Development of Fully Automatic Both-Side Welding(GMAW) for Pipeline

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ABSTRACT

Development of a fully automatic both-side welding method for pipeline construction was achieved in terms of combining an internal clamp and welding device with a two external head welding device. A double-V butt joint of 40 degree geometry was applied with simultaneous three head operation (one internal and two external heads), reducing the deposited area to a half and increasing the welding rate by about five times in comparison with the former 60 degree joint geometry and an external single head GMA penetration welding method. The new process also provides the method of inprocess on-line tracking of the weld line as the welding proceeds, because the optical sensor is capable of detecting the variation in .parameters such as joint and deposit geometries. In addition, as the welding conditions can be properly controlled under a real time, it was achieved to stabilize the weld quality and save labor.

1. Introduction

Rapid development of pipeline fluid transport in recent years has led to the slurry transportation of coal and iron ore and capsule transport as well as gas and liquid involved in long distance mass transfer of petroleum and natural gas, town gas piping, water transport lines, and local heating and cooling system lines. Further development in such field is expected to be continued in the future.

Development of pipelines of larger diameter and higher pressure in response to the increasing demand for natural gas is especially noted, while an advanced technology for the on-site girth welding which affects the quality and the cost of the pipeline is required because it is penetration welding.

In addition, since the operation has to be carried out under special circumstances different from those in a plant, generally automation is rather left behind than in other fields, though multiple efforts of development and application have been made.

Under these circumstances, we understood improvement of the conventional automatic welding method for pipeline and development of fully automatic both-side welding (GMAW) aimed at substantially increasing the welding speed. As it is likely to be commercialized, the outline of our research and development will be described below. Table 1 indicates the principal scope of pipe dimensions to be handled by this welding process.

Table 1 Principal scope of pipe dimensions to be handled by automatic welding process

Method	Steel Grade	100 500 1000 2000 O D (mm)
Gas Metal Arc Welding	Carbon Steel	Penetration Welding; Large Diameter GMA; Both-side GMA (3Head); Fillet Welding
Electrogas welding		E G W
Gas Tungsten Arc Welding	Carbon Steel Stainless Steel Alloy Steel	Automatic GTA
Diffusion Bonding		Amorphous Insert Metal

2. Outline and features of welding devices

As for welding equipment, "two external head welding device" and "internal clamp and welding device" were developed in order to use a double-V butt joint which could markedly reduce the deposited area and bring forth stable quality.

2.1 Two external heads welding device

Our company used to apply a single external head to automatic welding (Fully automatic GMA welding), and has developed a new device with two heads in order to improve the efficiency of operation.

In this device, weld line tracking has been improved to be carried out by in-process sensing by use of an optical sensor, which enables the device to cope with multilayer welding for thick wall and one operator to operate multiple head welding.

The weight and dimensions of the welding heads and the guide rail have been reduced to about a half of those in conventional devices in order to shorten the time required for setting up and dismantling the automatic welding device and also to minimize the interference between welding heads involved with the use of a two head device.

Fig. 1 shows the configuration of devices for on-site operation. The whole system of devices is constructed so as to be carried by a 2-ton truck including the internal clamp and welding device to be described later in order to enhance the maneuverability in on-site operation.

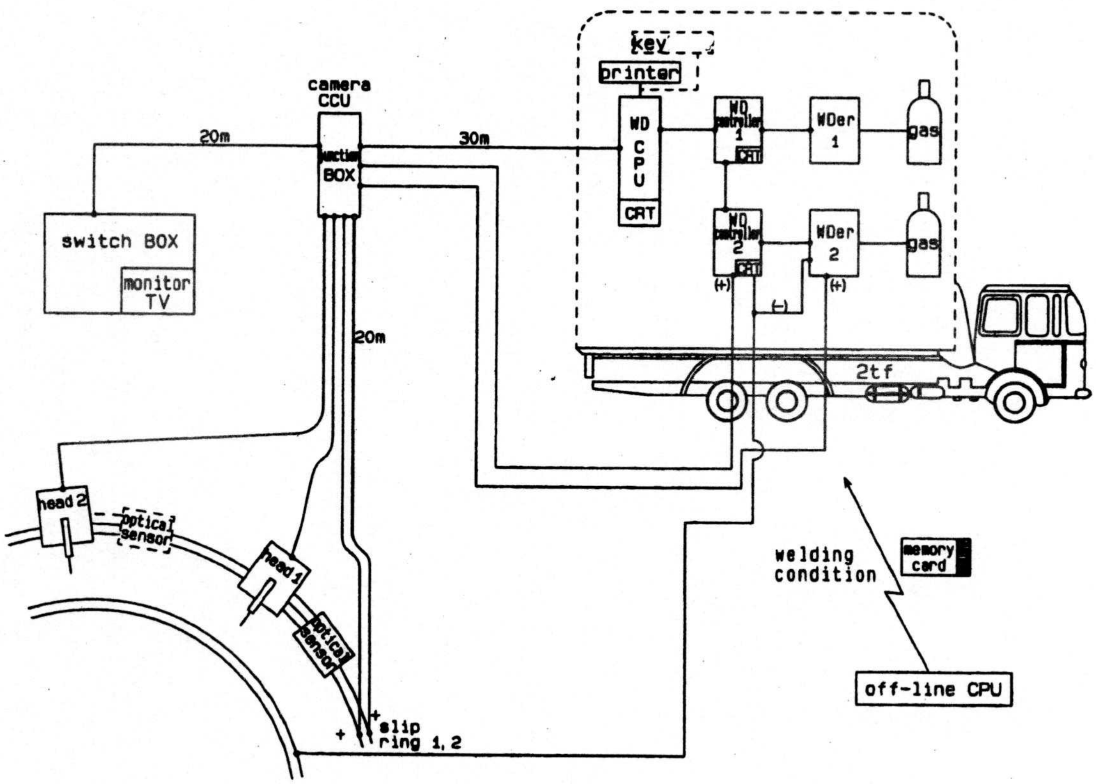


Fig. 1 Configuration of devices for on-site operation

Specifications and the appearance of the device are shown in Table 2 and Fig. 2 respectively.

Table 2 Specifications of two external head welding device

Item		Two External Head GMA	Fully Automatic GMA
Con-troller	Welding Head	2 Heads	1 Head
	Mode	Adaptive Control	Feedback Control
	Tracking of Weld Line	Inprocess sensing (Optical Sensor)	In advance (Contact Sensor)
	Welding Condition	Off-line Device	Off-line Device
Welding Head		2 Heads / Rail (1 Torch/1 Head)	1 Head /Rail (1 Torch/1 Head)
Rail	Traveling	Rack and Pinion	Rack and Pinion (Original Car Track)
	Setting	Cam	Bolt Joint

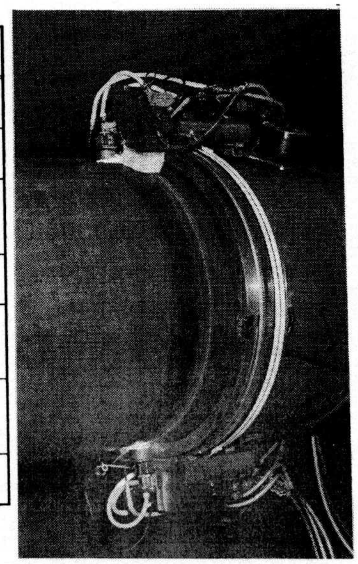


Fig.2 Appearance of two external head welding device

2.2 Internal clamp and welding device

In the conventional single-V butt joint penetration welding, alignment line-up and clamping (fixing a new pipe section to the installed section) is carried out by screwing down the inner clamp. Since, however, this part of operation is performed manually from inside the piping, it is a time consuming work under severe circumstances.

Furthermore, effects of the precision of laying the copper backing strip on the welding quality was appreciable.

Table 3. Specifications of internal clamp and welding device

Item		Specifications
Con-troller	Welding Head	1 Head
	Mode	Feedback Control
	Tracking of Weld Line	Inprocess sensing (Electromagnetic Sensor)
	Welding Condition	Off-line Device
Welding Torch		1 Torch / 1 Head
Shielding Gas		Ar 70% + CO_2 30%
Pipe Diameter		750 A (30 in)
Clamp		Hydraulic internal clamp (5 tf / Rod)

Hence, current device with both hydraulic clamping and internal welding functions was developed, with the penetration welding replaced by both-side welding (double-V butt joint) method for stabilized quality and remarkable shortening of alignment line-up time.

The outline and specifications of the device are shown in Figs. 3 and 4 and Table 3.

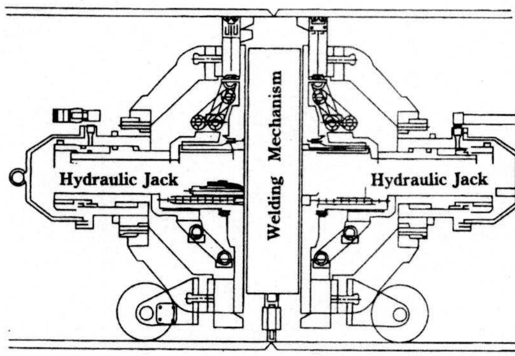


Fig. 3 Outline of internal clamp and welding device

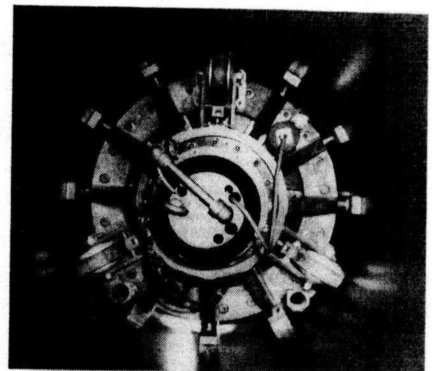


Fig. 4 Appearance of internal clamp and welding device

3. Features of fully automatic both-side GMA welding method

Combining the above mentioned two external head welding device and the internal clamp and welding device contributes not only to a large increase of welding rate but also to a welding application with various features, compared with conventional automatic welding.

3.1 Highly efficient welding operation

Elemental technologies developed for higher efficiency are listed in Table 4. Increased number of welding torches (from 1 to 3 torches), and decreased deposited area (single-V to double-V butt joint : about 50%) could reduce the welding time to about 20% of that required by the conventional automatic welding.

Table 4. Elemental technologies

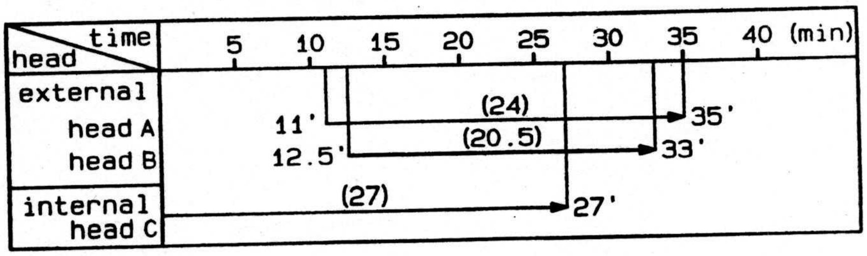
	Present Method	Conventional method
Torch	3 Torches (external 2+ internal 1) — A, B, C	1 Torch
Joint Geometory	(double-V)	(single-V) Cupper Backing
Build-up Sequence	12, 6; Arc Start, Direction, Arc Stop	12, 6; Arc Start, Direction, Arc Stop
Arcing Time	About 3 5 min	About 1 6 0 min

In the case, for example, of steel pipe of 762 mm outer diameter (19 mm in wall thickness), optimization of the joint groove made arcing time of each welding torch about 30 minutes to enable to dispense with the intermission of arcing which was required for cleaning the nozzles during welding, thus reducing the welding time.

Table 5 shows the arcing time of each welding head for a steel pipe of 762 mm in outer diameter and 19mm in wall thickness (API-5L-X65).

It took about 35 minutes from the arcing start of the internal head to the completion of the external welding.

Table 5 Arcing time of each welding head (ϕ 762 × t19)



3.2 "SPREAD" method

As for underground piping in Japan, in most cases a series of operations such as alignment line-up and clamping, welding and X-ray inspection at a location is completed at one site, and then moves to the next site. Hence the progress of construction in a day is limited to 10 to 30 m.

However, with the SPREAD method that is applicable to a number of locations separately, construction can be carried out for hundreds of meters in a day.

Although this SPREAD method came to be used for domestic installation of some large pipelines, manual welding or combination of manual and automatic weldings is prevalent.

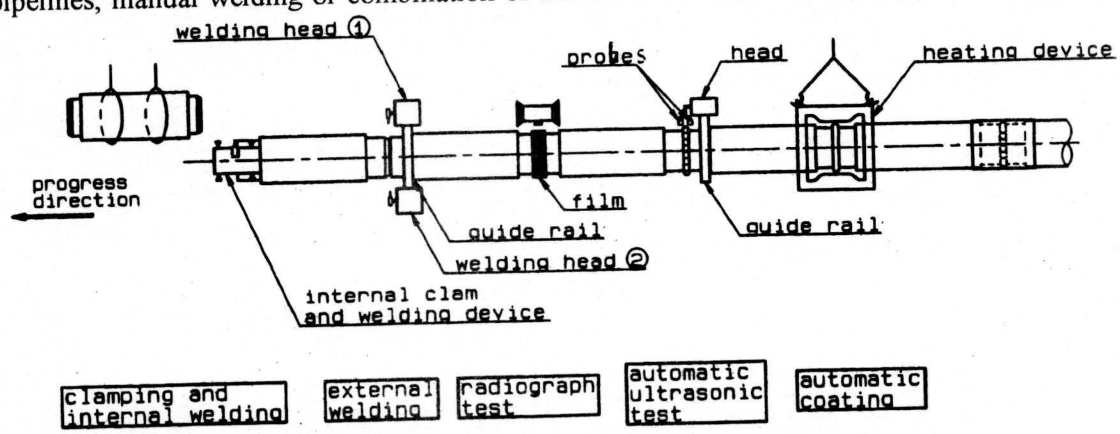


Fig. 5 Schematic diagram of SPREAD method

This is due to the fact that the back up strip is indispensable in conventional automatic welding and that the separation of the pipe alignment line-up and clamping from welding operation was difficult. However, with this welding method, as it is feasible to carry out the internal welding immediately after the alignment line up and clamping operation, the external welding can be conducted at any time, which makes the SPREAD method with efficient and fully automatic welding applicable. The concept of the procedure is shown in Fig. 5.

3.3 Control of optimized welding conditions

In conventional fully automatic welding, a contact sensor was used for weld line tracking in advance, hence all the weld line data in memory were reproduced for tracking the weld line.

In addition, the welding condition was fixed as prepared beforehand on the basis of the standard joint geometry, hence highly precise alignment line-up and joint geometry were required.

Points of detecting the joint geometry and a comparison of welding procedures are shown in Fig. 6 and Fig.7 respectively.

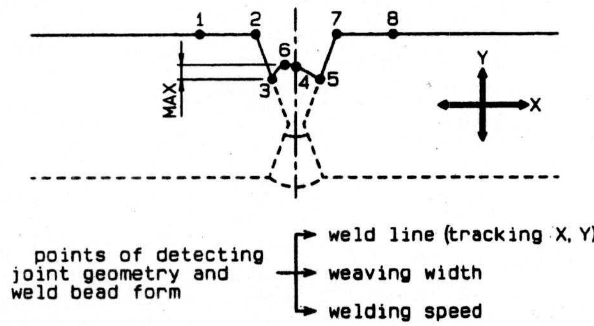


Fig. 6 Points of detecting joint geometry

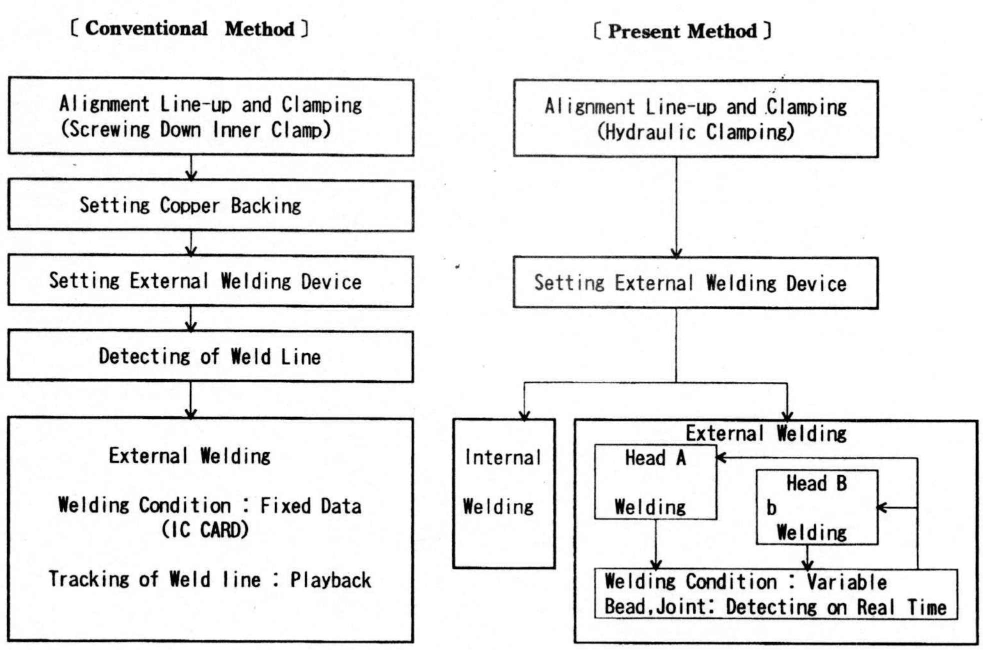


Fig.7 Comparison of welding procedures

Since by the present method the welding condition is variable and the weld line tracking is performed as the changing weld bead form and joint geometry are detected on real time while welding proceeds, the work can be fully carried out with the same accuracy of joint geometry as with manual welding.

3.4 Joint characteristics

Nondestructive testing such as radiographic examination as well as characterization by tensile tests, bend tests and Charpy impact testing demonstrated that the present weld joint has equivalent joint characteristics to those obtained by conventional automatic welding.

4. Conclusion

It is not too much to say that the performance and the construction cost of a pipeline depend on the on-site welding method of joints. Therefore further efforts will be made for development of a fully automatic welding method in order to enhance the process efficiency as well as stable quality.