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Analysis of Methods and Equipments for Forming Small and Medium Diameter Welding Pipes

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Abstract: The article examines the methods of forming small and medium-diameter pipes, provides calibration of the forming mill rolls, and analyzes the composition and purpose of the equipment of the pipe-electric welding machines. The structure and functional roles of the equipment in pipe-electric welding machines, such as forming stands, vertical stands, welding machines, seam-cooling systems, calibration stands, and finishing sections are described. Particular attention is given to the working of forming stands and their calibration, deformation forces and the importance of local heat treatment and weld seam cooling in achieving high product quality.

Keywords: welding pipes, forming mill n, pipe-electric welding machines, single-radius calibration, continuous forming, roll calibration, deformation scheme, pipe profiling, edge rolls, weld cooling, local heat treatment.

Welded pipes, being one of the types of finished metal products, are obtained by rolling a metal strip and joining with a weld. Due to their strength, tightness, and relatively low cost, welded pipes are widely used in various industries and construction.

One of the main principles of shaping various pipe profiles is ensuring maximum transformation at each technological transition. This is necessary to reduce the number of transitions for reducing the number of working stands of the mill and thereby its length. The choice of the number of bending operations equal to the number of roll pairs depends mainly on the complexity of the profile configuration and its dimensions, as well as on the required tolerances for dimensions, the ratio of the thickness and width of the workpiece, the configuration of individual sections of the profile, the mechanical properties of the material, the required rounding radius, etc. [1].

Depending on the pipe diameter, there are small diameter pipes (8-114 mm), medium diameter pipes (114-530 mm), and large diameter pipes (530-1620 mm and more).

By the ratio of diameter to pipe thickness (D/S), pipes are classified as particularly thick-walled (D/S < 5.5), thick-walled (D/S=5÷9), normal (D/S = 9÷20), thin-walled (D/S = 20÷50), and particularly thin-walled (D/S > 50).

Formation can be carried out in various ways. The traditional method is roller molding, which is performed in the forming machines included in the equipment of pipe-electric welding aggregates.

The strip deformation (forming) scheme in the continuous mill machine is shown in *Figure 1*.

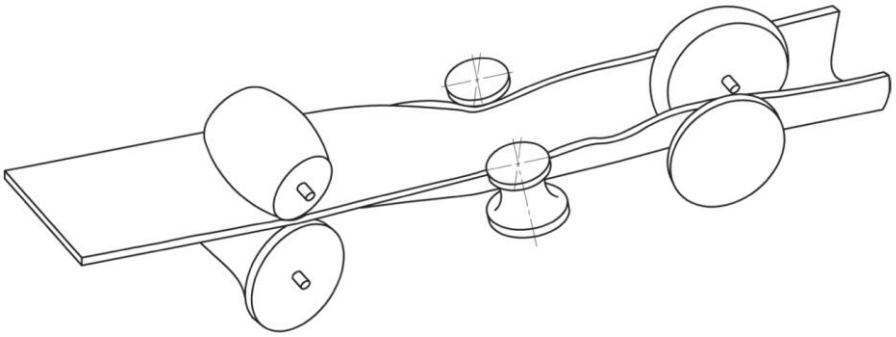

Fig. 1. Deformation scheme of the strip in the continuous roll forming stand

All the variety of existing roll calibrations can be represented by five main types:

1) single-radius;

2) two-radius with folded edges;

3) two-radius with a flat central section;

4) two-radius with central curvature;

5) oval along the second-order curves [2].

The assembly of the pipe-electric welding machine can be divided into two types of equipment: forming-welding and pipe finishing (Table 1).

Table 1. Composition and purpose of pipe-electric welding equipment [3]

Forming and welding equipment	
Roll forming stand	Non-driven vertical and driven horizontal stands form a circular shape from the strip
Pipe welding machine	Two-roller induction current equipment implements heating of the edges and welding. The scraper removes the scraps from the welding process
Seam cooling unit	With the help of air and water, it cools the welded joint
Calibration mill	Vertical non-conducting and horizontal drive stands perform final calibration
Pipe cutting machine	Carries out the cutting of a continuous flow of pipes into parts of a given length
Pipe finishing equipment	
Coil roller straightening machine	Equalizes the surface and shape of the pipe with longitudinal curvature
Pipe-cutting machine	Processes the ends of pipes for their subsequent welding when implementing the pipeline systems
Hydraulic press	Carries out pipe quality control through hydraulic pressure

The operations presented in the table are combined into a single cycle and carried out in a continuous mode of operation of the equipment. Depending on the diameter of the welded pipes, their purpose, and the steel grade, changes in the type of workpiece (sheet or roll strip), forming and welding methods are possible.

On pipe-electric welding machines, the strip is molded into a pipe blank on continuous forming stands with specially calibrated rolls. The number of forming stands is determined by the size of the pipe.

In practice, single-radius calibration is most common, which is used for pipes with a diameter of D=4...600 mm and a wall thickness of S = 0,2...20 mm. Typically, the pipe workpiece is forming

in the stands of the molding machine with driven horizontal rollers. The calibration of the stand rolls of a single-radius forming machine is shown in *Figure 2*.

To prevent the strip from incorrect forming, vertical (edge) non-driven rollers are installed between the stands *(Fig. 3)*.

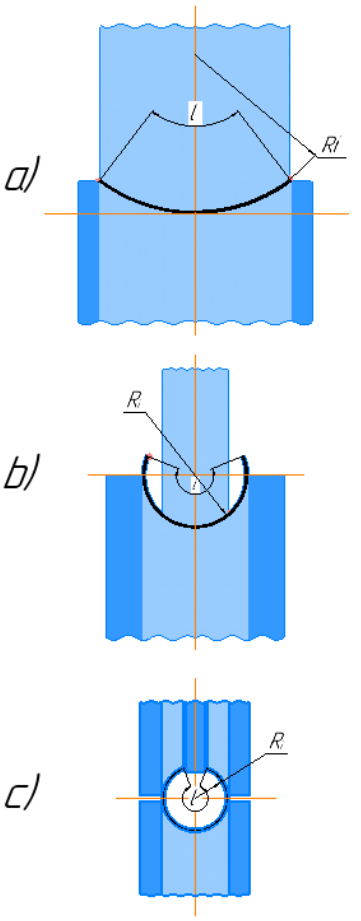

Fig. 2. Single-radius forming mill stands: a-open full-circuit caliber; b-open incomplete-circuit caliber; c-closed caliber

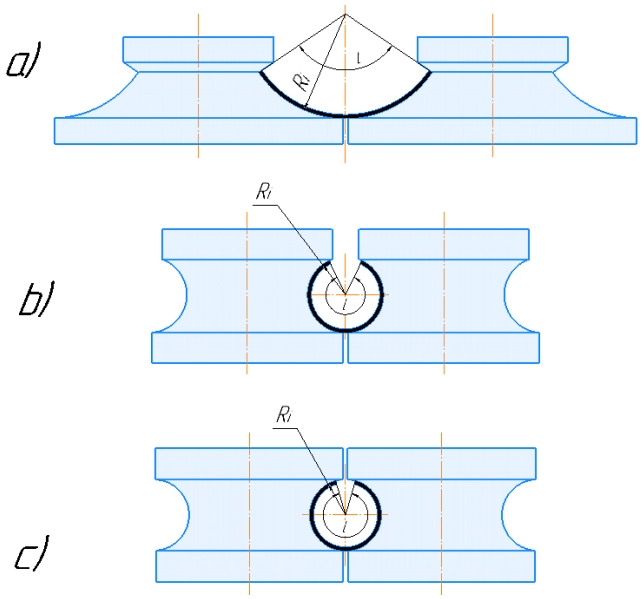

Fig. 3. Vertical stands of a single-radius forming mill: a-supported vertical stand; b, c - full-circuit vertical stand

Vertical rolls can also perform additional strip forming. *Figure 4* shows the general view and model of the forming mill stand.

a) b)

Fig. 4. Pipe forming mill: a - pipe forming stands; b – model of the pipe forming stand

Table 2. Technical characteristics of some small and medium-diameter forming and calibration machines

Parameters	**Types of machines**				
	6-32	**20-76**	**51-114**	**102-220**	**203-530**
Pipe diameter, mm	6…32	20…76	51…114	102…220	203…530
Wall thickness, mm	0,8…2,0	1…4	1…5	3…8	2…10
Forming (calibration) speed, m/min	30…70	30…120	40…120	35…65	28…80
Metal force on rolls, kN: horizontal	20	30	150	170	200/400
vertical	8	15	50	50	1000/2000
Diameter of the horizontal rolls along the bottom, mm	120	140	350	380	600
Number of stands: horizontal	6/3	6/3	8/3	8/4	8/4
vertical	5/3	7/3	7/3	12/4	5/-
Material of rolls	X12M	X12M	X12МЛ	X12МЛ	X12МЛ
Drive type	Group			Individual	
Number of electric motors	1/1	1/1	1/1	8/4	28/8
Total power of electric motors, kW	25/14	180/180	160/160	600/300	25/450
Total mass, t	10,5/5,4	16,7/13,6	64/43,4	107,5/55,4	300/113
numerator - forming mills; denominator - calibration mills					

Modern pipe-electric welding machines also include installations for local heat treatment (annealing) of welds with a pipe air or water-air cooling system.

The cooled pipe enters the calibration and (or) profiled (for the production of pipes with a non-circular cross-section) stands. The calibration stand serves to calibrate welded pipes by diameter and consists of alternately arranged stands with vertical and horizontal rolls.

Hot reduction of the pipe allows for a significant expansion of the pipe range and increases the mill's productivity. For this purpose, a multi-cage reduction tensile stand is installed in one line or in a line parallel to the forming and welding stand.

When checking the quality of electric welded pipes, non-destructive testing is used to detect defects in the strip, welded joint immediately after welding, and in the finished pipe. As part of the pipe-electric welding machines, electromagnetic or ultrasonic devices for non-destructive inspection of pipes are used, installed both at the exit of the welding stand and at the finishing section. In addition, an automated system for measuring the pipe wall is used. The thickness of the pipe walls is measured using the X-ray thickness gauge.

Thus, the production of small and medium-diameter (Ø8-530 mm) welded pipes is carried out at the pipe-electric welding, where pipe formation takes place at the forming stands. The accuracy calibration of the forming mill rolls directly affects the quality of the resulting pipe.

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