

A method for determination of internal pipeline or tubing corrosion

The invention relates to a method for determining the variations of the internal condition of a pipeline or tubing, by propelling a pig, which is sealed against the pipeline or tubing, through the pipeline by means of a constant flowing driving fluid and by measuring and recording the pressure of the said driving fluid during pigging of the pipeline or tubing and deriving from the recorded pressure signals information as to the internal diameter variations of the pipeline or tubing being inspected.

The steel wall of a pipeline or tubing may be subject to internal corrosion. This is dependent, obviously, on the matter that is transported through the pipeline or tubing. Both liquids and gases may attack the steel wall.

Two forms of corrosion may be of interest, namely uniform corrosion and pitting. In the case of uniform corrosion the wall thickness decreases more or less uniformly and it will be clear that this could lead to the pipeline becoming unserviceable, because the wall will become too weak to resist the internal pressure. Pitting could lead to leakage and this phenomenon must also be avoided.

It is obviously of great importance to be regularly informed about the state of the pipeline or tubing to be able to take measures in time.

Since downtime is costly, the inspection of pipelines or tubings should preferably be carried out during operation. Moreover, pipelines or tubings are often installed where access is difficult, e.g. underground or under water, so that methods of internal inspection are to be preferred.

From US—A—2.940.302 it is known that internal pipeline or tubing corrosion is determined by means of a pig adapted to be carried along by the flow of matter through the pipeline or tubing. Such a pig is fitted with an element responsive to fluid pressure during the course of travel of the pig through the pipeline. If a leak develops, the fluid pressure record will show a discontinuity, which can be related to a determined position on the pipeline, since the pig is also fitted with a position-identifying device.

However, such a pig is less suitable for use in pipes having a small diameter. Such small pipes are often used, e.g. in heat-exchangers, flow lines, etc.

Further, it is at times sufficient to obtain only qualitative information about the condition of the pipe wall without the need of an expensive instrumented pig and a time-consuming processing of signals.

It is therefore an object of the invention to provide a method for determining internal corrosion of a pipeline or tubing, which method provides information as to the internal condition

of the pipe wall in a relatively simple and cheap way.

Further, it is an object of the invention to provide a method for obtaining information about the internal condition of a pipe-line or tubing, which method can be used qualitatively as well as quantitatively.

It is another object of the invention to provide a method for obtaining information about the internal pipeline or tubing condition, which method can be used in pipes having a relatively small diameter as well as in pipes having a larger diameter.

The method of the invention therefore is characterized by the pressure differential across the pig is measured and a plurality of quantities representative of the pressure variations in selected successive intervals of the pipeline or tubing are derived from the measured pressure differential signals, each interval having a predetermined length, in such a way that the total length of the pipeline or tubing to be inspected is covered, and comparing the values of the quantities thus obtained with reference data of these quantities, said reference data representing a one-to-one correspondence between a determined pressure value and a determined diameter value of the pipeline.

As already indicated in the above the method according to the invention is in particular applicable to pipes having a small diameter and a relatively short length, for example up to a few kilometers.

In the following description the use of the term "pipeline" is intended to include also the term "tubing". Further, the said method according to the invention may be applicable as an addition to the above-mentioned known pigging methods to provide a rough indication of the pipe wall condition. The method according to the invention is in particular applicable for a qualitative survey and localization of regions of high corrosion.

The invention is based upon the fact that a correlation between the pressure recording obtained during pigging and the internal diameter of the pipeline exists. It will be clear for those skilled in the art, that a good sealing between pig and pipe wall should exist to prevent leakage.

Using this fact continuous pressure differential recording during pipeline pigging is a means for evaluating the internal corrosion condition of the line, a decrease of the pressure differential across the pig indicating an increase of the pipeline diameter due to corrosion. The information as to the pipeline wall condition may be obtained in several ways. One of the possibilities is that the pressure differential across the pig is continuously measured and recorded during each of several pig trips. The recorded fluctuations in pressure as obtained on

a specific trip may be considered as a "finger print" which may be used as reference data for trips which are carried out subsequently. In this way a qualitative indication as to the condition of the pipe wall may be obtained. Such a qualitative indication may be sufficient in many cases, if the pipeline is not too old.

Another way of using the correlation between pressure recording and the diameter of the pipe is obtaining a set of reference data from which the desired diameter data of the pipe to be inspected can be derived, by determining and recording reference data belonging to predetermined various known segments of the pipeline. This can for example be done by known devices, which measure and record the internal pipeline diameter. The pressure can be continuously measured and recorded by any means suitable for the purpose. For example a pig, provided with mechanical means may be used to measure and record the pipeline data. Of course any other device suitable for the purpose may be used. In this way a one-to-one correspondence between a determined pressure value or any suitable representation of the measured pressure variations in a predetermined pipe length, and a determined diameter value is obtained. Such a representation may be the average pressure in the pipeline, which can be derived from the measured pressure variations. Representing the reference data thus obtained may for example take place graphically. It will be clear to those skilled in the art that the form of such a reference graph will depend on the shape of the pig and the coefficient of friction between the pig and internal pipeline wall. So a set of different reference curves should be obtained.

In an advantageous embodiment of the invention the measured pressure values recorded during a run of the pig are compared with the reference data by means of a micro-processor. However, the said comparison may also be carried out graphically.

It will be appreciated that measuring and recording the pressure values may be carried out in several ways.

For example, the pig may be provided with any instrument suitable for the purpose to carry out the said pressure measurements and recordings. Also a non-instrumented pig may be used, in which case the pressure measurements and recordings may be done at any place of the pipeline suitable for the purpose.

According to an advantageous embodiment of the invention a pig is used, said pig mechanically being adapted in such a way, that the said pig measures the pressure differential between opposite locations on said pig in order to perform localized pressure measurements. The said pig may rotate about the axial line of symmetry of the pipeline.

The present invention will now be described by way of example in more detail with reference to the drawings, in which:

Fig. 1 shows schematically an example of carrying out the method of the invention.

Fig. 2 shows examples of recorded pressure data by a recording means covering a distance of 160 m of the pipeline.

Fig. 3 shows an example of a record of reference data, said record shows a one-to-one correspondence between the recorded pressure data and the measured diameter of the pipeline.

Fig. 4 shows a reference graph, representing a correlation between the average pressure and the diameter of the pipeline.

Fig. 5 shows examples of curves, each curve having a different coefficient of friction between pig and internal pipeline wall.

Referring now to Fig. 1 an example of carrying out the method of the invention is shown.

In a pipeline or tubing 1 a pig 2 is launched at a suitable inlet 1a. The pig is propelled through the pipeline by any suitable fluid by means of a pump 3. The fluid flow is measured by a flow transducer 4. The pressure is continuously measured by a pressure transducer 5. The measured pressure and flow signals are recorded on any suitable recorder means 6, which is connected by a suitable line with the said transducers 4 and 5. The pig 2 is received after its journey through the pipeline 1 at an outlet 7 of the pipeline or tubing. The instantaneous net volume flow of fluid is used to calculate the approximate location of the pig at all times and thus to correlate pressure data with location. Fluid leakage past the pig may introduce uncertainty in the calculated position, but may be corrected in a suitable way, for example as follows: the difference between the integrated volume of fluid used to propel the pig a known distance and the pipe volume swept by the pig in the same distance is the leakage volume. The leakage volume divided by the swept volume is the fractional error in calculated position at any point, and may be applied as a correction factor. Further refinements may be possible, such as off-line correction for localized leakage past the pig based on a pre-determined algorithm between pipe inner diameter and leak rate. Known artifacts in the pipe, such as welds, tees and valves will produce characteristic pressure pulses, which may serve as bench marks for position referencing.

Fig. 2 shows examples of pressure data as recorded by the recording means during pigging, covering a distance of 160 m of the pipeline. Along the horizontal axis the distance from the inlet of the pipeline (in metres) is represented, whereas the vertical axis represents the recorded pressure (in bar) in the pipeline. The reference numbers I and II represent serial runs. Run I may for example be considered as a "finger print" for Run II which is carried out a certain point of time after Run I.

Comparison of Runs I and II provides an

indication as to the change of internal condition of the part of the pipeline being inspected.

Fig. 3 shows an example of the recorded pressure data and measured diameter data, which are used to obtain reference data using a one-to-one correspondence between pressure and diameter values.

In Fig. 3 along the two horizontal axes the time t (upper axis) respectively distance d from the inlet (lower axis) are represented, whereas the upper vertical axis represents the pressure p (in bar). The large spikes I, II and III in Fig. 3 are due to weld material protruding into the pipe.

The lower horizontal axis represents the distance from the inlet, whereas the lower vertical axis represents the measured diameter $D_{\max}$ of the pipeline. As already mentioned in the above, reference data are obtained by launching a suitable pig into the pipeline and by measuring and recording the diameter data and pressure data. It appears that a one-to-one correspondence between the recorded pressure data and diameter data exists.

Fig. 4 shows a reference graph representing a correlation between the average pressure in the pipeline values and diameter values. Water was used as propelling medium in a 8-inch pipeline of 2 km length. The horizontal axis represents the diameter $D_{\max}$ in mm, whereas the vertical axis represents the average pressure p_{av} (in bar). A pipeline distance of 200 m was covered and p_{av} was taken over pipeline intervals of 4 metres.

The origin in this figure is: $p = 0$ bar
 $D = 190$ mm

Fig. 5 shows an example of a set of pressure versus diameter curves, each curve representing a different coefficient of friction μ between pig and internal pipeline wall for a cup-shaped pig. The horizontal axis represents the diameter D (in metres), whereas the vertical axis represents the pressure p (in bar).

It will be appreciated that any suitable pig may be used, said pig being propelled through the pipeline in any propelling medium suitable for the purpose. The distance from the inlet in the pipeline may be determined by any means suitable for the purpose, for example a count-wheel or clock means. Examples of such pigs are sphere-shaped pigs, cup-shaped pigs, etc. These pigs are known to those skilled in the art and are not described further in detail. An advantageous embodiment of a pig which may be used according to the method of the invention is an ellipsoidal shaped pig.

It will be appreciated that p average can be taken over intervals of any length suitable for the purpose and that any suitable pipeline distance can be covered.

Further the pump 3 may be any suitable pump, or constant volume source.

It will be appreciated that the pressures can be measured in any suitable way, for example

by means of a strain gauge transducer. Pressure and flow signals may be recorded on any recording device suitable for the purpose, for example a strip chart recorder, an oscillographic recording device or high speed data logger.

The flow transducer 4 may be any suitable transducer, e.g. an orifice plate or a mass flow meter. Such devices are known to those skilled in the art.

Various modifications of the invention will become apparent to those skilled in the art from the foregoing description and accompanying drawings. Such modifications are intended to fall within the scope of the appended claims.

Claims

1. A method for determining the variations of the internal condition of a pipeline (1) or tubing, by propelling a pig (2), which is sealed against the pipeline or tubing wall, through the pipeline by means of a constant flowing driving fluid and by measuring (4) and recording (5) the pressure of the said driving fluid during pigging of the pipeline or tubing and deriving from the recorded pressure signals information as to the internal diameter variations of the pipeline (1) or tubing being inspected characterized in that the pressure differential across the pig (2) is measured and a plurality of quantities representative of the pressure variations in selected successive intervals of the pipeline or tubing are derived from the measured pressure differential signals, each interval having a predetermined length, in such a way that the total length of the pipeline or tubing to be inspected is covered, and comparing the values of the quantities thus obtained with reference data of these quantities, said reference data representing a one-to-one correspondence between a determined pressure value and a determined diameter value of the pipeline.

2. The method as claimed in claim 1, characterized in that the quantities representative of the pressure variations are the average pressures in the pipeline.

3. The method as claimed in any one of claims 1—2, characterized in that a non-instrumented pig is used.

4. The method as claimed in any one of claims 1—3, characterized in that a sphere-shaped pig is used.

5. The method as claimed in any one of claims 1—4, characterized in that an ellipsoidal-shaped pig is used.

6. The method as claimed in any one of claims 1—4, characterized in that a pig is used, said pig mechanically being adapted in such a way, that the said pig measures the pressure differential between opposite locations on said pig to perform localized pressure measurements.

7. The method as claimed in claim 6, characterized in that the said pig rotates about

indication as to the change of internal condition of the part of the pipeline being inspected.

Fig. 3 shows an example of the recorded pressure data and measured diameter data, which are used to obtain reference data using a one-to-one correspondence between pressure and diameter values.

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The lower horizontal axis represents the distance from the inlet, whereas the lower vertical axis represents the measured diameter D max. of the pipeline. As already mentioned in the above, reference data are obtained by launching a suitable pig into the pipeline and by measuring and recording the diameter data and pressure data. It appears that a one-to-one correspondence between the recorded pressure data and diameter data exists.

Fig. 4 shows a reference graph representing a correlation between the average pressure in the pipeline values and diameter values. Water was used as propelling medium in a 8-inch pipeline of 2 km length. The horizontal axis represents the diameter D max. in mm, whereas the vertical axis represents the average pressure p av. (in bar). A pipeline distance of 200 m was covered and p av. was taken over pipeline intervals of 4 metres.

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It will be appreciated that any suitable pig may be used, said pig being propelled through the pipeline in any propelling medium suitable for the purpose. The distance from the inlet in the pipeline may be determined by any means suitable for the purpose, for example a count-wheel or clock means. Examples of such pigs are sphere-shaped pigs, cup-shaped pigs, etc. These pigs are known to those skilled in the art and are not described further in detail. An advantageous embodiment of a pig which may be used according to the method of the invention is an ellipsoidal shaped pig.

It will be appreciated that p average can be taken over intervals of any length suitable for the purpose and that any suitable pipeline distance can be covered.

Further the pump 3 may be any suitable pump, or constant volume source.

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by means of a strain gauge transducer. Pressure and flow signals may be recorded on any recording device suitable for the purpose, for example a strip chart recorder, an oscillographic recording device or high speed data logger.

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Various modifications of the invention will become apparent to those skilled in the art from the foregoing description and accompanying drawings. Such modifications are intended to fall within the scope of the appended claims.

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1. A method for determining the variations of the internal condition of a pipeline (1) or tubing, by propelling a pig (2), which is sealed against the pipeline or tubing wall, through the pipeline by means of a constant flowing driving fluid and by measuring (4) and recording (5) the pressure of the said driving fluid during pigging of the pipeline or tubing and deriving from the recorded pressure signals information as to the internal diameter variations of the pipeline (1) or tubing being inspected characterized in that the pressure differential across the pig (2) is measured and a plurality of quantities representative of the pressure variations in selected successive intervals of the pipeline or tubing are derived from the measured pressure differential signals, each interval having a predetermined length, in such a way that the total length of the pipeline or tubing to be inspected is covered, and comparing the values of the quantities thus obtained with reference data of these quantities, said reference data representing a one-to-one correspondence between a determined pressure value and a determined diameter value of the pipeline.

2. The method as claimed in claim 1, characterized in that the quantities representative of the pressure variations are the average pressures in the pipeline.

3. The method as claimed in any one of claims 1—2, characterized in that a non-instrumented pig is used.

4. The method as claimed in any one of claims 1—3, characterized in that a sphere-shaped pig is used.

5. The method as claimed in any one of claims 1—4, characterized in that an ellipsoidal-shaped pig is used.

6. The method as claimed in any one of claims 1—4, characterized in that a pig is used, said pig mechanically being adapted in such a way, that the said pig measures the pressure differential between opposite locations on said pig to perform localized pressure measurements.

7. The method as claimed in claim 6, characterized in that the said pig rotates about



the axial line of symmetry of the pipeline or tubing.

Revendications

1. Une méthode pour déterminer les variations de l'état interne d'un pipeline (1) ou d'une canalisation, en faisant avancer un racleur (2), qui est en contact étanche avec la paroi du pipeline ou de la canalisation, dans le pipeline au moyen d'un fluide d'entraînement à écoulement constant et en mesurant (4) et enregistrant (5) la pression de ce fluide d'entraînement durant le raclage du pipeline ou de la canalisation et en déduisant des signaux de pression enregistrés une information concernant les variations du diamètre intérieur du pipeline (1) ou de la canalisation que l'on inspecte, caractérisée en ce qu'on mesure la différence de pression de part et d'autre du racleur (2) et qu'une multiplicité de quantités représentatives des variations de pression dans des intervalles successifs choisis du pipeline ou de la canalisation sont déduites des signaux correspondant à la différence de pression mesurée, chaque intervalle ayant une longueur prédéterminée, de façon que la longueur totale du pipeline ou de la canalisation à inspecter soit couverte, et on compare les valeurs des quantités ainsi obtenues à des valeurs de référence concernant ces quantités, ces valeurs de référence représentant une correspondance univoque entre une valeur déterminée de pression et une valeur déterminée de diamètre du pipeline.

2. Une méthode selon la revendication 1, caractérisée en ce que les quantités représentatives des variations de pression sont les pressions moyennes dans le pipeline.

3. Une méthode selon l'une quelconque des revendications 1 et 2, caractérisée en ce qu'on utilise un racleur qui n'est pas équipé d'instruments.

4. Une méthode selon l'une quelconque des revendications 1 à 3, caractérisée en ce qu'on utilise un racleur en forme de sphère.

5. Une méthode selon l'une quelconque des revendications 1 à 4, caractérisée en ce qu'on utilise un racleur en forme d'ellipsoïde.

6. Une méthode selon l'une quelconque des revendications 1 à 4, caractérisée en ce qu'on utilise un racleur, ce racleur étant réalisé mécaniquement de manière que le racleur mesure la différence de pression entre des endroits opposés sur le racleur afin d'effectuer des mesures localisées de pression.

7. Une méthode selon la revendication 6, caractérisée en ce que le racleur tourne autour de la ligne axiale de symétrie du pipeline ou de la canalisation.

Patentansprüche

1. Verfahren zur Bestimmung der Veränderungen des Zustands im Inneren einer Rohrleitung (1) oder Verrohrung, bei dem ein gegen die Wand der Rohrleitung oder Verrohrung abgedichteter Molch (2) mittels eines konstanten, strömenden Antriebsfluids durch die Rohrleitung angetrieben wird und während des Durchmolchens der Rohrleitung oder Verrohrung der Druck des Antriebsfluids gemessen (4) und aufgezeichnet (5) wird und beim dem aus den aufgezeichneten Drucksignalen Information bezüglich der Veränderungen des Innendurchmessers der untersuchten Rohrleitung (1) oder Verrohrung gewonnen wird, dadurch gekennzeichnet, daß das Druckdifferential über den Molch (2) gemessen wird und von den gemessenen Druckdifferentialsignalen eine Anzahl von die Druckveränderungen in ausgewählten aufeinanderfolgenden Intervallen der Rohrleitung oder Verrohrung darstellenden Größen abgeleitet wird, wobei jedes Intervall eine vorbestimmte Länge aufweist, derart, daß die Gesamtlänge der zu untersuchenden Rohrleitung oder Verrohrung überdeckt wird, und daß die so erhaltenen Werte der Größen mit Bezugsdaten dieser Größen verglichen werden, wobei die Bezugsdaten eine Eins-zu-Eins-Zuordnung zwischen einem bestimmten Druckwert und einem bestimmten Durchmesserwert der Rohrleitung darstellen.

2. Verfahren nach Anspruch 1, dadurch gekennzeichnet, daß die die Druckveränderungen darstellenden Größen die Durchschnittsdrücke in der Rohrleitung sind.

3. Verfahren nach einem der Ansprüche 1 bis 2, dadurch gekennzeichnet, daß ein nicht mit Instrumenten versehener Molch verwendet wird.

4. Verfahren nach einem der Ansprüche 1 bis 3, dadurch gekennzeichnet, daß ein kugelförmiger Molch verwendet wird.

5. Verfahren nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß ein ellipsoidförmiger Molch verwendet wird.

6. Verfahren nach einem der Ansprüche 1 bis 4, dadurch gekennzeichnet, daß ein Molch verwendet wird, der mechanisch so angepaßt ist, daß der Molch das Druckdifferential zwischen gegenüberliegenden Stellen auf dem Molch mißt, um lokalisierte Druckmessungen durchzuführen.

7. Verfahren nach Anspruch 6, dadurch gekennzeichnet, daß der Molch um die axiale Symmetrielinie der Rohrleitung oder Verrohrung rotiert.

