New Compact Design Manufacturing Process for Small Size ERW Tube Mills

by

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Synopsis

Electric resistance welded (ERW) tubes have been used for a long time in many fields. Demand for application of ERW tube has been increasing becauuse of recently improved quality and reliability of the welded portion of the tube.

However, because ERW tube production technigues limit how thick walls can be, customers, especially automobile companies,have been using round steel bar and heavy-wall seamless tube instead of ERW tubes. Customers have been requesting that ERW tube with a thickness and reliability characteristics comparable to those of seamless tube be developed.

This report introduces a new ERW tube manufacturing process which has extended available tube size range through the development of a new type roll. Furthermore, the quality and reliability of welded portions of tube have been greatly improved using computerized welding technology and non-destructive inspection (NDI). In spite of the need for some additional equipment, the newly installed ERW tube manufacturing mill is designed simply and compactly,to minimize investment and production costs.

As a result, our newly installed ERW tube mill meets customer requirements.

1. Introduction

Electric resistance welded (ERW) tubes are used in many fields, especially for machine structure purposes.

However, conventional mills can only produce tube of a limited thickness range. Because of these limitations, customers, especially automobile companies, have been using round steel bar and heavy-wall seamless tube instead.

In order to increase wall thickness range, the authors have designed a new ERW tube mill for small size.

Special forming techniques, using 3-roll sizers, have expanded the available size range of tubes. The ultrasonic tester installed in-line assures the quality and reliability of the welded portion of the tube.

Furthermore, this new equipment is designed simply and compactly to minimize investment and production cost.

This paper describes the new ERW tube mill and specially developed equipment used with it.

2. The New ERW Tube Mill

Major specifications of the newly installed ERW tube manufacturing mill are given in **Table 1**.

With the new equipment, the mill's capabilities to manufacture heavier wall tube has been expanded(**Table 1**). The expanded range of tube sizes is shown in **Fig.1**, and mill specifications are given in **Table 2**.

The authors would like to share our knowledge of this new ERW tube mill.

Firstly, this paper will discuss the forming techniques, mainly with a 3-roll sizer,which have made it

possible to produce a broader range of tube sizes.

This paper will also discuss the quality assurance system which uses an ultrasonic tester installed in line.

Table 1 Specifications of main equipment

Equipment		Conventional mill	New mill
Uncoiler		Single charge	Double charge
Forming	Roll shaft	65 ϕmm	100 ϕmm
	Motor	110 kW×1	150 kW×1 200 kW×1
Welder		300 kW	500 kW
Sizer	VH type (2-Roll)	4 set	—
	3-Roll	—	1 set
Cut off		Single-press type	Double-press type
Ultrasonic tester (In-line)		—	1 set

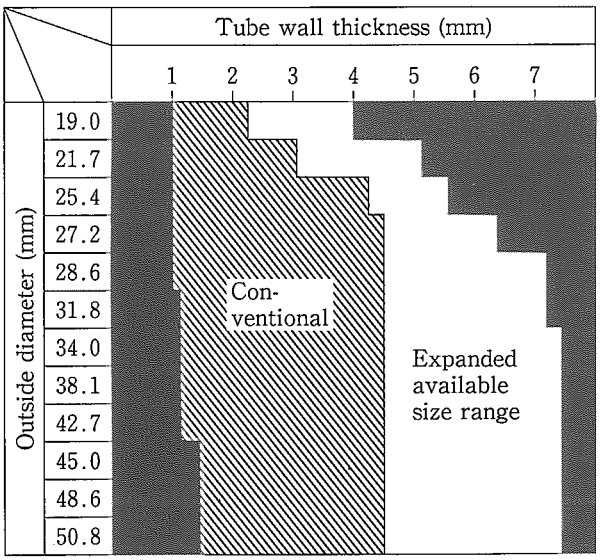


Fig. 1 Available tube size range

Table 2 New mill specifications

Item		Specifications
Production capacity		Max 3 000 t/Month
Available tube size	Outside diameter	ϕ 19~ϕ 50.8 mm
	Wall thickness	t 1.0~t 7.4 mm
	Length	Max 15 200 mm
Mill speed		Max 120 m/min
Available t/d		Max 25 %

3. Forming Technique

Forming technique is the most important issue in manufacturing tubes and increasing quality and productivity.

In order to obtain heavier wall tube, a larger forming roll, a high power welder, and other equipment are used.

3.1 3-Roll Sizer

Max t/d, where t represents tube thickness and D represents the outside diameter of tube, is generally limited to less than 20 %, because of productivity reasons and unstable welding conditions. Downsizing outside diameter is a good way to get higher t/d.

The conventional sizing method using a 2-roll sizer (V-H type) has some difficulties. A conventional 2-roll sizer can not render higher reduction without roll marking (scratch imperfection). These roll marking defects are caused by a large difference in driving speed between the bottom points and the flange roll points of the rolls. (**Fig. 2**)

To achieve a higher reduction without imperfections, the sizer needs more rolls. The 3-roll sizer developed by the authors eliminates roll marking defects because of a smaller difference in driving speed between the bottom and the flange points of rolls. (**Fig. 2**)

This 3-roll sizer (**Photo 1**) can achieve the higher reduction needed with only one sizer unit.

In addition to the driving speed difference, roll shape is also an important factor in roll marking defects and tube dimensional accuracy.

The roll shape of the new 3-roll sizer is designed with these factors in mind.

3.2 Idle-Flange Forming Roll

The roll design in the forming section is as important as in the sizer roll section if to prevent roll marking and obtain a high rolling speed. The driving speed difference between the bottom point and frange roll point is high, especially in the case of larger outside diameters.

Therefore, we have designed a special forming roll called an idle-flange roll. (**Fig. 3**)

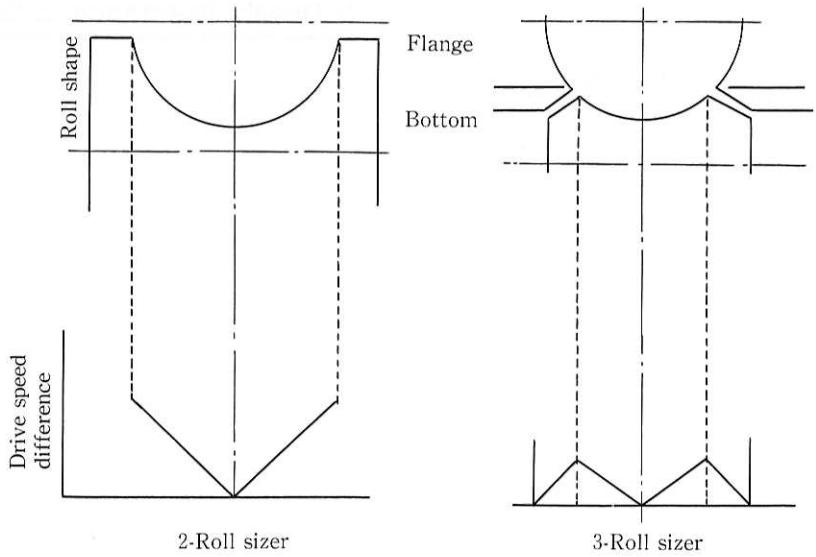


Fig. 2 Comparison of conventional 2-roll and 3-roll sizers

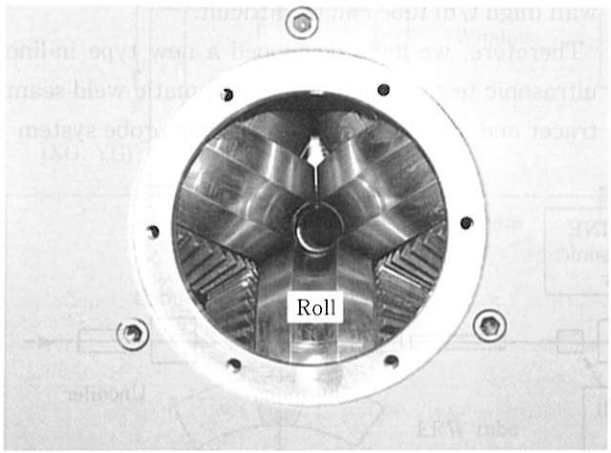


Photo 1 Appearance of 3-roll sizer

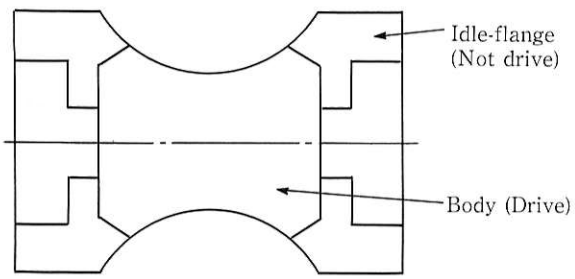
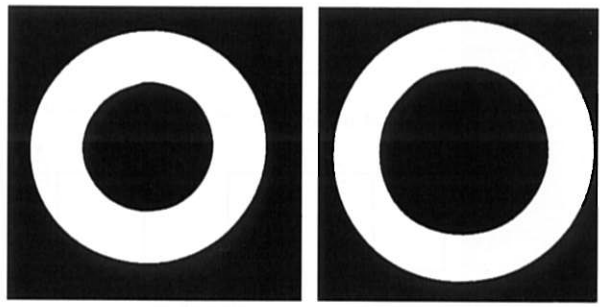


Fig. 3 Idle-flange forming roll

4. High t/d and Dimension Accuracy of ERW Tube

By using the special forming technique, described in part 3, we have been able to manufacture high t/D tube of high dimensional accuracy. The examples are shown in **Photo 2**. Comparison of outside diameter data between a conventional mill and the new mill is shown in **Fig. 4**.

The results of the new ERW tube mill have been excellent and the t/d ratio has been expanded from 20 % to 25 % max.



30 ϕ × 6.3 t
t/D : 21%

34 ϕ × 5.6 t
t/D : 16%

Photo 2 Example of high t/d tube (mm)

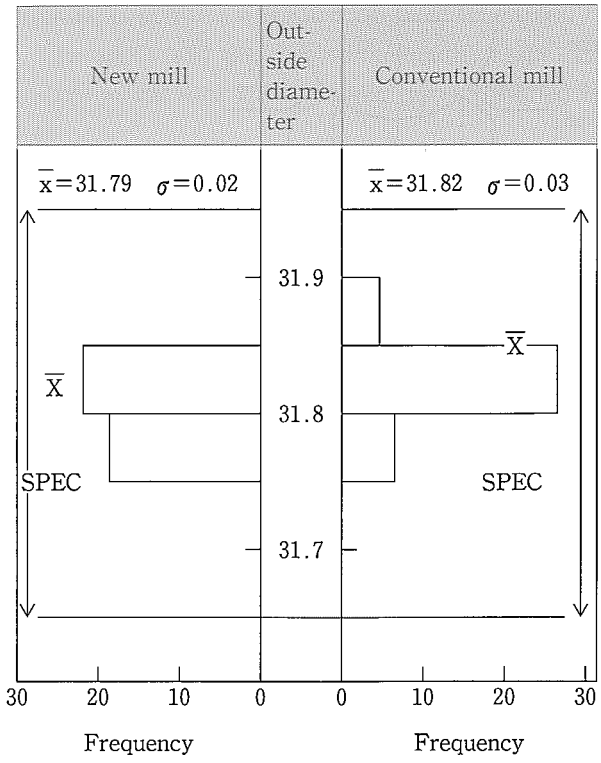


Fig. 4 Comparison of outside diameter accuracy (mm)

5. Quality Assurance of the ERW Tube

Assuring quality of the welded portion of the ERW tube is very important.

Usually, eddy-current inspection and/or ultrasonic inspection are applied for quality assurance. Ultrasonic inspection is more useful than eddy-current for heavy wall tube manufactured by the new ERW tube mill.

In order to minimize the investment costs, We designed and installed the ultrasonic tester in-line.

Using an in-line ultrasonic tester assures the quality of welded portions in a compact configuration and eliminates the need for an off-line ultrasonic tester **(Fig. 5)**. A in-line ultrasonic tester is very useful, but precisely adjusting the ultrasonic tester to the welded portion and applying the ultrasonic test with heavy-wall (high t/d) tube can be difficult.

Therefore, we have developed a new type in-line ultrasonic tester which has an automatic weld-seam tracer and a multi-channel ultrasonic probe system.

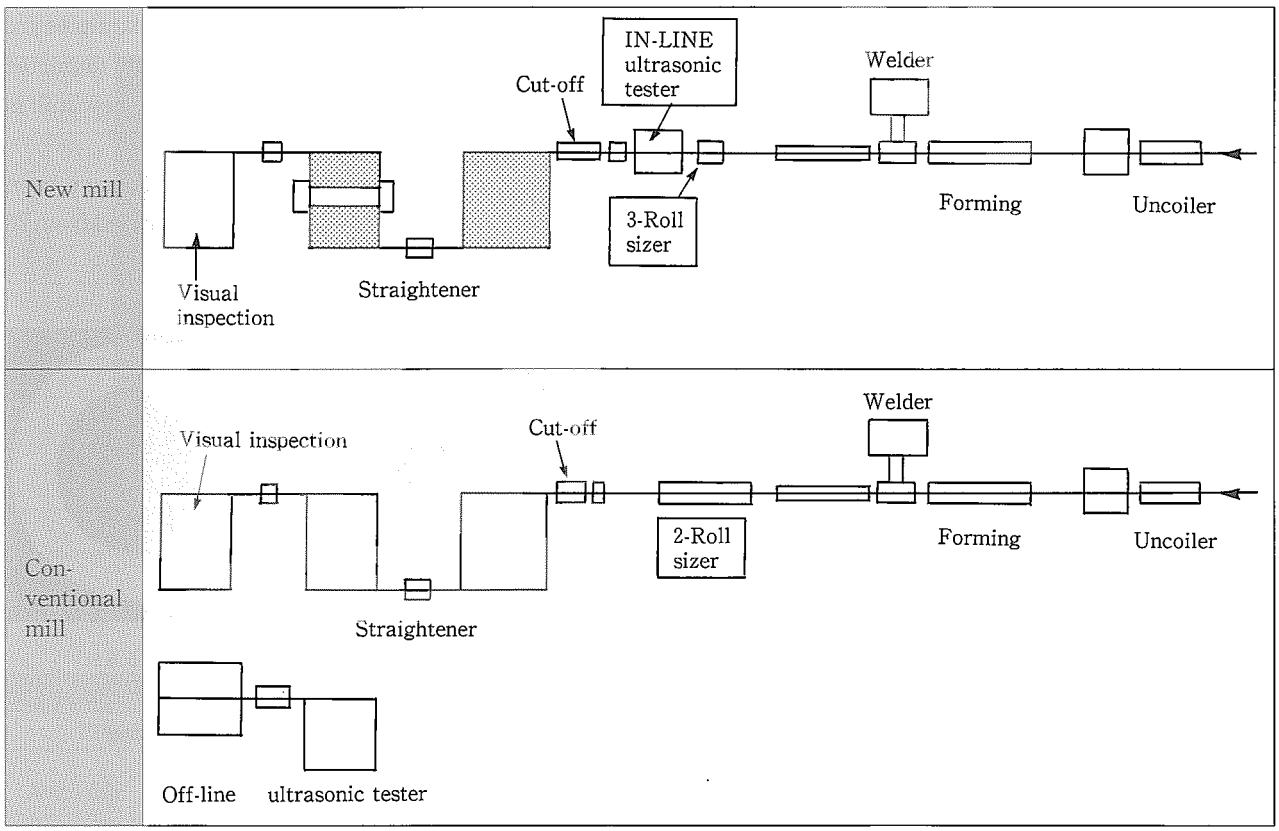


Fig. 5 Layout of ERW tube mill equipment

5.1 Automatic Weld Seam Tracer

Conventional weld seam-tracers detect the differences in reflected light strength from the weld seam and the pipe body, using a one-dimensional optical camera.

This method is difficult in the case of small outside diameter pipe because of the large curvature.

Our new method measures the difference in light and darkness between the weld seam line and pipe body by using a two-dimensional camera with fiber-scope lighting.

By combining an ultrasonic tester and this camera, weld-seam traceability is sufficient even if the tube weld line is twisted. The new automatic weld-seam trace system is shown in **Fig. 6**.

5.2 Multi Channel Ultrasonic Probe System

In order to ensure the reliability of the weld seam in the case of heavy-wall (high t/d) tube, we have installed a multi-channel ultrasonic tester (**Fig.7**).

6 channels inspect the outside portion of tube.

4 channels inspect the inside portion of tube.

2 channels inspect the middle portion of tube.

2 channels using the direct beam method inspect the middle portion of tube to assure high qualitiy in heavy-wall tube.

Figure 7 shows the multi-channel probe system. **Photo 3** shows the appearance of the in-line ultrasonic tester.

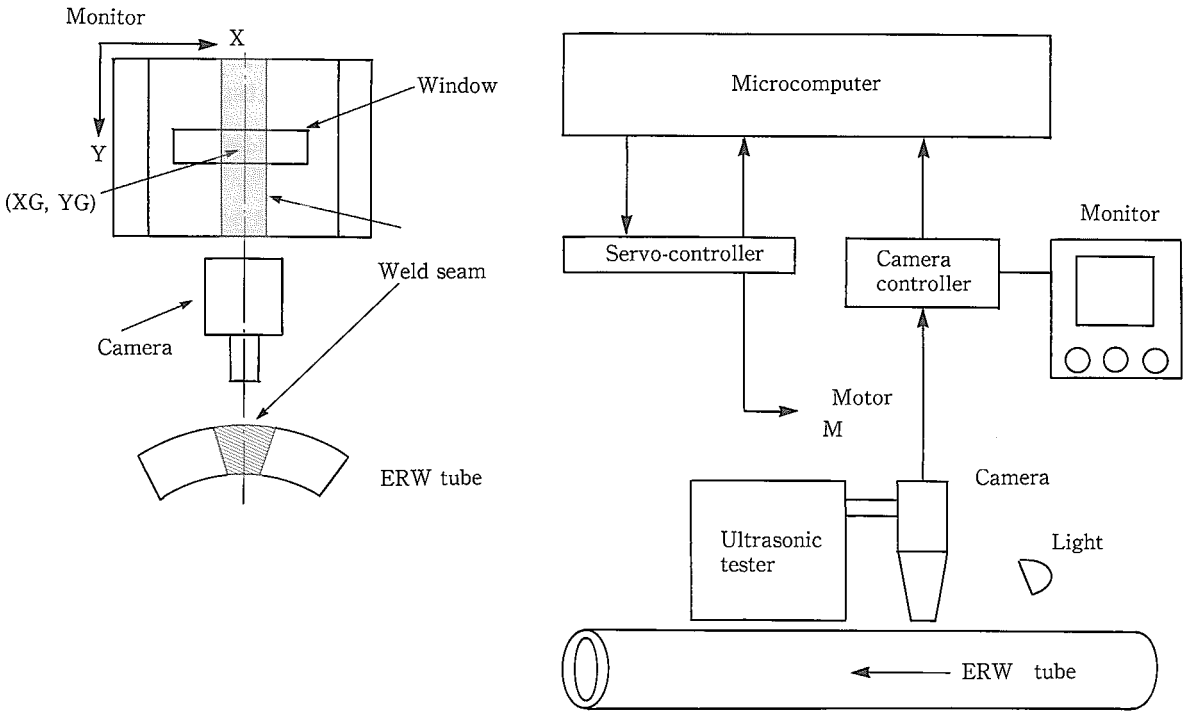


Fig. 6 Automatic weld seam-trace system

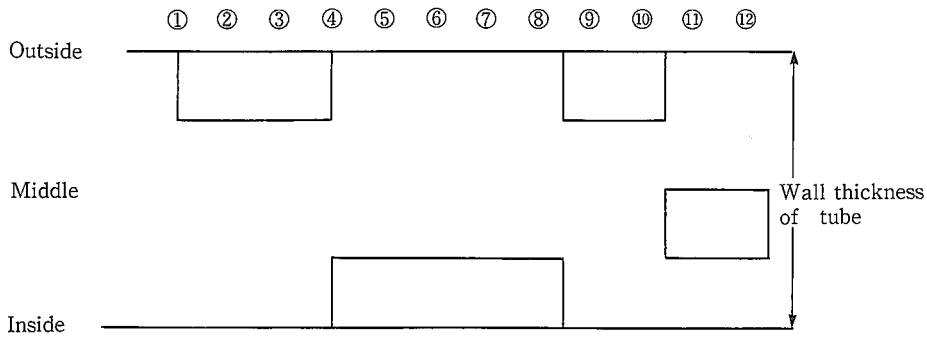


Fig. 7 Multi-channel probe system (Inspection area)

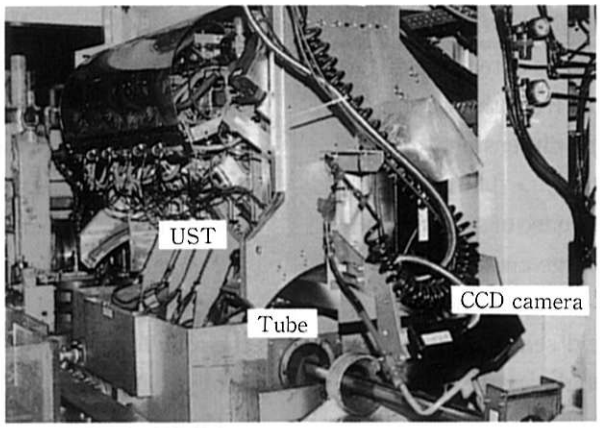


Photo 3 Appearance of in-line ultrasonic tester

6. Conclusion

Our new ERW tube mill, equipped with a 3-roll sizer and an in-line ultrasonic tester, expands the possible size range of tube, improves t/d ratio (Max 25 %), and assures high quality in welded portions of tubes.

Futhermore, this new equipment is designed simply and compactly to minimize investment and production costs.

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