and the detection parameter under analysis is located in the lower graph of each figure. The axis of the abscissas in the graphs represents the grinding wheel passes during the test, while the axis of the coordinates indicates the amplitude of the corresponding signal (acoustic emission in the upper graph; electrical power in the center graph; and burn parameter in the lower graph).

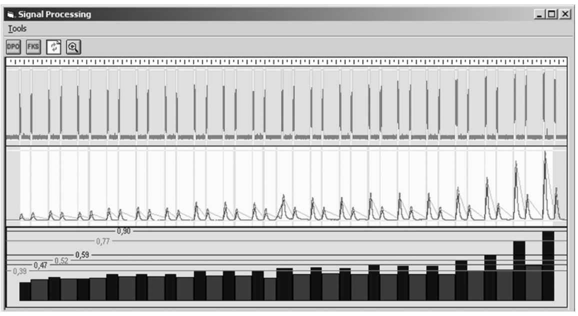


Figure 6. Processing of the DPO Parameter for Workpiece 2.

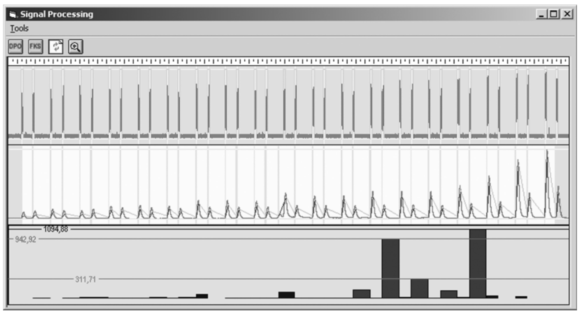


Figure 7. Processing of the FKS Parameter for Workpiece 2.

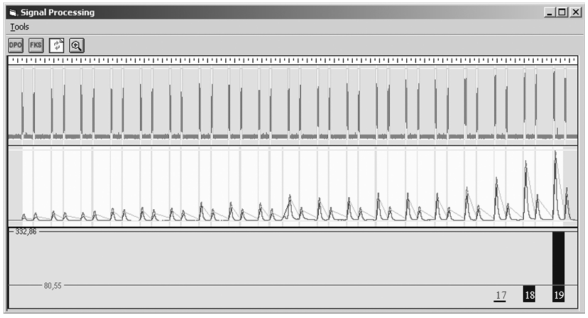


Figure 8. Processing of the DPKS Parameter for Workpiece 2.

Note that almost all the parameters presented good results in identifying the burn, with the exception of FKS, which shows a certain imprecision regarding the definition of a safe burn threshold, as indicated in Figures 7.

Also note that the DPKS and DAREA parameters in Figure 9 and 10 did a good job of identifying the beginning and end of the burn, the former effectively identifying slight burning and the latter identifying severe burning. These parameters demonstrate that, in each pass, there was in fact a beginning of the burn, whose levels varied significantly.

Based on these results, it has been possible to define the burn thresholds under the machining conditions described earlier. Table 3 summarizes all the results obtained with the definition of burn thresholds for each parameter.

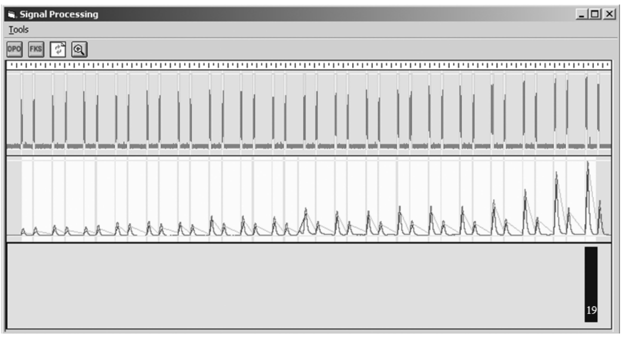


Figure 9. Processing of the DAREA Parameter for Workpiece 2.

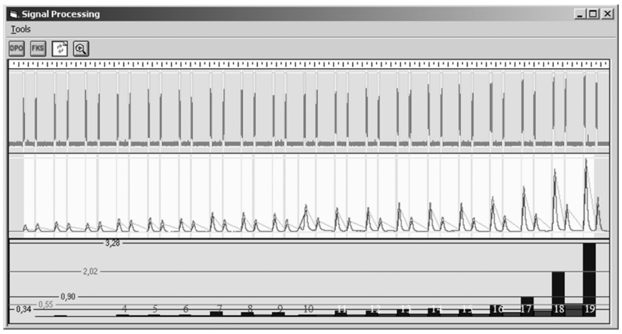


Figure 10. Processing of the DIFP Parameter for Workpiece 2.

Table 3. Definition of the Burn Thresholds.

	DPO	DIFP	FKS	DPKS	DAREA
Severe Burn	>0,99	>4,09	ND*	-	detected
Medium Burn	>0,81	>1,90	ND*	-	-
Slight Burn	>0,61	>0,90	ND*	detected	-

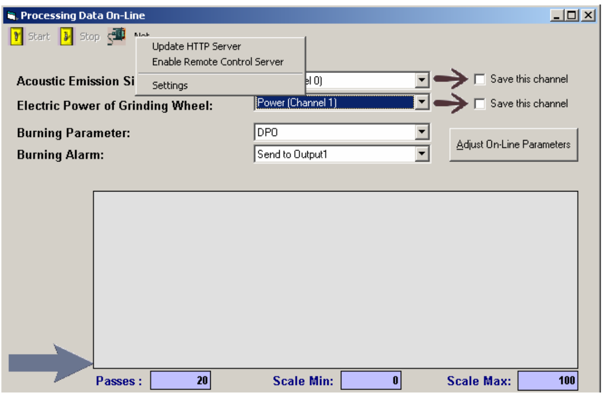
*ND – The parameter did not detect the burn

Table 3 was drawn up taking into account the worst case, i.e., starting from the defined threshold, the probability of the occurrence of burning is great. The DIFP parameter clearly presented a much greater variation than the DPO, and it can be refined in other tests to present even more precise results. The FKS parameter did not succeed in reliably detecting burning in any of the cases, so no threshold could be defined.

The DPKS and DAREA parameters successfully detected the burn situations, providing excellent results. DPKS, for example, got the onset of burning correctly in almost every case, while DAREA righteously identified the situation of severe burning in every case.

Internet Results

It is necessary the development of a server and client applications in order to establish a server-client communication. Thus, the implementation of routines for remote access in the newly software was carried out after a detailed study. The online data processing window is shown in Figure 11.



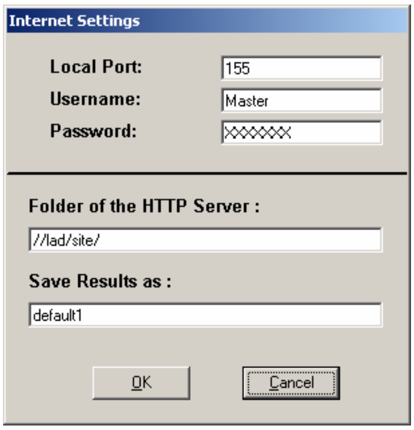
Acoustic Emission Si… …el 0)
Electric Power of Grinding Wheel: Power (Channel 1)
Burning Parameter: DPO
Burning Alarm: Send to Output1
Passes : 20
Scale Min: 0
Scale Max: 100

Figure 11. Processing Data On-Line Windows for Remote Access.

The “Net” button in this window is visible only when there is an active network communication. Clicking on this button a menu will be displayed referred here as to Internet Menu on which all the options needed to activate the remote access are available. There are three options: “Update HTTP Server”, “Enable Remote Control Server” and “Settings” (HTTP stands for HyperText Transfer Protocol). The first and second options of this menu may be selected or deselected with the mouse, activating or deactivating each resource. The option “Update HTTP Server” is a very interesting option, which allows the users connected to the Internet through their browsers (Internet Explorer®, Netscape® etc) to visualize the process running.

A copy of the bar graph image is updated, in each grinding pass, in the remote HTTP server previously configured. Thus, as the grinding passes are taking place, a new graph is placed into a specific folder of this HTTP server, allowing its visualization in any browser. When the option “Enable Remote Control Server” is selected, resources are allocated and a server (server application) for remote access is initialized in the software. Hence, the visualization of the grinding process as well as altering the process parameters is possible through the remote control software.

If the option “Settings” is selected, the windows shows in Figure 12 will be presented.



Local Port: 155
Username: Master
Password: xxxxxxx

Folder of the HTTP Server :
//lad/site/

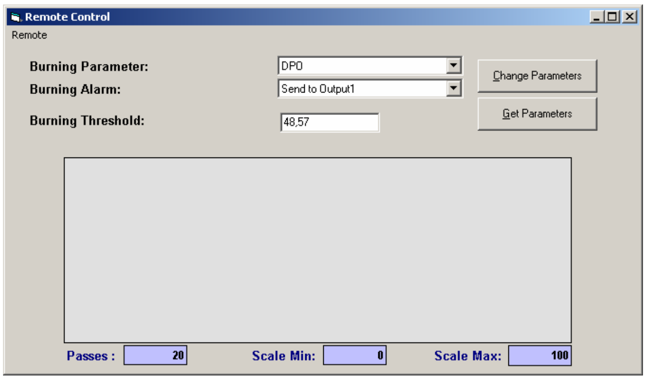
Save Results as :
default1

Figure 12. Internet Settings Window.

The fields “Local Port”, “Username” and “Password” are utilized to define in which port the client application must be connected, and what the user name and password valid for the communication. It can be noted that neither the public key nor the private key can be altered or redefined by the user. These fields are concerned to the remote server settings and they are only valid when the option “Enable Remote Control Server” is selected.

The options “Folder of the HTTP Server” and “Save Results as” are useful when the option “Update HTTP Server” is selected. By these two options it is possible to set the folder where the windows that contains the burn parameter while the process is running will be saved. The mentioned folder must be shared in the network and mapped through an HTTP server with an adequate logical name. A web page with extension “.htm” must be created in order to allow the browser to load the image saved by the software. The image name can be defined in the field “Save Results as” and it will be the extension “.jpg” as default.

The Remote Control software was developed to be run in any computer with Internet access, for its goal is to allow an operator distant from the grinding process being able to visualize its status, checking up the occurrence or not of burn or even altering the parameters when needed. Figure 13 shows the look of the Remote Control Software developed.



Burning Parameter: DPO
Burning Alarm: Send to Output1
Burning Threshold: 48,57
Passes : 20
Scale Min: 0
Scale Max: 100

Figure 13. Remote Control Software.

Almost the same parameters of the Processing Data On-Line Window can be observed in Figure 13. This is because the objective is to offer to the remote user the same images displayed in the process control.

In Figure 14, the field “Burning Parameter” allows the user to modify the burn parameter remotely. The field “Burning Alarm” enables the operator to change the way by which the software will send an alarm signalizing that workpiece burn took place. Simply simply replacing the new value in the field “Burning Threshold” can change the burn threshold.

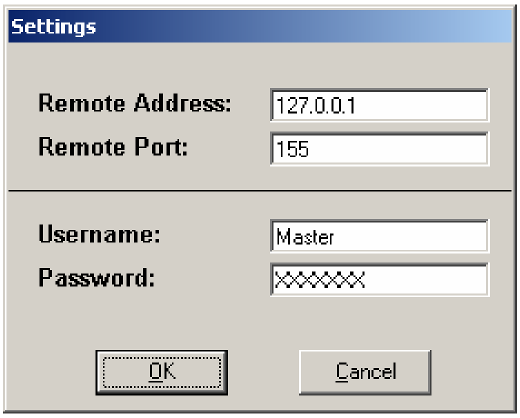
There are two buttons in this software that has special functions. The button “Get Parameters” makes possible to update all options of the main window in order to have the same values of the Processing Data On-Line Window. This is necessary for the purpose of checking if all the data was in fact changed, for a transmission error may occur and then compromise the operator command that is remotely actuating the system.

The button “Change Parameters” is very important because it is actually responsible to alter the grinding process, for there is no command sent to the server application when it is not selected. Thus, this button has to be pressed whenever changes are carried out in order to send them to the server that will alter the grinding parameters instantaneously.

The grey window in the middle of the software main window is a region designated to display the online graphics, that is, while the process is running a bar graph is generated to show the increase or decrease of the parameter values considered. So, the user is able to exactly see what is going on in the process.

The Fields “Passes”, “Scale Min” and “Scale Max” are exactly the same to which contained on the Processing Data On-Line with their identical functions. Despite being below the graphical window, they can be changed like the other fields and these changes are also passed on to the Grinding Analysis Software when the “Change Parameters” button is pressed.

The upper menu referred as to “Remote” has two options: “Connect”, which initializes the communication process with the server; and “Settings” that allows the alteration of the parameters for connecting with the server. Figure 14 shows the Settings Windows.



Remote Address: 127.0.0.1
Remote Port: 155
Username: Master
Password: XXXXXX

Figure 14. Settings Windows of the Remote Control Software.

In Figure 14, the parameters for connecting with the server can be clearly noted. The field “Remote Address” is related to the IP of the computer in which the server application is being run. The client software to locate the server application in the network utilizes this address, and it should be previously known in order to establish the communication.

The “Remote Port” is a parameter that depends on the server application as well, for it keeps on running a “listen’ at a specific port in order to verify whether a client wish to be connected. Hence, this parameter must also previously be obtained and in the same way as the server application.

The fields “Username” and “Password” are aimed at validating the operator during a request of connection to the server application. These values are compared with those established in the server and in case of they are not the same, the connection is instantaneously interrupted. These two fields are utilized to guarantee the minimum safety at the beginning of the communication.

Besides the name and password, there still exists the cryptography process of the data to assure more safety in the process.

Both server and client applications were tested many times in the Sao Paulo State University Network, where the online process could be monitored as well as the parameters changed. The tests have shown very good performance of the software developed.

Conclusions

The new software program displayed an excellent performance; however, it should be noted that its good performance depends on the use of correct burn parameters, for the inappropriate use of such parameters may impair the performance of the grinding process.

Records can be included in the new software’s database during testing, allowing the generation of a general record of machining conditions associated with a given burn parameter.

As intended, monitoring and parameter changes can now be done by remote access. No problems were encountered with regard to communication, for, as discussed earlier herein, the TCP protocol of the transport layer ensures error-free communications via the Internet.

All the parameters proved satisfactory except for FKS, which failed in every analysis. However, it is important to point out the excellent efficiency of both the DPO and the DIFP parameters, which may be applied in practical situations.

Therefore, it is reasonable to state that the parameters can be used jointly to offer more precise results, thereby avoiding hasty decisions.

Other studies are being conducted with different materials, and other monitoring modules to be added to the software are being developed, such as dressing control and contact detection.

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