High Productivity Welding Technology for Offshore Pipeline “RAIDEN”

1 Improvement of the Productivity for Offshore Pipeline Laying

Nippon Steel & Sumikin Engineering (NSENGI) has been engaged in the construction of a wide variety of coastal steel structures for oil and gas facilities as a comprehensive marine contractor since the 1970s. The total length of the offshore pipelines that NSENGI has laid has reached a total of 4,000 km in Japan and overseas.

Offshore pipelines are laid by a specialized pipeline-laying barge, repeating the processes of welding, inspection, coating, and pipe feeding by utilizing the forward movement of a barge with about 12 m-length pipes (Fig. 1, Fig. 2).

Fig. 1: Specialized pipeline-laying barge “Kuroshio No. 2” owned by NSENGI (photo)

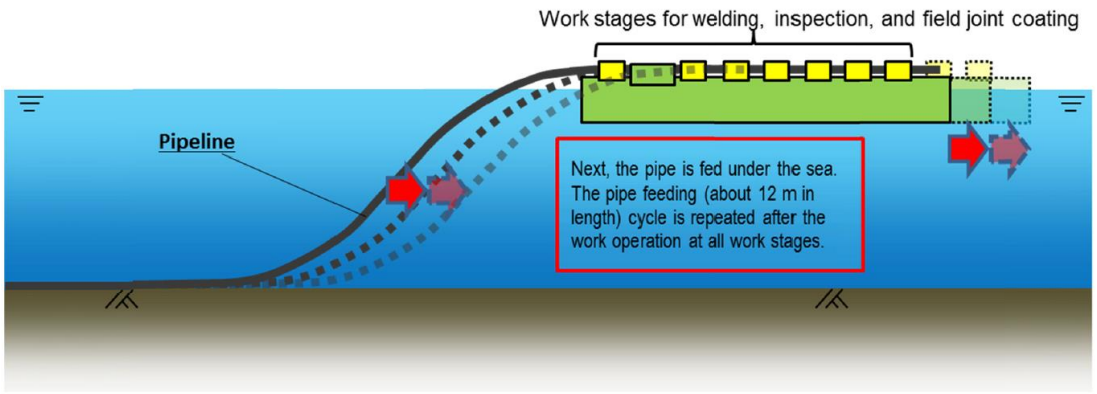

Fig. 2: Laying of an offshore pipeline

The cost of the offshore pipeline construction varies significantly depending on the productivity speed of the pipeline laying. NSENGI has developed a unique automatic welding system "RAIDEN" for the purpose of achieving extremely high productivity pipeline laying. Our high speed welding technologies of offshore pipelines are described below.

2 High speed Welding Technology

As shown in Fig. 3, several work stages are allocated in- line on a laying barge. Each process of root / fill / cap welding, inspection, and coating is performed in parallel at the same time to lay a pipeline.

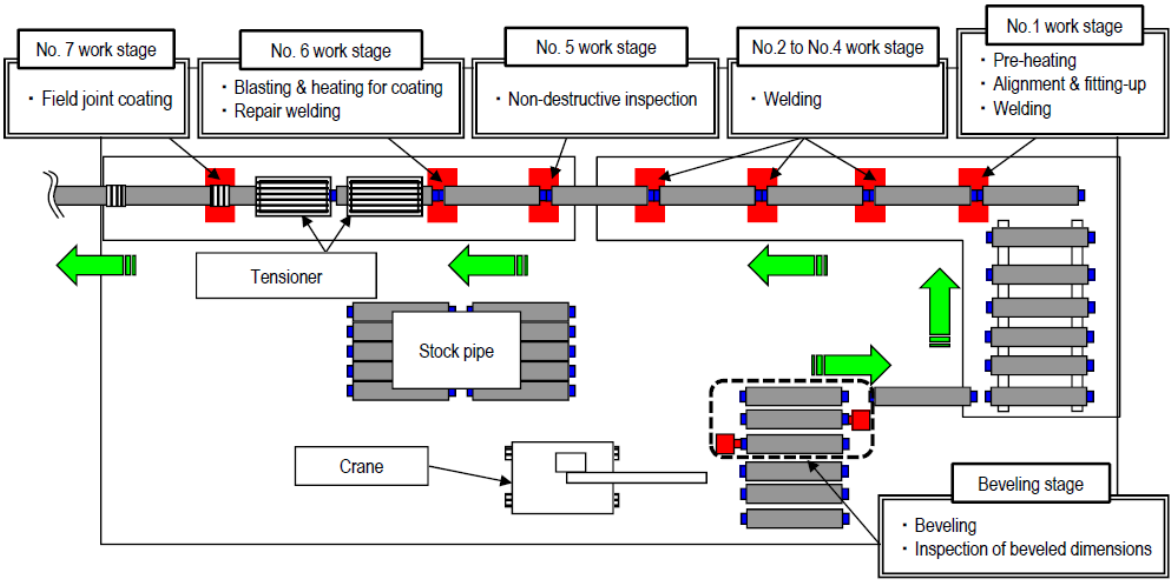

Fig. 3: Work stage layout on a pipeline laying barge

Each stage work takes about five minutes to complete its cycle before the next cycle starts. The most time-consuming stage is at the No. 1 stage, where it is responsible for the processes of root welding after preheating and alignment / fitting-up of the pipe. In order to speed up the entire laying work, it is important to reduce the time taken at the No. 1 stage. Furthermore, when a welding defect occurs, the pipe laying barge could not move forward until the completion of the repair welding. It is important to note that improvement in the welding quality does considerably minimize the welding defects.

Given such characteristics of pipeline construction, NSENGI has developed automation technology for (1) high efficiency/high quality of welding, (2) high speed/high accuracy of welding preparation, (3) advanced information management of all work stages.

2.1 Technology for high efficiency/high quality of welding

RAIDEN performs all-position welding (welding by changing positions downward → vertical → upward along the circumferential direction of the pipe) using MAG welding. This is because fixed

position welding while the pipes are rotating cannot be applied for offshore pipelines since the front portion of the pipes is already laid on the seabed, and they cannot be welded by being rotated on a barge. In order to overcome this issue, furthermore, the welding by RAIDEN has features, such as high speed welding (about 1 m/min), U-shaped narrow gap, two-torch welding, etc., to improve the efficiency (Fig. 4).

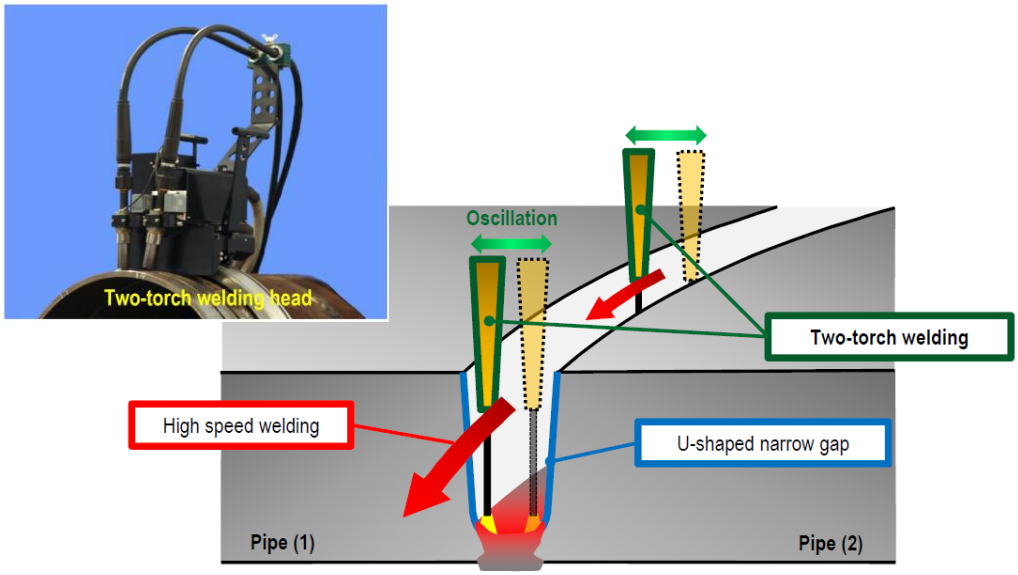

Fig. 4: Welding head (photo) and features of the offshore pipeline welding

In order to achieve high quality (welding defect minimization) welding, the welding arc position must be accurately held in a narrow U-shaped gap. In addition, various welding parameters must be continuously adjusted in detail simultaneously with the travel of welding. These operations have conventionally been performed by skilled welders. However, it becomes difficult to make accurate adjustment at a higher welding speed even with an excellent skilled welder.

RAIDEN has made it possible to automate the arc positioning and welding parameter adjustment using its unique technology. For the adjustment of arc positions, arc sensor technology is used to determine the appropriate arc position by comparing welding currents and welding voltage at the left/right ends of the torch oscillation range in a groove. This method has an issue of accuracy in the target position adjustment in unstable arc conditions during overhead welding at low currents. However, this difficulty has been resolved and automated arc positioning control for all positions has been made workable and achievable using a new welding signal measurement method and control algorithms developed recently. In addition, RAIDEN has a function to automatically adjust the welding parameters such as the torch oscillation width and the travel speed to appropriate values according to the welding position and alignment condition.

Such automation technology has allowed even an inexperienced welder to perform highly efficient and high-quality welding just through experiential

training for equipment operation and arc monitoring just within a short period of time.

2.2 Technology for speeding up/accuracy improvement of welding preparation

○ **Highly accurate bevel shape control**

While welding a U-shaped narrow gap is introduced to reduce the volume to be welded in order to improve the welding efficiency, narrow gap welding is likely to have a welding defect when slight groove shape changes exist. NSENGI has improved the bevel shape measurement accuracy by using an automatic bevel inspection system with multiple laser sensors (Fig. 5) that has the function of automatic judgment for acceptance of the bevel shape using the measurement data analysis.

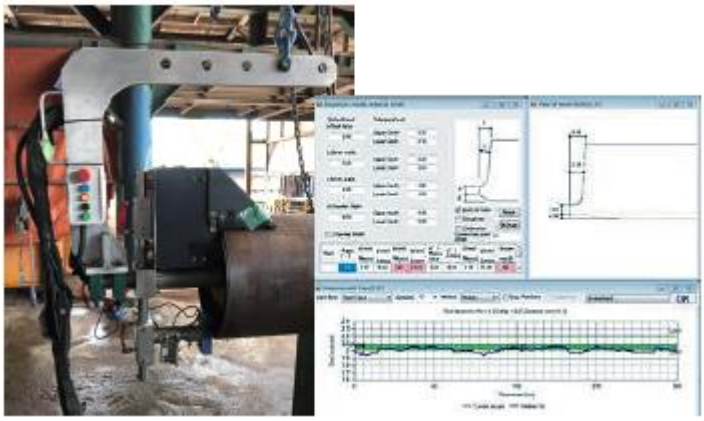

Fig. 5: Automatic groove inspection system (photo) and measurement results

The introduction of this system controls the bevel shape in a highly reliable manner using a measurement system with higher accuracy than that of general manual measurement. This is making significant contributions to welding defect reduction in actual construction sites.

○ **Speeding up/accuracy improvement of pipe alignment and fitting-up**

Not only the bevel shape control, but the alignment / fitting-up process to adjust the relative positions of two pipes to be welded requires high accuracy as well, in order to minimize welding defects. Furthermore, the alignment / fitting-up process needs to be completed in a short time for high-productivity laying.

Conventionally, the alignment / fitting-up process is performed by operators who manually operate two roller platforms. This method causes significant variation in the time taken to complete the work depending on the operators’ skill. In addition, it is difficult to strictly control the fitting-up accuracy.

NSENGI has quantified the pipe relative position by laser sensor measurement, and analyzed the operation of roller platforms by highly skilled operators. Using the data thus obtained, we built up an automatic sequence of the alignment process and created a system of the sequence. In addition, a function to perform the fixing of pipes using internal line-up clamps at the optimum timing was added. In this way, a series of alignment/fitting-up tasks have been automated.

The introduction of the system achieves a significant reduction in the time taken for the tasks performed during the preparation for welding, while maintaining high welding quality.

2.3 Technology on sophisticated information management of all work stages

Pipes are welded on a barge by performing a sequence of specific tasks in work stages. Since it takes multiple work stages to make a welding joint, it is necessary to timely and infallibly convey the information obtained during each work stage to the next stage. In these particular stages, NSENGI has built an information management system to collect an enormous quantity of information from the preparation to the completion of welding and process the information in order to appropriately transfer it between the stages.

The system has allowed the centralized management of settings, control, monitoring, etc. for the devices in welding equipment, hence reducing the time taken to find flaws and take action. The analysis of an enormous quantity of accumulated data has allowed the discovery of improvement points effective for the entire system. This is of great use for the improvement of devices, equipment, and work procedures. In order to meet future technologies, control and analysis functions that can be readily added to the system, the system is expandable.

3 Conclusion

Since the inception of RAIDEN and its practical use for pipeline construction in 2006, NSENGI has continued relentlessly to introduce innovative technologies as described herein while continuously laying a total length of more than 500 km of pipelines.

Currently, we have achieved a laying speed of 3 km or more per day. This is the fastest level for a pipeline laying ship of the same class.

We will constantly strive to improve the productivity and quality of our automatic welding system “RAIDEN” by means of in-depth technological innovation, in pursuit of meeting sophisticated needs relevant to offshore pipelines.

Fig. 6: Welding of pipelines using RAIDEN (photo)

Contact information:

Marine Engineering & Construction Division

Project Management Department, Offshore Operation Sect.
TEL +65-6278-8312

Engineering Department
Marine Asset Development, Planning Sect.
TEL (03) 6665-3435