

PIPELINE INSPECTION

The invention relates to pipeline inspection and more specifically to a vehicle which can be towed through a pipeline to allow analysis of its wall structure.

Large diameter pipes can be tested using complex pipeline pigs which may even operate when the pipes are 'live', i.e. when gas, for example, is flowing through the pipe.

In US4292589A an eddy current method and apparatus for lowering into an oil well casing is disclosed using transmitting coils and receiving pads.

In US4203069A an eddy current producing coil is shown for use with a rotor for concentrating the field.

In US5532591A an arrangement uses a rotating magnetic field to test flaws in the wall of a drinks can.

In EP0065325A a flaw detector uses eddy currents from a source coil with an associated detector.

In JP08005611A a flaw detector uses transmission and receiving coils utilising eddy current detection with reduced noise.



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In JP03120457A an eddy current flaw detector uses coils for reducing the influence of an external baffle plate.

In JP61133856 a detector system uses both eddy currents and ultrasonic thickness measurement to aid diagnosis.

According to the invention there is provided a pipeline inspection device for travelling through a pipeline and including generator means for generating an eddy current field within the pipeline; and detector means for detecting the resultant field and characterised in that the inspection device is configured to determine the presence of faults in both ferrous and non-ferrous pipelines, the detector means comprising first and second receivers spaced longitudinally on either side of a transmitter coil at a single location forming the generator means, said receivers being configured to receive information derived from the transmitter coil at two longitudinally spaced locations on the pipeline, said information being updated as the device travels through the pipeline and means being provided for selecting a coil excitation frequency dependent on the ferrous or non-ferrous nature of the pipeline to be tested.

Further according to the invention there is provided a method of testing a pipeline using a pipeline inspection device, said method including generating an eddy current in a coil in said device and detecting the eddy current induced in the wall of the pipeline and characterised by the steps of: selecting a coil excitation frequency dependent on the nature of the pipeline to allow both

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ferrous and non-ferrous pipelines to be tested, detecting the induced eddy current at two longitudinally spaced locations from the coil positioned at a single location therebetween and updating the information as the device travels along the pipeline to allow faults in the pipeline to be determined.

Preferably, the present invention provides an improved arrangement which also allows both ferrous and non-ferrous small diameter pipes to be tested for defects.

Preferred embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings in which:

Figure 1 shows an embodiment of the pipeline vehicle of the present invention;

Figure 2 shows the control and data handling arrangements of Figure 1 in more detail;

Figure 3 shows a sensing configuration with associated processing; and

Figure 4 shows a flow chart associated with system operation.

The pipeline inspection arrangement of Figure 1 comprises a towed vehicle 10 shown within pipe 11 which can be towed by a winch (not shown) via cable 12

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to allow testing of a pipe through which it passes. The towed vehicle comprises several linked devices. These include a power unit 20 and master processor module 21 and a master sensor ring 22. A coil 24 generates a

remote field eddy current which is detected via sensor ring 22. The coil is separated from the sensor ring 22 by means of separator 23 to attenuate any directly transmitted field between the coil 24 and sensor 22. A slave ring 25 is also provided separated from the coil 24 by attenuating separator 26. The sensor ring 25 is connected to slave processor module 27. A base station 30 provides the link between the vehicle 10 and a computer 31 so as to initiate testing and to receive resulting information. A distance encoder 32 is provided to generate distance information as the vehicle travels through the pipeline. The distance encoder can conveniently be mounted on the cable wheel (not shown) associated with the winch so that as the vehicle is towed the distance travelled is continuously updated back to the base station 30.

The arrangement is configured to induce eddy currents into the wall of the pipeline due to the a.c. field generated by coil 24. We have determined that such eddy currents can be used in both ferrous and non-ferrous pipelines (i.e. magnetic and non-magnetic) and with a smooth pipe wall a uniform field decaying with distance is provided. When non uniformity in the surface is present due to pitting, cracks, etc., then changes in the detected eddy currents field occurs and

these are detected via sensors 22 and 25. By utilising two sensor array sets the ability to pinpoint the defect point is enhanced. In addition each sensor array have typically twenty-four sensors in each so that in total 48 amplitude sensing and 48 phase sensing measurements can be made covering the periphery of the pipe. We have determined that by taking phase measurements in addition to the amplitude measurements it is possible to discriminate between internal and external pipe wall defects. The information to and from the base station can be passed on 48 analogue and 48 digital channels.

The arrangement described is capable of operating within small pipes of 4" diameter or less and has capability of coping with 1.5D bends in the pipeline.

The system can typically provide a 6mm scan interval with a winch speed of about 6 metres per minute. An x and y accelerometer is incorporated within the vehicle to allow orientation information to be sent to the computer as the vehicle may partially rotate during its travel through the pipeline. The towing range can be several hundred metres so providing a very useful and cost effective inspection mechanism.

The information passed to computer 31 via base station 30 allows a number of parameters to be determined from the detected information. This can give a 'real-time' display of:

1. amplitude and phase
2. azimuth 0-360°
3. velocity

In addition the defects can be calculated to include the size and position of defects using the computer.

The vehicle of Figure 1 will have electronic control, power and data transmission requirements which are shown in more detail in Figure 2.

The vehicle power requirements are received on line 35 and pass to power unit 20. The input can be 110V a.c. supply and the power unit output will be 150V d.c. for the coil drive requirements using line 33. Low voltage d.c. will be available for the electronics circuits within the vehicle (e.g. $\pm 5V$). Communication to and from the vehicle and the base station will be via connection 30. A suitable communication protocol will be employed (e.g. RS 232).

The master processor 21 will be microprocessor

controlled and include data links between the master sensor assembly 22 and the slave processor to ensure synchronism as well as control 32 to the coil drive. Serial data passes between master processor 21 and sensor 22 via line 31. There is also passage of data between slave processor 27 and sensor 25 via line 34. Rather than incorporating all the processing requirements within the slave and master processors 27 and 21, it is possible to provide signal conditioning and processing within the sensor assembly as shown in Figure 3 for the master sensors 22. Here dedicated acquisition hardware (signal conditioning 22d,e and microcontroller 22f) give improved noise performance and reduced processing load to the processor in the master pack 21, and allow increased front-end processing.

Timing of data sampling will be controlled by the phase reference input. Sample rate will be dependent upon the excitation frequency selected.

The microcontroller will be implemented using an 8 bit microcontroller with minimum port capability. The serial data interface will adopt a standard protocol.

Channels will be paired as shown, each microprocessor

22f supporting two sensor channels 22a, 22b with associated signal conditioning 22d, 22e.

Returning to Figure 2, the single drive coil 24 provides field excitation and the sensors are maintained in close proximity to the pipe wall with x and y orientation sensors in each sensor assembly 22, 25 to compensate for rotation within the pipe and skew between the two sensor assemblies. Prior to operation, the vehicle identification is read and data is loaded into a calibration file within the computer 31.

Vehicle configuration is then set up via the computer to give the number of channels and sensor address requirements.

In addition the coil current is set to meet operational requirements.

Finally the coil excitation frequency is set. This may be within the range of 20Hz to 1KHz and selected dependent on the pipeline material under investigation as both ferrous and non-ferrous pipelines are to be tested. In operation the vehicle is towed through the pipe and as it does so the distance encoder 32 of

Figure 1 will produce data for distance travelled.

To determine defects in the pipeline, a data scan command is sent from the computer and received via the base station in the vehicle master controller. This information is then repeated to the slave controller by the master. Scanning to the channels is then effected. The slave sends the data to the master in packet format and the master receives data also from the master sensors. The master assembles the data including amplitude and phase information and orientation data from both sensor rings and sends this to the host computer for display and processing. A flow chart of typical system operation is shown in Figure 4. In addition the master controller synchronises the slave and generates the drive coil excitation signal. Compensating time delays can be incorporated to ensure synchronisation between master and slave.

It is to be understood that, if any reference to prior art is made herein, such reference does not constitute an admission that the prior art forms a part of the common general knowledge in the art, in Australia or any other country.

In the claims which follow and in the preceding summary of the invention, except where the context requires otherwise due to express language or necessary implication, the word "comprising" is used in the sense of "including", that is the features specified may be associated with further features in various embodiments of the invention.

THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

1. A pipeline inspection device for travelling through a pipeline and including generator means for generating an eddy current field within the pipeline; and detector means for detecting the resultant field and characterised in that the inspection device is configured to determine the presence of faults in both ferrous and non-ferrous pipelines, the detector means comprising first and second receivers spaced longitudinally on either side of a transmitter coil at a single location forming the generator means, said receivers being configured to receive information derived from the transmitter coil at two longitudinally spaced locations on the pipeline, said information being updated as the device travels through the pipeline and means being provided for selecting a coil excitation frequency dependent on the ferrous or non-ferrous nature of the pipeline to be tested
2. A device as claimed in claim 1 wherein the means is configured to select a frequency within the range of 20 Hz to 1 kHz.
3. A device as claimed in claim 1 or 2 wherein the transmitter coil is a single drive coil and is spaced from the first and second receivers by separator means configured to attenuate any signal reaching the receivers other than via the pipeline wall.

4. A device as claimed in claim 1, 2 or 3 wherein a master processor is connected to the first receiver and the transmitter coil to control said receiver and coil and to provide synchronising information to the second receiver via a slave processor.
5. A device as claimed in any one of claims 1 to 4 including means for determining eddy current information concerning both amplitude and phase and means for discriminating between internal and external pipe wall defects dependent on said information.
6. A device as claimed in any one of claims 1 to 5 including means for towing the inspection device through the pipeline, means for determining distance information and means for determining azimuth orientation of the inspection device as it travels through the pipeline.
7. A device as claimed in any one of claims 1 to 6 wherein computer means are configured to display information on detected amplitude and phase as well as azimuth and velocity information as the device travels along the pipeline.
8. A device as claimed in any one of claims 1 to 7 including means for generating data packets for transmission to a remote computer for evaluation.
9. A device as claimed in any one of claims 1 to 8 including means for determining the dimensions of a faulty portion on the pipeline.

10. A device as claimed in any one of claims 1 to 9 wherein the detector means includes a plurality of sensor coils connected via signal conditioning means to a microprocessor forming a processor channel, said processor receiving a phase reference signal for data sampling timing.

11. A device as claimed in any one of claims 1 to 10 wherein each receiver means for detecting the field comprises a ring of sensors spaced around its periphery.

12. A device as claimed in any one of claims 1 to 11 wherein the device comprises a towed vehicle capable of passing through bends in the pipeline and including a first azimuth sensor located with the first receiver and a second azimuth sensor located with the second receiver to provide orientation information to compensate for vehicle rotation within the pipeline and any skew between the first and second receivers.

13. A method of testing a pipeline using a pipeline inspection device, said method including generating an eddy current in a coil in said device and detecting the eddy current induced in the wall of the pipeline and characterised by the steps of:

selecting a coil excitation frequency dependent on the nature of the pipeline to allow both ferrous and non-ferrous pipelines to be tested, detecting the induced eddy current at two longitudinally spaced locations from the coil positioned at a

single location therebetween and updating the information as the device travels along the pipeline to allow faults in the pipeline to be determined.

14. A method as claimed in claim 13 wherein the frequency is selected within the range 20Hz to 1kHz.

15. A method as claimed in claim 13 or 14 including attenuating any signal received by the detecting step other than received via the pipeline wall.

16. A method as claimed in claim 13, 14 or 15, wherein the detecting step includes detecting the amplitude and the phase of the eddy current to discriminate between internal and external pipe wall defects.

17. A method as claimed in any one of claims 13 to 16 including the steps of towing the device along the pipeline, determining the distance travelled and determining the orientation of the detector position in the pipeline as the device travels through the pipeline.

18. A method as claimed in any one of claims 13 to 17 including the step of determining the dimensions of a fault in the pipeline from detected information.

19. A method as claimed in any one of claims 13 to 18 wherein the device comprises a towed vehicle capable of passing through bends in the pipeline and the steps include towing the vehicle through the pipeline, sensing a first

azimuth value at a location of a first receiver and sensing a second azimuth value at a location of a second receiver to provide orientation information to compensate for vehicle rotation within the pipeline and any skew between the first and second receivers as the vehicle travels through the pipeline.

20. A method as claimed in any one of claims 13 to 19 including the steps of sending a scanning command from means remote from the device, collecting amplitude data in response to said command, collecting phase data in response to said command, formatting the data into a packet and transmitting the packet to said remote means and detecting azimuth information to allow for device rotation within the pipeline.