

SYSTEMS AND METHODS FOR INSPECTING LARGE ENGINE CYLINDER LINERS

5 FIELD OF INVENTION

Embodiments of the present invention provide systems and method for inspecting engine cylinder liners, especially in large engine used in marine applications.

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BACKGROUND

Large internal combustion engines are used in many applications. For example, such engines may be used to power large ships, or to drive generators for the production of electricity. The engine cylinder liner is an important component of these engines. The cylinder liner surface must be free from defects such as pitting, high and low patches, scratches and scuff marks in order to seal the high-pressure combustion gases and to reduce friction between the liner and the rings of the piston. Surface defects on the cylinder liner surface can cause serious consequences, such as overheating of the liner, breakage of the piston rings, and damage to the piston and/or cylinder liner itself. These defects can affect the performance of the engine and increase the fuel consumption. In extreme cases, these defects may result in the engine seizing up. As these engines are very large, they are extremely expensive to replace.

Consequently, it is a good practice to periodically check the surface of the cylinder liner for defects and wear. Currently this is done during major engine overhauls. During a major overhaul, large portions of the engine are disassembled to gain access to the cylinder liners. A worker must then climb into the cylinder to perform a visual inspection and manually measure the cylinder liner diameter using, for example, a large inside micrometer length gauge. The cylinder liners must be maintained within specific dimensional tolerances so that the engines function properly. Measurements of the cylinder liner diameter are thus needed to determine the wear rate of the liner and to predict when and whether the cylinder liner should be replaced. The cylinder liner

surface is also inspected visually whenever a cylinder head is removed, for example when replacing the piston rings or the piston itself.

5 In these prior art methods, the wear of the cylinder liner is determined by measuring the cylinder liner diameter at several positions over its entire length. A large engine cylinder liner diameter could range from 0.6 m to 1.2 m with a height of from 2.5 to 4m.

10 Visual inspection of the cylinder liner surface gives an indication of liner scuffing, inadequate lubrication, polishing of the surface, corrosion, or blow past gases, which are assessed by the inspecting engineer. Using present manual methods, it is very difficult to check the condition of the cylinder liner. It requires removal of the exhaust valve, cylinder head, other pipes and various attachments. The process takes time and manpower to carry out the detailed checking and measuring. Clearly, when these components are being inspected, the engine is not operable.

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In alternate implementations of the manual inspection method, a worker must physically climb into the cylinder liner to perform the manual measurements using an inside micrometer length gauge. He will also carry out the visual inspection. This is a very unsafe practice, as the worker must climb down to the cylinder liner using a portable ladder in a very narrow and tight space. During the process, a slip or fall could result in serious injuries.

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It would therefore be a great improvement in the art if a system and method could be devised which addresses one or more of the problems discussed above.

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SUMMARY

30 One aspect of the present invention provides a system for remotely inspecting a cylinder liner of an engine, the system comprising: an imaging device operable to be inserted into said cylinder liner and to capture an image of at least a portion of an inside surface of said cylinder liner; wherein said captured image can be used to determine a condition of said cylinder.

In alternate embodiments, the system may further include a laser sensor capable of measuring a diameter of said cylinder liner. The imaging device and said laser sensor may be coupled to a support, said support being capable of moving said imaging device and said laser.

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In further embodiments, the support may further include a base; a spherical bearing hub coupled to said base; a bearing housing coupled to said bearing hub such that said bearing housing is capable of rotating about an axis of said hub; and means for temporarily clamping said support to said cylinder liner; wherein said imaging device
10 and said laser sensor are coupled to said bearing housing to facilitate imaging and measurements of a circumference of said cylinder liner.

The base may further include an upper X-Y table plate coupled to said spherical hub; and a lower X-Y table plate moveably coupled to said upper X-Y table plate;
15 wherein said means for temporarily clamping said support to said cylinder liner comprises a clamping actuator coupled to said lower X-Y table plate; said clamping actuator is capable of fixing a position of said support within said cylinder liner; and said upper and lower X-Y table plates are moveable with respect to each other such that a position of said spherical hub may be adjusted when said support is fixed
20 within said cylinder liner.

In alternate embodiments, the imaging device may include one of a charge coupled device (CCD) or a Complementary Metal Oxide Semiconductor (CMOS) camera. The system may further include a plurality of imaging devices and a plurality of laser
25 sensors. The laser sensor may be capable of determining a diameter of said cylinder liner to within 20 micrometers.

In further embodiments, the system may also include a computer connected to said imaging device, and said support, wherein said computer is capable of: controlling
30 and operating said imaging device, said laser sensor and said support; receiving and processing images captured by said imaging device; and receiving and processing information from said laser sensor. In this embodiment, the step of processing images captured by said imaging device may further include comparing said images to a reference image to determine a condition of said inside surface;

and said step of processing information from said laser sensor further comprises comparing said diameter measurements to a reference measurement to determine a condition of said cylinder liner.

- 5 An alternate aspect of the present invention provides a method for remotely inspecting a cylinder liner of an engine, the method comprising the steps of: introducing an imaging device into said cylinder liner; capturing an image of at least a portion of an inside surface of said cylinder liner; and analysing said captured image to determine a condition of said cylinder liner.

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In alternate embodiments, the method may also include introducing a laser sensor into said cylinder capable of measuring a diameter of said cylinder liner. The imaging device and laser sensor may be coupled to a support comprising: a base comprising; an upper X-Y table plate coupled to said spherical hub; and a lower X-Y table plate moveably coupled to said upper X-Y table plate; a spherical bearing hub coupled to said upper X-Y table plate; a bearing housing coupled to said bearing hub such that said bearing housing is capable of rotating about an axis of said hub; and a clamping actuator coupled to said lower X-Y table plate; wherein said clamping actuator is capable of fixing a position of clamping said support within said cylinder liner; and said upper and lower X-Y table plates are moveable with respect to each other such that a position of said spherical hub may be adjusted when said support is fixed within said cylinder liner.

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In alternate embodiments, the imaging device may be one of a charge coupled device (CCD) or a Complementary Metal Oxide Semiconductor (CMOS) camera. A plurality of imaging devices and a plurality of laser sensors may be coupled to said support.

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In further embodiments, the method may further include the steps of: moving said support to a desired position along the cylinder liner; and engaging said clamping actuator to fix clamp said support to said inside surface of said cylinder.

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In additional embodiments, the imaging device, laser sensor and support may be connected to a computer. The method may further include the steps of: using said

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laser sensor to measure a position of said support within said cylinder liner; and using said computer to adjust said position to center said hub within said cylinder liner. In this embodiment, the method may also include engaging said laser sensor; rotating said bearing housing; sending said laser sensor data to said computer; and
5 calculating a diameter and an ovality of said cylinder liner. The method may also include the steps of: capturing image data; sending said image data to said computer; and using said computer to process said image data to determine a condition of said cylinder liner.

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BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention will be better understood and readily apparent to one of ordinary skill in the art from the following written description, by way of example
15 only, and in conjunction with the drawings, in which:

Figure 1 is a perspective view of one embodiment of a system for inspecting cylinder liners;

20 Figure 2 is a perspective view of the system for inspecting cylinder liners shown in Figure 1;

Figure 3 is a top view of the system of Figure 2;

25 Figure 4 is a bottom view of the system of Figures 2-3;

Figure 5 is a side view of the system of Figures 2-4;

30 Figure 6 is a flow chart illustrating one method for inspecting a cylinder liner using the system of Figures 1-5; and

Figure 7 is a schematic diagram of one embodiment of a computer system which may be used to control the system of Figures 1-5 and to implement the method shown in Figure 6.

DETAILED DESCRIPTION

Embodiments of the present invention provide a system and method for remotely
5 inspecting an engine cylinder liner without the need for an individual to physically access
the cylinder liner. Figure 1 is a perspective view of one embodiment of a system 100
for inspecting cylinder liners located within a cylinder liner 200. In some
embodiments, the system 100 may be connected to and controlled by an industrial
PC or computer 700. As discussed in detail below, the system 100 provides the
10 capability to remotely inspect the inside surface 210 of the cylinder liner 200 for
various types of defects, including, but not limited to liner scuffing, inadequate
lubrication, polishing of the surface, corrosion, the presence of blow past gases, the
ovality of the cylinder liner, and the like.

15 Figure 2 is a perspective view of the system 100 of Figure 1. Figure 3 is a top view
of the system 100 of Figure 2. Figure 4 is a bottom view of the system 100 of
Figures 1-3. Figure 5 is a side view of the system 100 of Figures 1-4.

With reference to Figures 1-5, in this embodiment, the system 100 includes one or more
20 imaging devices 110 capable of being inserted into the engine cylinder liner 200
(Figure 1) and of capturing an image of at least a portion of the inside surface 210 of
the cylinder liner 200. In some embodiments, the system 100 may also include one
or more laser sensors 120 capable of sensing and measuring an inside diameter of
the cylinder liner 200.

25 In these embodiments, the system 100 may be connected to the computer 700
using a cable 212. Similarly, the imaging device 110 and laser sensor 120 may be
connected to the computer 700 using cables 214, 216 respectively. The cables 212,
214, 216 may be any type of cable known to those of skill in the art which can be
used to effect these connections. In a preferred embodiment, the cables 212, 214,
30 216 are provided by the manufacturers for this purpose. It is understood that other
types of cabling, and/or wireless connections may also be used to control the
system 100, imaging devices 110, and laser sensors 120 as desired.

In a preferred embodiment, the system 100 may also include a support structure 130 which is configured to support and direct the imaging devices 110 and laser sensors 120. The support structure 130 may include a base 140 which supports a spherical bearing hub 150. A bearing housing 160 may be mounted on the bearing hub such that
5 the bearing housing 160 is capable of rotating with respect to the hub 150. One or more mounting brackets 115 may be mounted on the bearing housing 160. The mounting brackets 115 support the imaging devices 110 and laser sensors 120.

In some embodiments, the base 140 may include a lower X-Y table plate 142 and an
10 upper X-Y table plate 144. In this embodiment, the spherical bearing hub 150 is coupled to the upper X-Y table plate 144. The lower X-Y table plate 142 and upper X-Y table plate 144 may be configured to move with respect to each other using, by way of example and not limitation, one or more linear bearings 146 mounted on bearing rails
148. The linear bearings include electric motors (not shown) which can be controlled by
15 the computer 700. This configuration allows for centering of the system 100 within the cylinder liner 200. This will be discussed in more detail below.

In the preferred embodiment, the support structure 130 of the system 100 may also include a right and left clamping actuator 170a, 170b (Figure 4) coupled approximately
20 centrally to an underside 143 of the lower table plate 142. The clamping actuators 170a, 170b include clamping pads 172a, 172b which allow the support structure 130 to be clamped to the inside surface 210 of the cylinder liner 200. The computer 700 may also be used to control this function. The clamping actuators 170a, 170b activate the clamping pads 172a, 172b using, for example, electrically powered motors (not shown).
25 It is understood that various other methods for actuating the clamping pads 172a, 172b may also be used. The specific functions of the support actuators 170a, 170b will be discussed in more detail below with reference to Figure 6.

In an alternate embodiment, the mounting brackets 115 may also include a folding gear
30 117 and a folding motor 119 which drives the folding gear 117. The folding gear 117 allows the brackets 115 to be folded inward when, for example, the system 100 is being lowered into position within the cylinder liner 200 using, for example, a cable 105 (Figure 2). This may help to prevent damage to the imaging devices 110 and laser sensors 120. In a preferred embodiment, the mounting brackets 115 may be located 90 degrees apart

from each other, and four imaging devices 110 and four laser sensors 120 are used. However, it is understood that one or more imaging devices 110 and/or laser sensors 120 may be used.

- 5 The imaging devices 110 may be any type of camera that has sufficient resolution to produce useful images of the inside surface 210 of the cylinder 200. By way of example and not limitation, the imaging devices 110 may be a charge coupled device (CCD) or a Complementary Metal Oxide Semiconductor (CMOS) camera having a resolution of at least 1 megapixel. It is understood that other imaging devices may also be
10 used.

The laser sensors 120 may be any type of laser sensor capable of measuring the inside diameter of the cylinder liner 200. In one embodiment, the laser sensors 120 may be of a linear displacement type, with a measuring range of approximately
15 80mm and a resolution of approximately 20-25 microns. It is understood that other types of laser sensors 120, having both larger and smaller measuring ranges and resolutions, may also be used.

The support structure 130 may also include a rotating pinion 162 and a rotating
20 motor 164 that may be used to rotate the bearing housing 160 about the bearing hub 150. This will be discussed in more detail below.

It is understood that details concerning the specific design of the illustrated embodiment of the support structure 130 are provided by way of example only.
25 Many other types and configurations of support structures 130 may be used by one skilled in the art given the details provided in this description. All such structures are deemed to fall within the limits of the appended claims.

It is understood that in the simplest form, the system and method of inspection of the
30 present embodiments may be implemented by lowering an imaging device into the cylinder liner and capturing a sufficient number of images to perform an inspection based on the captured images. In alternate embodiments, both an imaging and a measuring device may be lowered into the cylinder liner. Images and measuring data may then be captured and processed.

Figure 6 illustrates another alternate method, designated generally as reference numeral 300, for using the system 100 to remotely inspect the inside surface 210 of a cylinder liner 200. The method 300 includes a first step of lowering the system 100 using, for example, the cable 105, to a desired position along the cylinder liner 200, as shown with reference numeral 302. Next, the computer 700 activates the clamping actuator 170a, 170b until the clamping pads 172a, 172b engage the inside surface 210 of the cylinder liner 200, as shown with reference numeral 304. In an alternate embodiment, the system may be placed directly on the cylinder head (not shown) within the cylinder liner 200. In either embodiment, the system 100 may be operated through the exhaust valve hole with minimum removal of the various connecting accessories, as required in the prior art.

In the next step, as shown with reference numeral 306, the computer 700 activates the laser(s) 120. A measurement is taken to determine the exact position of the support structure 130 with respect to the cylinder liner 200. The computer 700 then adjusts the position of the central hub 150 to be in the center of the cylinder liner 200 by controlling the position of the X-Y tables 142, 144 which move on the linear bearings 146. Preferably, the central hub should be within ± 20 mm distance of the center to provide for effective measurements.

Once the central hub 150 is positioned, the computer 700 will activate the rotating motor 164 to drive the rotating pinion 162 to rotate the bearing housing 160, as shown with reference numeral 308. The computer 700 also activates the laser sensors 120, and receives the sensor data for a complete 360 degree revolution of the bearing housing. The computer 700 then calculates the diameter and ovality of the cylinder liner 200. This information may be saved in the computer 700 for later analysis. In a preferred embodiment, the laser sensors 120 are capable of accurately measuring the diameter of the cylinder liner to within 20 micrometers. It is understood that other ranges of values may be used, from 5-100 micrometers.

In the next step, as shown with reference numeral 310, the computer 700 activates the imaging device(s) 110 to capture images of a portion of the inside surface 210 of the cylinder liner 200. These captured images are sent to the computer 700 for analysis. In

one embodiment, the captured images may be compared to a reference image of, for example, a new cylinder liner. Alternately, the images may be compared to prior images from the same cylinder liner 200. In other alternate embodiments, the operator of the computer 700 may view the images utilizing the display 708.

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In further embodiments, the captured images may be compared to reference images of specific types of damage that may occur to the inside surface 210 of the cylinder liner 200. In this embodiment, once the captured images are analysed, the computer will make a determination as to whether or not the captured images match a corresponding
10 reference image for a particular type of damage, as shown with reference numeral 312. If the captured image(s) match, the computer 700 may generate a log entry in a cylinder liner health report, as shown with reference numeral 314. Additionally, the computer 700 may generate an alarm or other indication to the operator to identify the existence of a potential problem.

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If the captured images do not match, the computer will then check to determine if all programmed positions for the measurements have been completed, as shown with reference numeral 316. If additional measurements in additional positions are required, the computer 700 will revert to the moving step 302, as shown with reference numeral
20 318. If measurements from all positions have been completed, the process ends, as shown with reference numeral 320. In a preferred embodiment, the position of the system may be adjusted by approximately 200mm throughout the length of the cylinder liner 200. It is understood that other displacement distances, both smaller and larger, may also be used.

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The computer 700 may be controlled using, for example, a logic sequence program in PLC, motion control and measurement software such as Labview, and/or other types of software written for this purpose. It is understood that many types of commercially available software may be used to provide control of the system 100 and/or to make the
30 various image comparisons discussed above.

The discussion of the system 100 presented above provides a description of one example embodiment of a system for remotely inspecting an inside surface of an engine cylinder liner. It is understood that there are many ways of implementing the

system given the information provided in the present disclosure. For example, in its simplest form the system may include an imaging device introduced into the cylinder liner for capturing an image of the inside surface of the cylinder liner. All such systems are deemed to fall within the scope of the appended claims.

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Some portions of the description above are explicitly or implicitly presented in terms of algorithms and functional or symbolic representations of operations on data within a computer memory. These algorithmic descriptions and functional or symbolic representations are the means used by those skilled in the data processing arts to convey most effectively the substance of their work to others skilled in the art. An algorithm is here, and generally, conceived to be a self-consistent sequence of steps leading to a desired result. The steps are those requiring physical manipulations of physical quantities, such as electrical, magnetic or optical signals capable of being stored, transferred, combined, compared, and otherwise manipulated.

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Unless specifically stated otherwise, and as apparent from the following, it will be appreciated that throughout the present specification, discussions utilizing terms such as "scanning", "calculating", "determining", "replacing", "generating", "initializing", "outputting", or the like, refer to the action and processes of a computer system, or similar electronic device, that manipulates and transforms data represented as physical quantities within the computer system into other data similarly represented as physical quantities within the computer system or other information storage, transmission or display devices.

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The present specification also discloses apparatus for performing the operations of the methods. Such apparatus may be specially constructed for the required purposes, or may comprise a general purpose computer or other device selectively activated or reconfigured by a computer program stored in the computer. The algorithms and displays presented herein are not inherently related to any particular computer or other apparatus. Various general purpose machines may be used with programs in accordance with the teachings herein. Alternatively, the construction of more specialized apparatus to perform the required method steps may be appropriate. The structure of a conventional general purpose computer will appear from the description below.

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In addition, the present specification also implicitly discloses a computer program, in that it would be apparent to the person skilled in the art that the individual steps of the method described herein may be put into effect by computer code. The computer
5 program is not intended to be limited to any particular programming language and implementation thereof. It will be appreciated that a variety of programming languages and coding thereof may be used to implement the teachings of the disclosure contained herein. Moreover, the computer program is not intended to be limited to any particular control flow. There are many other variants of the computer program, which can use
10 different control flows without departing from the spirit or scope of the invention.

Furthermore, one or more of the steps of the computer program may be performed in parallel rather than sequentially. Such a computer program may be stored on any computer readable medium. The computer readable medium may include storage
15 devices such as magnetic or optical disks, memory chips, or other storage devices suitable for interfacing with a general purpose computer. The computer readable medium may also include a hard-wired medium such as exemplified in the Internet system, or wireless medium such as exemplified in the GSM mobile telephone system. The computer program when loaded and executed on such a general-purpose computer
20 effectively results in an apparatus that implements the steps of the preferred method.

The invention may also be implemented as hardware modules. More particularly, in the hardware sense, a module is a functional hardware unit designed for use with other components or modules. For example, a module may be implemented using discrete
25 electronic components, or it can form a portion of an entire electronic circuit such as an Application Specific Integrated Circuit (ASIC). Numerous other possibilities exist. Those skilled in the art will appreciate that the system can also be implemented as a combination of hardware and software modules.

30 The method and system of the example embodiment can be implemented on the computer system 700, identified in Figure 1, and schematically shown in Figure 7. It may be implemented as software, such as a computer program being executed within the computer system 700, and instructing the computer system 700 to conduct the method of the example embodiment.

The computer system 700 can include a computer module 702, input modules such as a keyboard 704 and mouse 706 and a plurality of output devices such as a display 708, and printer 710. The computer module 702 can be connected to a
5 computer network 712 via a suitable transceiver device 714, to enable access to e.g. the Internet or other network systems such as Local Area Network (LAN) or Wide Area Network (WAN).

The computer module 702 in the example includes a processor 718, a Random
10 Access Memory (RAM) 720 and a Read Only Memory (ROM) 722. The computer module 702 also includes a number of Input/Output (I/O) interfaces, for example I/O interface 724 to the display 708, and I/O interface 726 to the keyboard 704. The components of the computer module 702 typically communicate via an interconnected bus 728 and in a manner known to the person skilled in the relevant
15 art.

The application program can be supplied to the user of the computer system 700 encoded on a data storage medium such as a CD-ROM or flash memory carrier and read utilizing a corresponding data storage medium drive of a data storage device
20 730. The application program is read and controlled in its execution by the processor 718. Intermediate storage of program data maybe accomplished using RAM 720.

Embodiments of the present invention as described above have several advantages
25 over prior art systems. The embodiments provide the capability to perform a remote inspection and measurement of the engine cylinder liner by using computer vision and accurate laser displacement measuring sensors. Thus, no inspector is required to physically enter the cylinder liner. The software implemented on the computer system analyses the maximum wear and ovality against set limits, liner wear rates from the
30 previous overhauls, etc., and provides the operator with reports in order to make appropriate decisions for the adjustment of the lube oil feed rate, the ridge on the liner, water ingress, ring conditions and the liner life against the feed rate etc. The software may also identify the type of defects and provide or predict a maintenance schedule for the engine, reducing downtime during repairs.

Additionally, measurements taken with the laser sensors are more accurate, more consistent, more precise and less error prone than measurements taken by an inspector using measuring gauges. The measurement and inspection data may be recorded and
5 documented in reports for engineers to review and undertake appropriate measures. Additionally, the systems and methods described herein may also be used for diameter measurements and defect inspections on the internal surface of any large cylinders or pipe. The system and method also eliminate the need to remove all pipes and accessories connected to the engine cylinder head prior to performing an inspection.

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It will be appreciated by a person skilled in the art that numerous variations and/or modifications may be made to the present invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects to
15 be illustrative and not restrictive.

CLAIMS

1. A system for remotely inspecting a cylinder liner of an engine, the system comprising:
5 an imaging device operable to be inserted into said cylinder liner and to capture an image of at least a portion of an inside surface of said cylinder liner;
wherein said captured image can be used to determine a condition of said cylinder.
- 10 2. The system of claim 1, further comprising a laser sensor capable of measuring a diameter of said cylinder liner.
3. The system of claim 2, wherein said imaging device and said laser sensor are coupled to a support, said support being capable of moving said
15 imaging device and said laser.
4. The system of claim 3, wherein said support further comprises:
a base;
a spherical bearing hub coupled to said base;
20 a bearing housing coupled to said bearing hub such that said bearing housing is capable of rotating about an axis of said hub; and
means for temporarily clamping said support to said cylinder liner;
wherein
said imaging device and said laser sensor are coupled to said bearing
25 housing to facilitate imaging and measurements of a circumference of said cylinder liner.
5. The system of claim 4, wherein said base further comprises:
an upper X-Y table plate coupled to said spherical hub; and
30 a lower X-Y table plate moveably coupled to said upper X-Y table plate; wherein
said means for temporarily clamping said support to said cylinder liner comprises a clamping actuator coupled to said lower X-Y table plate;

said clamping actuator is capable of fixing a position of said support within said cylinder liner; and

said upper and lower X-Y table plates are moveable with respect to each other such that a position of said spherical hub may be adjusted when said support is fixed within said cylinder liner.

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6. The system of any one of the preceding claims, wherein said imaging device comprises one of a charge coupled device (CCD) or a Complementary Metal Oxide Semiconductor (CMOS) camera.

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7. The system of any one of claims 2-6, further comprising a plurality of imaging devices and a plurality of laser sensors.

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8. The system of any one of claims 2-7, wherein said laser sensor is capable of determining a diameter of said cylinder liner to within 20 micrometers.

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9. The system of any one of claims 3-8, further comprising a computer connected to said imaging device, and said support, wherein said computer is capable of:

controlling and operating said imaging device, said laser sensor and said support;

receiving and processing images captured by said imaging device; and

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receiving and processing information from said laser sensor.

10. The system of claim 9, wherein:

said step of processing images captured by said imaging device further comprises comparing said images to a reference image to determine a condition of said inside surface; and

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said step of processing information from said laser sensor further comprises comparing said diameter measurements to a reference measurement to determine a condition of said cylinder liner.

11. A method for remotely inspecting a cylinder liner of an engine, the method comprising the steps of:
introducing an imaging device into said cylinder liner;
capturing an image of at least a portion of an inside surface of said
5 cylinder liner; and
analysing said captured image to determine a condition of said
cylinder liner.
12. The method of claim 11, further comprising introducing a laser sensor into
10 said cylinder capable of measuring a diameter of said cylinder liner.
13. The method of claim 12, wherein said imaging device and said laser
sensor are coupled to a support comprising:
a base comprising;
15 an upper X-Y table plate coupled to said spherical hub; and
a lower X-Y table plate moveably coupled to said upper X-Y
table plate;
a spherical bearing hub coupled to said upper X-Y table plate;
a bearing housing coupled to said bearing hub such that said bearing
20 housing is capable of rotating about an axis of said hub; and
a clamping actuator coupled to said lower X-Y table plate; wherein
said clamping actuator is capable of clamping said support within said
cylinder liner; and
said upper and lower X-Y table plates are moveable with respect to
25 each other such that a position of said spherical hub may be adjusted when
said support is fixed within said cylinder liner.
14. The method of any one of the claims 11-13, wherein said imaging device
comprises one of a charge coupled device (CCD) or a Complementary
30 Metal Oxide Semiconductor (CMOS) camera.
15. The method of any one of claims 13-14, wherein a plurality of imaging
devices and a plurality of laser sensors are coupled to said support.

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16. The method of any one of claims 13-14, further comprising the steps of:
moving said support to a desired position along the cylinder liner; and
engaging said clamping actuator to clamp said support to said inside
surface of said cylinder.
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17. The method of claim 16, wherein;
said imaging device, said laser sensor and said support are
connected to a computer, the method further comprising the steps of:
using said laser sensor to measure a position of said support within
said cylinder liner; and
10 using said computer to adjust said position to center said hub within
said cylinder liner.
18. The method of claim 17, further comprising the steps of:
engaging said laser sensor;
rotating said bearing housing;
sending said laser sensor data to said computer; and
calculating a diameter and an ovality of said cylinder liner.
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19. The method of claim 18, further comprising the steps of:
capturing image data;
sending said image data to said computer; and
20 using said computer to process said image data to determine a
condition of said cylinder liner.