IMCA GUIDANCE ON SUBSEA METROLOGY

A Comparison of Five Main Metrology Techniques in Use Today

Subsea metrology is the process of acquiring accurate measurements for the connection of subsea structures and pipelines. IMCA's guidance covers the most commonly used techniques today. These are long baseline (LBL) acoustics, both diver taut wire and digital taut wire, photogrammetry and inertial navigation systems (INS). This article covers basic principles, along with engineering requirements, different methods and technologies, and some of the advantages and limitations for each technique.

The objective of subsea metrology is to determine accurately the relative horizontal and vertical distance between subsea assets, as well as their relative heading and attitude. Absolute positioning is not necessary as the objective is to know the three-dimensional range and bearing between relative hubs or flanges. A primary issue is defining the measurement point on the hub or flange. Ideally, it should be as close as possible to the centre, but this is not always possible. The hub might have a pressure cap, the instrument package might be too big to fit on to the hub or access to the hub might be restricted. An offset sensor mounting is then created, called the observation point. There are many different solutions for mounting sensors, depending on the instrument – how much it weighs, what measurement procedure is required, etc. For many subsea applications the most widely used solution is a female receptacle on the structure and the instrument mounted on a male stab.

Subsea Metrology Methods

LBL Acoustic Metrology

Acoustic metrology is the most widely used technique in use today. It is a flexible technique; the equipment is extensively available, supported by the majority of offshore survey contractors and is not solely used for metrology. Long baseline (LBL) techniques are employed to provide an accurate hub to hub range. A pressure/depth survey then determines the hub depths, and subsea gyros and instrumented transponders are used to measure the hub pair's attitudes. Accurate knowledge of the speed of sound in seawater is essential. This method is most widely used because it is adaptable, has redundancy and the results can be processed within hours. Arrays can be pre-planned to encompass multiple metrologies and seabed structures. It is also attractive because the results can be referenced to an absolute datum. Another advantage is that the equipment may already be in use for structure installation so a separate mobilisation of equipment and personnel may not be necessary. The disadvantages are that it is susceptible to subsea noise, and it is equipment and time intensive.

Diver Taut Wire Metrology

Diver taut wire metrology is essentially a tape measurement of the direct distance between hubs. This method was the first subsea metrology procedure employed by divers and is still widely used today. The metrology system consists of two 'jig' plates with protractor markings etched on them, mounted directly above each of the hubs in a stab-receptacle assembly or bolted onto one of the flange bolts. One jig plate is the anchor and the other is the reel jig. The plates are used to measure the wire departure angle relative to hub headings. The reel or winch has a device that can measure how much cable has been paid out, or the wire itself is marked off. The wire is paid out, anchored and then tensioned by a hand cranked winch, and readings of distance and departure angle are then made by the diver. Accuracy depends on the correct alignment of the jigs and the accuracy with which the length of taut wire deployed can be measured. Sagging of the taut wire will of course increase with length, affecting the accuracy of direct distance measurement.

Digital Taut Wire Metrology

Digital taut wire is a more sophisticated version of the diver's tape measurements. Additional sensors provide a more accurate distance measurement; depth is also resolved with pressure sensors and relative hub attitude with digital inclinometers. However, it still requires line of sight and is not redundant. As with diver taut wire metrology, there is a limitation on the length of spool that can be measured as the weight of the wire deployed causes sagging. The digital technique has been primarily developed for ROV operations, but can be diver operated. The tension of the wire is measured digitally and is calibrated before each deployment. The system can also measure vertical and horizontal wire departure angles, and the inclination of the hub is measured with digital inclinometers inside the sensor package. The system has the same anchor-reel principle as does the diver taut wire technique; however, the system needs to be powered via the ROV or a dedicated umbilical. The digital taut wire method can also be augmented with pressure sensor measurements and gyro observations of hub attitude.

Photogrammetry

Photogrammetric metrology is a highly specialised application for subsea metrology applications. The basis of photogrammetry is to build a three-dimensional model based on a sequence of two-dimensional photographs. Measuring bars placed on the seabed and reflective markers on the structures provide scaling and reference. Cameras are deployed on an ROV and sequences of photographs taken along the intended spool route. The images are processed using software to derive a three-dimensional model of the positions of the hubs, the seabed and other points of interest on the subsea structures. The advantages of this system are the potential high accuracy of the results, and the fact that in a single survey a very high quantity of information can be gathered. The disadvantages are that image processing makes very intensive demands on computer time; good subsea visibility is required, and also specialist personnel and equipment.

INS Metrology

INS metrology is relatively new to the offshore industry and the use and availability of inertial navigation systems has greatly increased in recent years. Inertial navigation systems (INS) use three accelerometers and three gyros to compute a position based on a known start point and the measured changes in velocity and attitude. Unaided INS do not need an outside signal or reference to compute a position; because they are self-contained they do not require line of sight and they are not affected by poor subsea visibility or a noisy subsea acoustic environment. The main drawback of INS metrology is that without such external references, it is subject to cumulative error over time, referred to as INS drift. In order to mitigate these cumulative errors and maintain accuracy, INS technology offshore is generally used in hybrid or aided form with other positioning systems. Data input from existing positioning systems is used to augment INS data to provide a more robust and accurate overall positioning solution than would otherwise be possible.

Conclusion

Every spool design is different, and hence every metrology project is different. There may be one or more metrology techniques that provide an optimal solution, depending on such factors as required accuracy; water depth; vessel availability; costs and client preference. A balance must be struck between widely used and understood techniques on the one hand, and new and more unusual techniques on the other. Environmental conditions - subsea noise and visibility - will play a part, as well. An important conclusion is that any of these techniques might be merged or used in combination with another. This is particularly true of INS, which, as noted above, is used primarily in hybrid or aided form with other positioning systems.

Acknowledgements

IMCA acknowledges the assistance of Jose M Puig, Keith Vickery and Frank Pritz in the development of this document.

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