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(54) Title: SYSTEM FOR DETECTING PARAMETERS APPLIED TO A COMPRESSOR PISTON

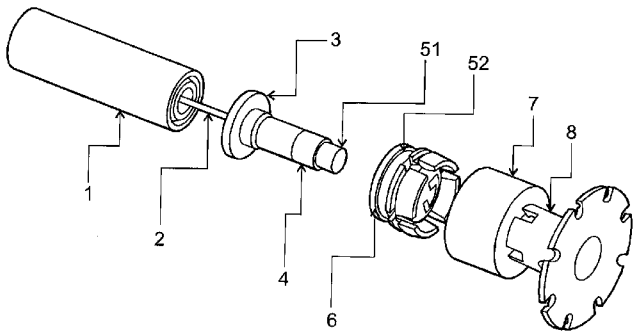


FIG. 1

(57) Abstract: The present application refers to a system for detecting parameters applied to a compressor piston, comprising simultaneously detecting certain parameters of said compressor piton, such as: piston speed, piston position and occurrence of impact between said piston and the plate of valves. The system for detecting parameters applied to a compressor piston comprises at least an axially movable arrangement driven by an electric engine (9); at least a sensor (5) comprising at least a displaceable portion (51) and at least a fixed portion (52); at least an electronic circuit comprising at least a processing core (10), and said system differs from the conventional systems in that said electronic circuit further comprises at least a filtering module (11); said output signal (SS) of sensor (5) is sent to said filtering module (11); and said filtered signal (SF) of the filtering module (11) is sent to said processing core (10).

WO 2012/167337 A1

"SYSTEM FOR DETECTING PARAMETERS APPLIED TO A COMPRESSOR PISTON"

Field of the Invention

The present application refers to a system for detecting parameters applied to a compressor system (pertaining to a cylinder/piston assembly). More specifically, the present system, which is preferably applied to a piston driven by a linear engine, is capable of detecting at least one of the parameters of piston speed or piston position (within the compressor cylinder). Preferably, the system now described provides for simultaneous detection of the cited parameters.

Background of the Invention

It is known by those skilled in the art that cylinder/piston assemblies, particularly when associated with linear compressors, can be advantageously applied to cooling system and the like.

In said applications, a cylinder/piston assembly is physically secured to a plate (or structure) at which inlet valves and exhaustion valves of the cooling fluid to be compressed are disposed. Also, displacement course of a piston is virtually defined by this plate (or structure).

Therefore, a linear engine (which forces the piston to move) should displace the piston so as to prevent same from striking (stroke) said "plate of valves". To this effect, it is ideal that a linear engine displaces the piston only in reduced course relative to the total displacement course.

It also occurs that efficiency of a cooling system is proportional, among other aspects, to the actual course that a piston develops within a cylinder, that is, the more reduced the piston displacement course is, the lower the efficiency of the cooling system (and of the compressor itself).

Hence, it is ideal that the linear engine displaces the piston as much as possible without having, however, any kind of impact between said piston and the "plate of valves". To this effect, there is a need for introduction of systems and/or devices (either installed in the linear engine or installed in the piston/valve assembly) intended to perform this control.

The present state of the art comprises different systems and/or devices for the same purposes, that is, intended to control/manage a linear engine such that same displaces a piston in a safe and efficient form. In general lines, each of these solutions permits for a feedback system which based on certain parameters controls power supply to the linear engine and, consequently, the piston displacement.

One of the mostly known solutions consists of monitoring at least one of parameters of the liner engine itself. In this solution, electric current and voltage values of a linear engine act as feedback parameters thereof. If on one hand such solutions are simple and not

expensive (after all, no spare sensors and/or transducers are used), on the other hand, they present low accuracy and low efficiency (after all, it is necessary to reduce actuation course of the piston due to the existing accuracy lack).

Solutions employing independent sensors associated with a piston/cylinder assembly to detect certain parameters related to said assembly are also known.

A first example of this kind of solution is described in document BR PI 0704947-1, which teaches a piston position recognition system based on an electromagnetic flow variation sensor (SVF). This system is especially appliable to linear engine-driven piston/cylinder assembly where movement transmission (between engine and piston) takes place through magnetic fields, or where said piston movement is linked to at least one magnet or the like. In this system, the piston movement (and the resulting movement of the magnet linked to the piston) proportionally generates a magnetic oscillation measurable by the SVF to which same is attached. Since magnetic oscillation can be related to the real time position occupied by a piston, it is possible to stop and reciprocate its advance before eventual collisions with the "plate of valves". Although the concept of this system is functional, it should then be observed that same has some aspects apt to be improved. A possible aspect to be improved refers to the complexity involving measuring the real cylinder dimensions and the position of the "plate of valves", since when determining the piston displacement course through the magnetic field oscillation this information and the SVF position must be previously considered.

A second example of this type of solution is described in document BR PI 0301969-1, which refers to a piston position recognition system based on an accelerometer-type sensor. In this case, where no magnetic parameter is considered, measuring the piston position through pressure stimuli imposed onto said accelerometer is effected, wherein said stimuli are generated by contact or vibration of said piston. This accelerometer is of piezoelectric-type and its terminals in conjunction with a signal amplifier circuit are associated with power supply of the linear engine, thus causing direct "interference" with same (feedback). This concept also comprises some aspects capable of being improved, wherein it is herein highlighted that accelerometers present an optimized functioning upon an impact; therefore, applications of these systems are limited to those constructions capable of physical contact and/or piston vibration.

These two examples cited above are especially intended for the control of a linear engine (associated with a piston/cylinder assembly) based on parameters of the piston positioning and impact condition of the piston. It is clear that the first concept exemplified in document BR PI 0704947-1 is better applied to a determined range of operations while the second concept exemplified in document BR PI 0301969-1 is better applied to another determined range of operations. In any way, details disclosed in said documents only

illustrate construction variations where a SVF detects a sole parameter of the piston/cylinder assembly to drive the linear engine associated with this assembly (close feedback system).

Nevertheless, none of these examples, as designed and assembled, is capable of simultaneously detecting displacement speed and instantaneous piston position.

Hence, as it is known by those skilled in the art, there is a need for the addition of some specific sensors, such as, for example, the known "Hall's cells."

In brief, and in accordance with the specialized literature, "Hall's cells" comprise sensors intended to measure speed and angular displacement of a body. Although said "Hall's cells" can be used in a piston/cylinder assembly (also allowing for very low speeds to be detected), it is observed that this type of application is not viable because said "Hall's cells" require substantially complex conditioning circuits, in addition to the fact that their implementation and maintenance are very expensive.

In view of the foregoing, it is evident that there is a need for developing a system capable of precisely, reliably and simultaneously detecting more than one parameter existing in a cylinder/piston assembly.

Objects of the Invention

Hence, one of the objects of the present invention is to provide a system for detecting parameters applied to a compressor piston essentially comprised of a single sensor.

Additionally, another object of the present invention is to provide a system which is capable of simultaneously detecting at least two parameters relative to a compressor piston.

Especially, a further object of the present invention is to detect piston speed, piston position and also eventual occurrences of impact between said piston and the "plate of valves" (or similar structure) of the compressor. In this regard, an additional object of the present invention is to provide a parameter detection system applied to a compressor piston which allows for rapid initial gauging of the piston course (within its respective cylinder).

Summary of the Invention

These and other objects are fully accomplished by the presently proposed system for detecting parameters applied to a compressor piston, which comprises at least an arrangement capable of axial movement driven by an electric engine, at least a sensor comprised of at least a displaceable portion and at least a fixed portion, at least an electronic circuit comprised of at least a processing core. Said movable arrangement is essentially comprised of at least a piston, at least a connecting rod and at least a guide-body. Said displaceable portion of the sensor is secured to said movable arrangement. The sensor output signal is sent to the processing core.

Said system for detecting parameters applied to a compressor piston differs from similar systems in that the electronic circuit further comprises at least one filtering module;

the sensor output signal is sent to a filtering module; and a filtered signal from the filtered module is sent to the processing core.

In accordance with the concepts of the present invention, said processing core simultaneously receives a sensor output signal and the filtered signal from the filtering module.

Preferably, the piston speed parameter is measured through the sensor output signal frequency, and the piston positioning parameter is measured through the sensor output signal intensity. With regard to the parameter of occurrence of impact between the piston and said plate of valves, same is measured by analyzing the noise existing in the sensor output signal and shown in the filtered signal from the filtering module.

Preferably, noise analysis shown in the filtered signal from the filtering module consists of analyzing harmonics of higher order existing in the filtered signal. Further preferably, analysis of noise shown in the filtered signal from the filtering module occurs in the processing core.

Optionally, and in accordance with the concepts of the present invention, the sensor can be coupled to an electromagnetic shielding body.

Brief Description of Drawings

The present invention is described in more details on the basis of figures listed below, wherein:

Figure 1 illustrates a piston (in conjunction with its connecting rod and sensor) in an exploded perspective view;

Figure 2 illustrates a schematic cut view of the (assembled) components depicted in Figure 1;

Figure 3 illustrates a magnetic flow "map" of a cross-section of a sensor used in the system for detecting parameters applied to a compressor piston;

Figure 4 illustrates a block diagram of the system for detecting parameters applied to a compressor piston;

Figure 5 illustrates a signal measured by the sensor used in the system for detecting parameters applied to a compressor piston;

Figures 6.1 and 6.2 illustrate, respectively, an example of a signal measured by the sensor and filtered by the system for detecting parameters before and after a impact between the piston and its "plate of valves" occurs; and

Figures 7.1 and 7.2 illustrate, respectively, an example of the order of harmonics of a signal measured by the sensor and filtered by the system for detecting parameters before and after an impact between the piston and its "plate of valves" occurs.

Detailed Description of the Invention

The essential concept of the present invention consists of implementing an

electromagnetic flow variation sensor (comprised of a portion apt to displacement and of a fixed portion) and analyzing the output signal of said sensor. This analysis preferably takes place in an electronic circuit, which is capable of interpreting the output signal of said sensor under normal condition and optimized condition (output signal of the sensor after its passage through a filter, where only signal spectra relevant to the analysis of the position at which an impact between a piston and the "plate of valves" occurs are isolated).

Therefore, in accordance with the essential concept of the present invention, the system for detecting parameters applied to a compressor piston is capable of measuring the axial displacement speed of the piston, estimating the relative position of the piston (within the cylinder), and detecting occurrence of impact between the piston and the plate of valves.

Figures 1, 2, 3 and 4 illustrate a preferred embodiment of the present invention. In accordance with this preferred embodiment, it can be noted that a piston (pertaining to a compressor) is preferably intended, but not limited, to be applied to fluid compression, is apt to be applied to conventional cooling systems, and is functionally associated with a group of components interconnecting it with the driving engine (also pertaining to a compressor).

In this regard, Figure 1 illustrates a movable arrangement essentially consisting of a piston 1, a connecting rod 2 and a guide body 3. In this arrangement, said connecting rod 2 is disposed between said piston 1 and said guide body 3.

Also in accordance with the preferred embodiment of the invention, it is provided a sensor 5 responsible for reading parameters related to the movable arrangement movement (specifically, parameters related to axial movement of piston 1 within a (not shown) cylinder)). Said sensor 5 preferably comprises an electromagnetic flow variation sensor and is constituted by at least a displaceable portion 51 and a fixed portion 52. Said displaceable portion 51 of sensor 5 can be considered as "displaceable" because it is (directly or indirectly) associated with the movable arrangement comprised by piston 1, connecting rod 2 and guide body 3. With regard to said fixed portion 52 of sensor 5, same is secured to any fixed portion of a compressor.

Preferably, said displaceable portion 51 of sensor 5 comprises a permanent magnet preferably with axial magnetization and is attached to said guide body 3 by means of a first support 4.

Preferably, said fixed portion 52 of sensor 5 comprises a coil (electric conductor disposed at an annular coil) preferably supported by a structure by means of a second support 6. Further preferably, said fixed portion 52 of sensor 5 is disposed within a shielding body 7 (for reduction of interference from the electromagnetic field of the compressor engine) and is secured to the static part of the (not show) compressor by a structure 8.

In accordance with an embodiment of the present invention, the axial displacement of the moveable arrangement approaches and goes away, preferably in a cyclic form, the

displaceable portion 51 of sensor 5 of the fixed portion 52 of sensor 5. Such a cyclic movement of the displaceable portion 51 of sensor 5 induces a voltage in the fixed portion 52 of sensor 5, and said voltage can be considered as the output signal of sensor 5.

Figure 3 schematically illustrates a magnetic flow "map" of the displaceable portion 51 of sensor 5. From this figure, it can be noted that speed and positioning of the displaceable portion 51 of sensor 5 relative to the fixed portion 52 of sensor 5 can be estimated on the basis of the voltage intensity induced in said fixed portion 52 of sensor 5, that is, the movable arrangement speed (consequently, the speed of piston 1) is directly proportional to the intensity of the output signal of sensor 5.

As previously mentioned, the main embodiment of the present invention allows for the analysis of output signal of sensor 5. Preferably, said analysis is carried out through different perspectives.

Hence, said output signal of sensor 5, from now on referred to by SS signal, is sent to an electronic circuit essentially comprising at least a processing core 10 and comprising at least one filtering module 11.

Preferably, said processing core 10 comprises a (conventional) electronic microprocessor or a (conventional) electronic microcontroller.

Further preferably, said filtering module 11 comprises a simple RC circuit (low-pass filter) or a RLC circuit (high-pass filter). Optionally, said filtering module 11 can be incorporated into the processing core 10, itself, in case there is sufficient processing capacity for the function of signal filtering.

Further preferably, said processing core 10 can be directly responsible for power supply to engine 9 with (not shown) compressor.

From Figure 4, it can be noted that SS signal is directly sent to the processing core 10 and to the filtering module 11. It can also be observed that the filtered signal SF originated from the filtering module 11 is also sent to said processing core 10.

Therefore, it can be asserted that said processing core 10 receives and analyzes two essential distinct signals. SS signal allows for estimating the position (signal amplitude) and speed (signal frequency) of piston 1. Said SF filtered signal permits to check the occurrence of impact between said piston 1 and the (not shown) plate of valves.

In this regard, said SF filtered signal, which comprises the SS signal subjected to a (analogical or digital) electronic filter of the "bandpass filter strip"-type or "low-pass"-type, in which the main frequency is attenuated, possesses a visibly different wave for these conditions under which impact does not occur (Figure 6.1) and for the conditions under which impact occurs (Figure 6.2). These wave forms are mathematically decomposed in real time and the decomposition result, mainly harmonics of higher order (Figure 7.2), is analyzed by the processing core (10) to decide the best strategy for avoiding impact (mainly in situations

where said processing core 10 controls the power feed for engine 9).

In Figures 7.1 and 7.2, it is clear shown the difference between the harmonics of higher order in situations where impact does not occur and situations where impact occurs.

Further, it should be evidenced that a signal difference between the conditions under which impact does not occur (Figures 6.1 and 7.1) and the conditions under which impact occurs (Figures 6.2 and 7.2) essentially takes place in function of vibration of the moveable arrangement (consequently, the vibration of the displaceable portion 51 of sensor 5) during the occurrence of impacts, such vibration being capable of generating a magnetic field (consequently, an SS output signal) with noise which is evidenced by the filtering module 11, and analyzed by the processing core 10.

Preferably, said system for detecting parameters applied to a compressor piston is capable of simultaneously detecting the cited three parameters (speed, position and impact), wherein speed and position of piston 1 obtained on the basis of the SS signal and the occurrence of impact between said piston 1 and the plate of valves by analysis of harmonics of the SF filtered signal.

Based on the concepts and principles of functioning as detailed above, it can be observed that said system for detecting parameters applied to a compressor piston can be used in real time (during the whole functioning of a compressor) and/or at the time the initial course of piston 1 is gauged and defined.

After describing a preferred exemplary embodiment, it should be understood that the scope of the present invention encompasses other variations. The present invention is solely limited by the content of claims, including therein possible equivalents.

CLAIMS

1. System for detecting parameters applied to a compressor piston, comprising:

at least an axially movable arrangement driven by an electric engine (9); at least a sensor (5) comprising at least a displaceable portion (51) and at least a fixed portion (52); at least an electronic circuit comprising at least a processing core (10);

said moveable arrangement essentially comprising at least a piston (1), at least a connecting rod (2), and at least a guide body (3), wherein said displaceable portion (51) of sensor (5) is attached to the moveable arrangement; and the output signal (SS) of sensor (5) is sent to said processing core (10);

the system for detecting parameters applied to a compressor system being CHARACTERIZED in that:

said electronic circuit further comprises at least a filtering module (11);

said output signal (SS) of sensor (5) is sent to said filtering module (11);

said filtered signal (SF) of the filtering module (11) is sent to said processing core (10).

2. System for detecting parameters applied to a compressor piston, in accordance with claim 1, CHARACTERIZED in that said processing core (10) simultaneously receives said output signal (SS) of sensor (5) and said filtered signal (SF) of said filtering module (11).

3. System for detecting parameters applied to a compressor piston, in accordance with claim 1, CHARACTERIZED in that a speed parameter of said piston (1) is measured by the frequency of said output signal (SS) of sensor (5).

4. System for detecting parameters applied to a compressor piston, in accordance with claim 1, CHARACTERIZED in that a positioning parameter of said piston (1) is measured by the intensity of said output signal (SS) of sensor (5).

5. System for detecting parameters applied to a compressor piston, in accordance with claim 1, CHARACTERIZED in that the parameter of occurrence of impact between said piston (1) and the plate of valves is measured by means of said filtered signal (SF).

6. System for detecting parameters applied to a compressor piston, in accordance with claim 1 or 5, CHARACTERIZED in that said parameter of occurrence of impact between said piston (1) and said plate of valves is measured by analysis of noise existing in the output signal (SS) of sensor (5) and evidenced in the filtered signal (SF) of the filtering module (11).

7. System for detecting parameters applied to a compressor piston, in accordance with claim 6, CHARACTERIZED in that said analysis of noise evidenced in said filtered signal (SF) of the filtering module (11) consists of analyzing harmonics of higher order existing in the filtered signal (SF).

8. System for detecting parameters applied to a compressor piston, in accordance with claim 1, 6, or 7, CHARACTERIZED in that said analysis of noise evidenced in the filtered signal of said filtering module (11) occurs in the processing core (10).

9. System for detecting parameters applied to a compressor piston, in accordance with any of preceding claims, CHARACTERIZED in that said sensor (5) is applied to an electromagnetic shielding body (7).

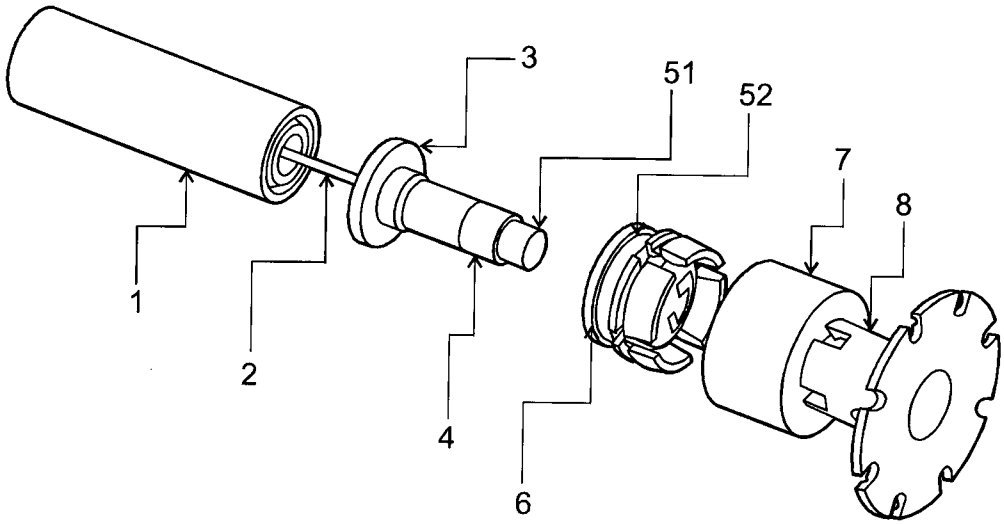


FIG. 1

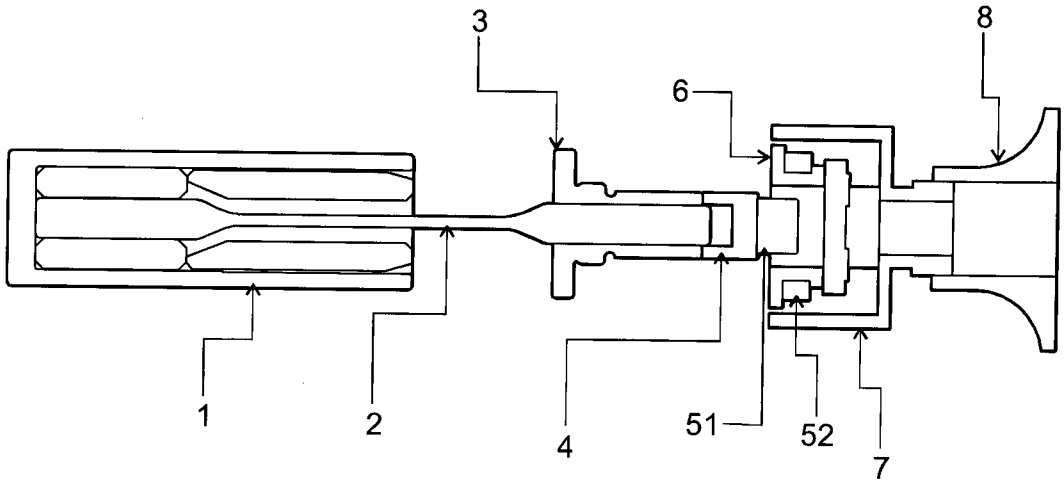


FIG. 2

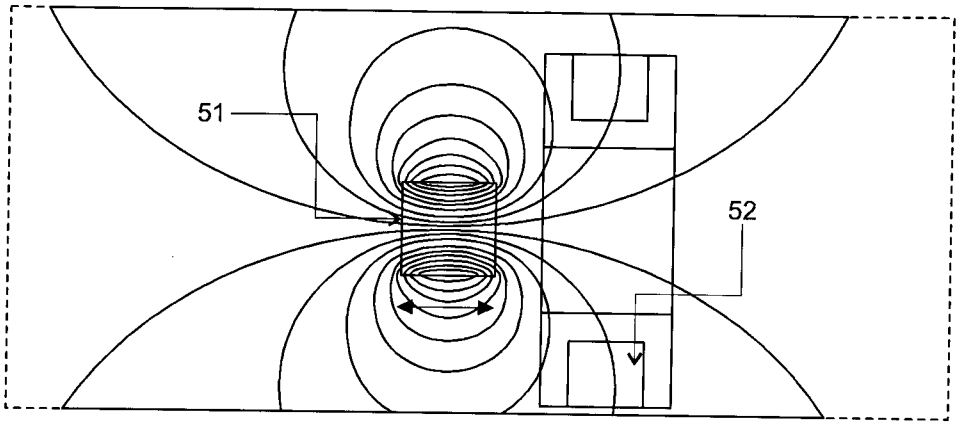


FIG. 3

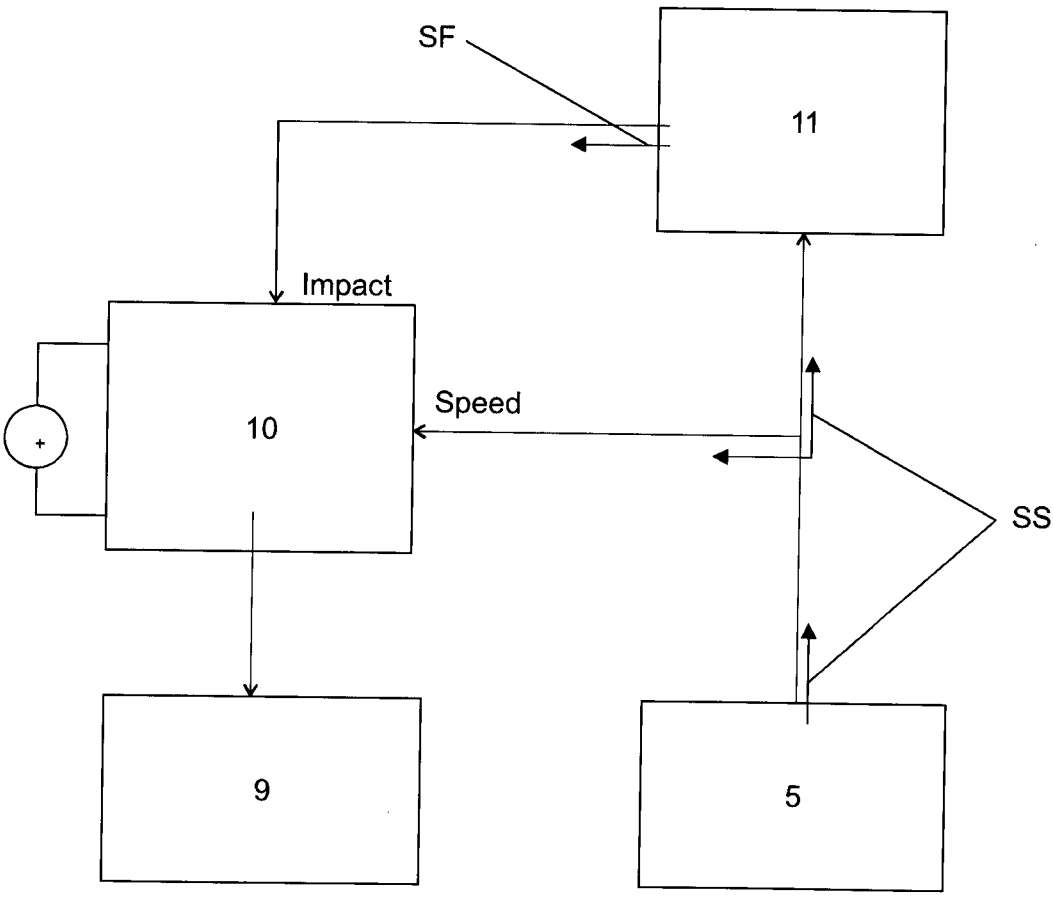
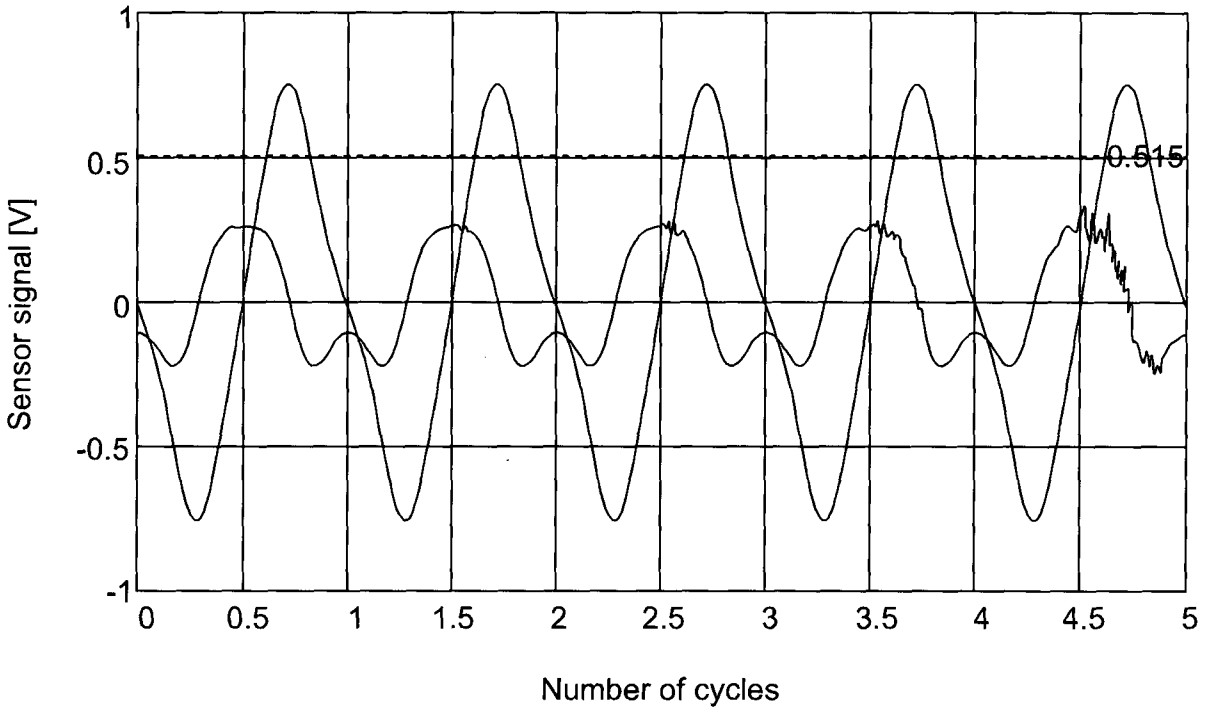


FIG. 4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0
-0.5
-1
0.515
Sensor signal [V]
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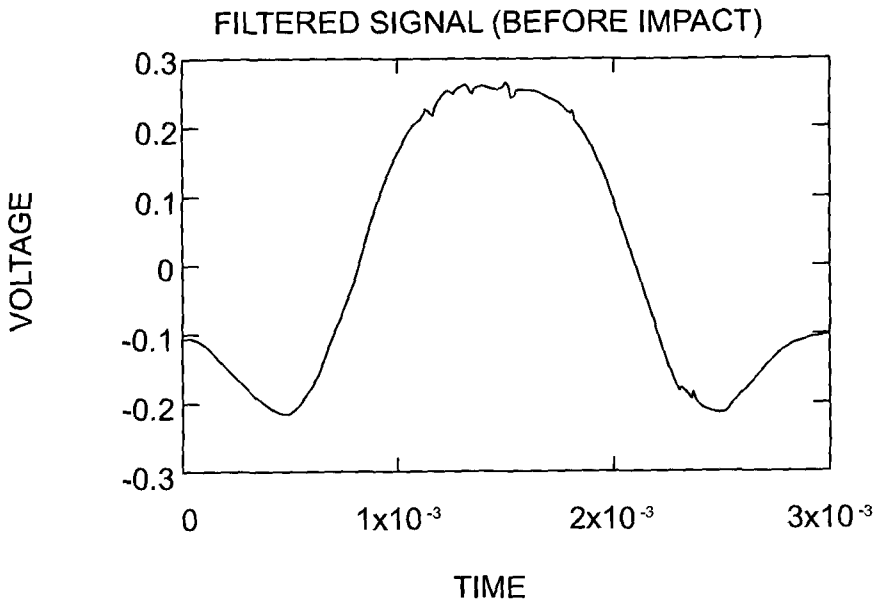
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
Number of cycles

FIG. 5


FILTERED SIGNAL (BEFORE IMPACT)
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-0.2
-0.3
0
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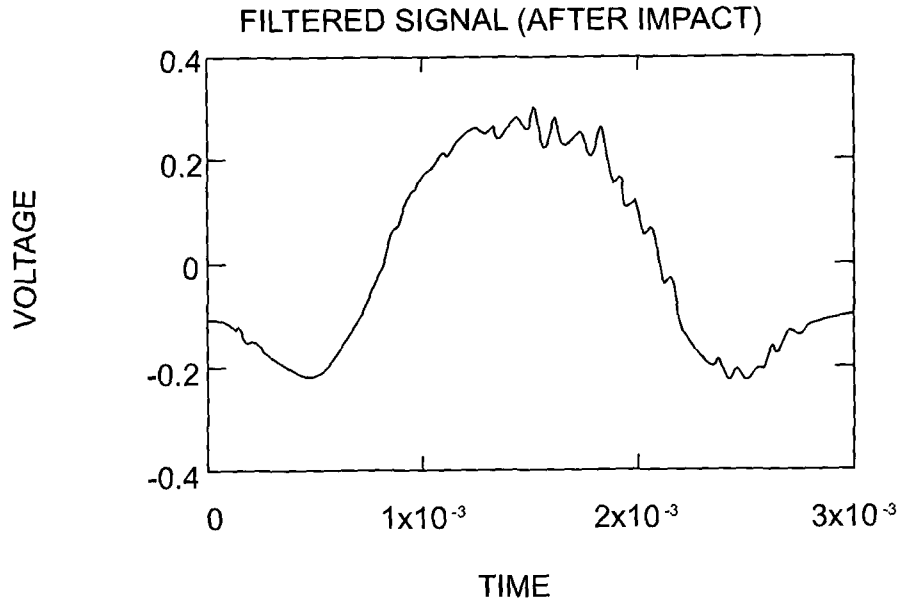
2x10-3
3x10-3
TIME

FIG. 6.1


FILTERED SIGNAL (AFTER IMPACT)
VOLTAGE
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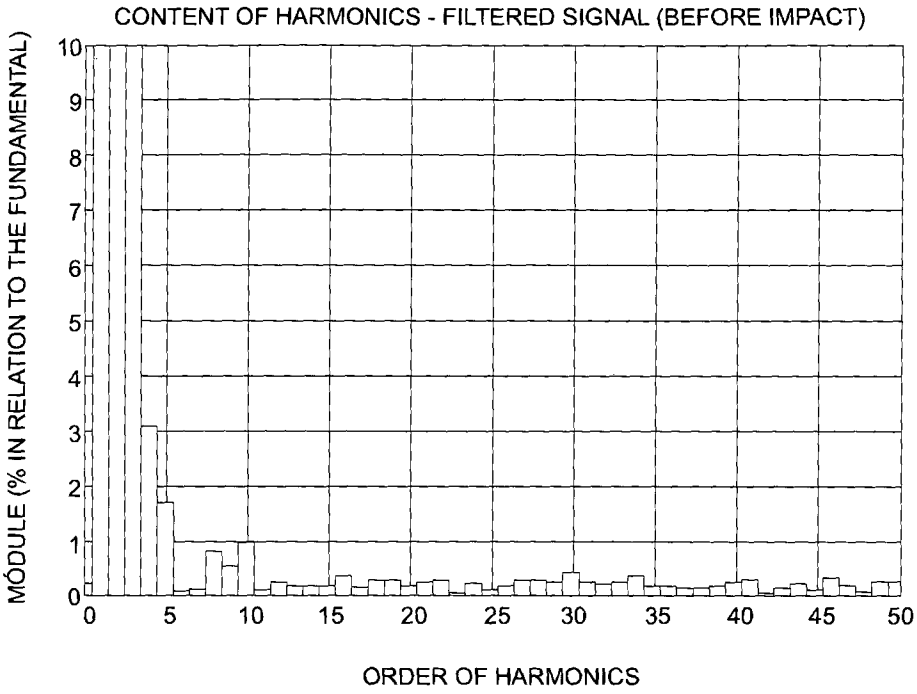
-0.2
-0.4
0
1x10-3
2x10-3
3x10-3
TIME

FIG. 6.2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2
3
4
5
6
7
8
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10
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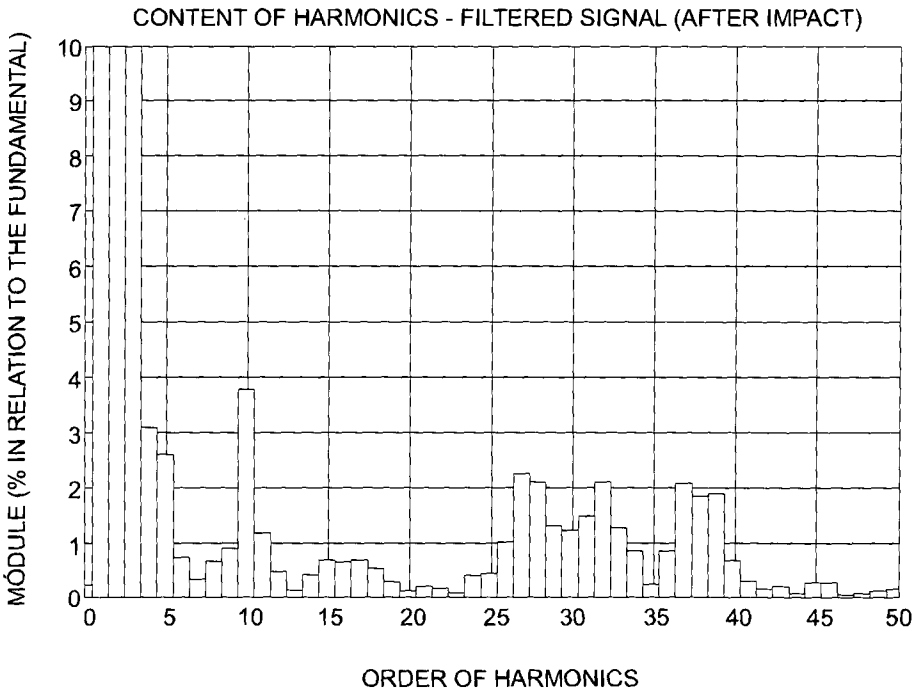
5
10
15
20
25
30
35
40
45
50
ORDER OF HARMONICS

FIG. 7.1


CONTENT OF HARMONICS - FILTERED SIGNAL (AFTER IMPACT)
MÓDULE (% IN RELATION TO THE FUNDAMENTAL)
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3
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5
6
7
8
9
10
0
5
10
15
20
25
30
35
40
45
50
ORDER OF HARMONICS

FIG. 7.2

INTERNATIONAL SEARCH REPORT

International application No
PCT/BR2012/000171

A. CLASSIFICATION OF SUBJECT MATTER
INV. F04B49/06 F04B49/10
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
F04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2009/103138 A2 (WHIRLPOOL SA [BR]; DAINEZ PAULO SERGIO [BR]; ERICH BERNHARD LILIE DIET) 27 August 2009 (2009-08-27) page 21, line 18 - page 22, line 2 page 16, line 6 - line 16	1-9
X	WO 2005/054676 A1 (BRASIL COMPRESSORES SA [BR]; DAINEZ PAULO SERGIO [BR]; BERWANGER EGIDI) 16 June 2005 (2005-06-16) claims 6-17	1
X	US 2003/161735 A1 (KIM NAM-SU [KR] ET AL) 28 August 2003 (2003-08-28) claims 13-15,23-25,29-31	1

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 September 2012	26/09/2012

Name and mailing address of the ISA/	Authorized officer
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