

MEASUREMENT OF OVALITY IN PIPE INTRODUCED DUE TO BENDING

Kale A. V.

Assistant Professor, Mechanical Engg. Dept. Yashwantrao Chavan College of Engg. Hingna Road, Nagpur-441110
Tel. 9422826893, 07104-232376
Email: kanil_1960@yahoo.com

Thorat H. T.

Professor, Mechanical Engg. Dept. Visvesaraya National Institute of Technology, Nagpur-440011
Tel. 9822563643, 0712- 2223230
Email: htthorat@yahoo.com

Abstract: Commonly used pipe bending mechanisms are studied in the small-scale industries. Defects introduced in the pipe due to bending on these mechanisms are observed and reasons behind these defects are studied. Ovality is a main defect in the entire pipe bending techniques. To measure the ovality, experimentation is carried out on the existing compression bender. Out of various sizes and materials available, ten pipes of three different materials with variable thickness are selected. Their maximum and minimum diameters are checked before bending. From these diameters, initial ovality and percentage ovality is computed and recorded. These ten pipes are bent on the existing compression bender. Maximum and minimum diameters of these pipes are measured after bending. Increase in percentage ovality after bending is computed. Average values of the percentage ovality are presented in this paper. From the experimental results, it is observed that bent pipe is almost flattened in the bent portion in the existing mechanism, which reduces strength and aesthetics of the fabrication work and hence required to be controlled.

Key Words: Pipe Bending, Defects in Pipe Bending, Compression Bending.

1. INTRODUCTION

Bending of pipes is one of the important processes for many industrial or engineering applications; it has been viewed only as a handicraft that required experienced and skilled labour. However, the transition from handicraft to technical control has necessitated a careful study of the basic mechanics involved in pipe bending. In addition, it is frequently desired to bend the pipe to certain geometrical profiles to satisfy the functional requirements. Therefore, various techniques are developed to bend the pipes [1]. It is observed that ovality is a major defect in addition to other defects like kinkling or buckling, wrinkling, bumps and scratches[2]. Key bending technologies for tubular blanks and an understanding of the fundamental guidelines behind production bending are provided by R.A.Darlington, D.Huges, M.Rees V.P.[3].

Product manufacturers and furniture fabricators require an endless variety and vast quantity of bent parts. The small-scale industries are using simple, cheap, readily available and easy to maintain tools and equipments to achieve higher rate of production. These industries use devices and fixtures for manual bending of the pipes for furniture fabrication. Press brakes, conventional mechanical and hydraulic presses, horizontal bending machines, draw bending, rotary-compression bending mechanism and bending presses are also used. Simple machines and tooling are more versatile in the furniture

manufacturing and they are relatively inexpensive and easy to set up as compared to the sophisticated systems [4].

After visiting small scale industries for studying pipe bending processes, it was observed that most of the small scale industries are using either rotary draw bender or rotary compression bender. Straight pipes with initial circular cross section are processed into smooth bends but pipes are flattened with thickness variation in the bent portion with several other defects. Considering ovality and thickness variation as two major defects, it was decided to measure actual amount of ovality introduced due to bending on existing pipe bending equipments. Experimentation is carried out in small scale furniture manufacturing industry and results of experimentation are presented.

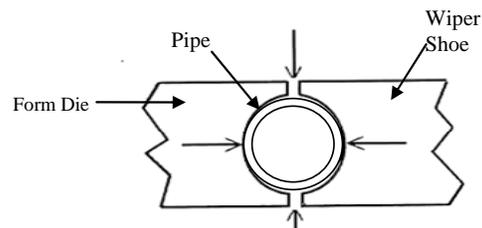


Figure 1 Gap between Form Die and Pipe Diameter

2. REASONS FOR OVALIZATION

With the available methods of pipe bending, the major defect observed is that of ovality. This may be due to the following reasons:

a) In the draw and compression bending, pipe diameter is not supported for maximum of its periphery between fixed roller or a form die and a wiper shoe. This is because the wiping die has gap between its contour and the pipe diameter as shown in Fig.1. While bending, the pipe is pushed into this gap as it is compressed at high points between the wiping die and form die. The pipe takes the shape to conform to the shape of the die. Therefore, the cross section of the pipe becomes oval.

b) In the existing method of pipe bending using rotary compression bender, as shown in Fig. 2, the pipe is clamped to a stationary-bending die and a wiper shoe revolves around the die to bend the pipe. This type of bender is actuated manually for light manufacturing operations. The wiper shoe is placed between the pipe and small roller. The small roller exerts the compressive force on the pipe. It revolves around itself and wipes the pipe for bending with the help of wiper shoe. It presses the pipe against the inner radius of the stationary-bending die, thus the pipe is deformed on tension side producing the ovality i.e. elliptical cross section [5].

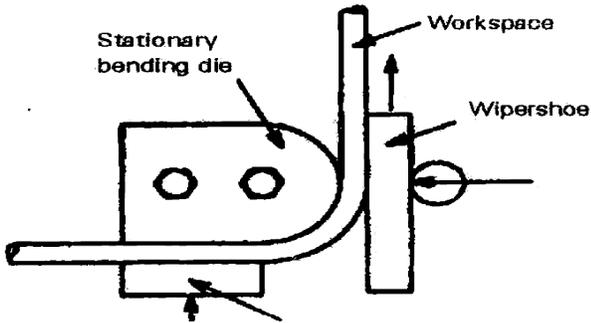


Figure 2 Existing Design of Rotary Compression Bender.

c) No clamps are required while bending the pipe to normal radii since the neutral axis is on the outer section of the pipe being bent. About two thirds of the pipe is in compression and pipe tends to expand along the centre of gravity thereby locking it into the radius of the die. Therefore, pipe cross section becomes flat at the centre of the bend as shown in Fig. 3.

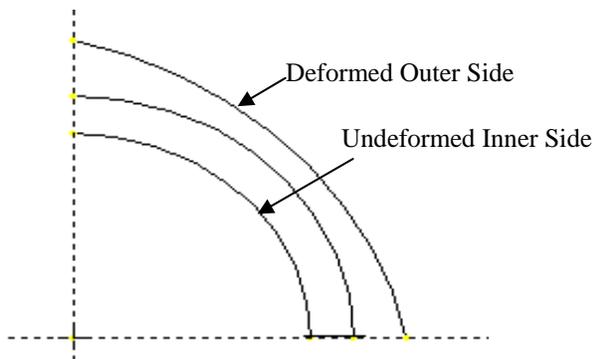


Figure 3 Deformation of the Pipe

3. MEASUREMENT OF PIPE DIMENSIONS BEFORE BENDING

A market survey is carried out to check the availability of pipes for bending. Out of various sizes and materials available, ten pipes are selected of three different materials. Their maximum, minimum diameters and thicknesses are checked before bending i.e. outside diameter (OD), inside diameter (ID) and wall thickness. These diameters are measured at two points 180° to each other with the help of digital vernier calliper. From these diameters, initial ovality and percentage ovality is computed and recorded in tables 1, 2 and 3.

4. MEASUREMENT OF PIPE DIMENSIONS AFTER BENDING

When the above ten pipes are bent on the existing rotary draw bender, major problem observed is that of the ovality of the pipe. Maximum and minimum diameters of these pipes are measured after bending with the help of digital vernier caliper and the values are recorded in tables 4, 5 and 6. From these values, percentage ovality and increase in percentage ovality after bending is computed and recorded in the same tables.

Table 7 shows average values of percentage ovality before bending and table 8 shows average values of percentage ovality and increase in ovality after bending

Table 7.

Average Percentage Ovality before Bending

Material	Low Carbon Steel Pipe	Galvanized Carbon Steel	Mild Steel
Nominal Dia. D	22.000	22.000	18.000
Max. Outside Dia. $D_{o_{max}}$	20.820	21.335	18.337
Max. Inside Dia. $D_{i_{max}}$	16.720	16.385	15.373
Wall Thickness	02.064	02.465	01.473
Min. Outside Dia. $D_{o_{min}}$	20.772	21.348	18.306
Max. Inside Dia., $D_{i_{min}}$	16.526	16.412	15.273
Wall Thickness	02.170	02.468	01.503
Ovality= $D_{o_{max}} - D_{o_{min}}$	00.240	00.169	00.270
% Ovality= $100 \times (D_{o_{max}} - D_{o_{min}}) / D$	01.158	00.730	01.480

Table 8.

Average Percentage Ovality after Bending

Material	Low Carbon Steel Pipe	Galvanized Carbon Steel	Mild Steel
Nominal Dia. D	21.669	21.360	18.320
Major Dia. D_{max}	24.081	24.634	20.665
Minor Dia. D_{min}	17.448	18.036	15.892
Ovality= $D_{max} - D_{min}$	06.633	03.299	04.773
% Ovality After Bending ($\%O)_b = 100 \times (D_{max} - D_{min}) / D$	31.583	15.920	26.050
Initial % Ovality ($\%O)_i$	01.158	00.790	01.480
Increase in % Ovality= $(\%O)_b - (\%O)_i$	30.428	30.583	25.018

5. CONCLUSION

From the above tables, it is clear that the pipes are available with variations in the diameter and wall thickness. Large amount of ovality is introduced during bending of the pipes on the existing mechanisms. It is of the order of:

- Average initial percentage ovality in the pipes before bending is in the range of 0.79 -1.48 %.
- 5 - 7 mm in a pipe with outside diameter of 22 mm and
- 4 - 5 mm in a pipe with outside diameter of 18 mm
- As compared to initial ovality of 0.79% – 1.158%, ovality increases to almost 30 % for outside diameter of 22 mm and with 1.48 % initial ovality for a pipe diameter of 18 mm, ovality increases to 25%.

Thus, bent pipe is almost flattened in the bent portion in the existing mechanisms, which reduces strength and aesthetics of the fabrication. This flattening or ovality of pipe must be controlled

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Table 1.
Dimensions of Low Carbon Steel Pipe and Percentage Ovality before Bending
(Nominal Diameter 21 mm)

Nos.	1	2	3	4	5	6	7	8	9	10	Average
Max. OD	21.04	21.05	20.74	20.65	20.81	20.73	20.71	20.65	20.62	21.20	20.82
Max. ID	16.44	16.64	16.61	15.90	16.86	16.66	17.20	17.13	16.57	17.20	16.72
Wall Thick(t)	2.3	2.305	2.07	2.105	2.10	2.415	1.925	1.995	1.71	1.715	2.064
Min. OD	20.54	20.53	20.81	20.71	20.54	21.26	20.48	20.65	20.45	21.25	20.772
Min. ID	16.48	16.38	16.55	15.93	16.32	16.58	16.65	17.13	16.46	16.78	16.526
Wall Thick.	2.065	2.165	2.165	1.995	2.665	2.08	1.90	2.06	2.55	2.06	2.17
Initial Ovality	0.50	0.52	0.07	0.06	0.27	0.53	0.23	0.00	0.17	00.05	0.24
% Ovality	2.42	2.53	0.33	0.29	1.32	2.46	1.12	0.00	0.83	00.24	1.158

Table 2.
Dimensions of Galvanized Steel Pipe and Percentage Ovality before Bending
(Nominal Diameter 21 mm)

Nos.	1	2	3	4	5	6	7	8	9	10	Average
Max. OD	21.51	21.32	20.37	21.02	21.17	21.43	21.35	21.54	21.27	21.37	21.335
Max. ID	16.44	16.45	17.04	16.11	16.27	16.28	16.33	16.27	16.44	16.22	16.385
Wall Thick.	2.535	2.435	2.165	2.455	2.45	2.475	2.51	2.635	2.415	2.575	2.465
Min. OD	21.11	21.15	21.57	21.32	21.08	21.44	21.38	21.54	21.65	21.24	21.348
Min. ID	16.10	16.56	17.12	16.18	16.41	16.42	16.38	16.28	16.34	16.33	16.412
Wall Thick.	2.505	2.295	2.225	2.57	2.335	2.51	2.50	2.63	2.655	2.455	2.468
Initial Ovality	0.40	0.17	0.20	0.30	0.07	0.01	0.03	0.00	00.38	0.13	0.169
% Ovality	1.90	0.80	0.93	1.42	0.34	0.04	0.14	0.00	01.78	00.61	0.79

Table 3.
Dimensions of Mild Steel Pipe and Percentage Ovality before Bending
(Nominal Diameter 18 mm)

Nos.	1	2	3	4	5	6	7	8	9	10	Average
Max. OD	18.04	18.30	18.02	18.47	18.64	18.36	18.32	18.28	18.52	18.42	18.337
Max. ID	15.38	15.17	15.32	15.27	15.40	15.48	15.52	15.38	15.48	15.33	15.373
Wall Thick.	1.43	1.435	1.49	1.375	1.535	1.58	1.42	1.47	1.4	1.595	1.473
Min. OD	18.52	18.05	18.01	18.22	18.34	18.17	18.25	18.54	18.06	18.90	18.306
Min. ID	15.38	15.27	15.18	15.27	15.24	15.08	15.48	15.37	15.04	15.42	15.273
Wall Thick.	1.57	1.39	1.415	1.475	1.45	1.545	1.535	1.585	1.51	1.55	1.5025
Initial Ovality	0.48	0.25	0.01	0.20	0.30	0.19	0.07	0.26	0.046	0.048	0.27
% Ovality	2.66	1.38	0.05	0.09	1.64	1.04	0.38	1.42	0.254	0.260	1.48

Table 4.
Dimensions of Low Carbon Steel Pipe and Percentage Ovality after Bending
(Nominal Diameter 21 mm)

Nos.	1	2	3	4	5	6	7	8	9	10	Average
Avg. Dia.	21.79	21.79	21.78	21.68	21.66	21.99	21.60	21.65	21.53	21.22	21.669
Max. Dia	24.29	24.15	24.11	24.08	24.13	24.03	23.98	24.07	23.93	24.04	24.081
Min. Dia	17.79	17.95	17.59	17.19	17.49	17.43	17.43	17.23	17.3	17.08	17.448
Ovality	6.50	6.20	6.52	6.89	6.64	6.6	6.55	6.84	6.63	6.96	6.633
%Ovality	30.95	29.52	31.04	32.80	31.61	31.42	31.20	32.57	31.57	33.15	31.583
Initial %Ovality	02.43	02.53	00.33	00.29	01.32	02.46	01.12	00.00	00.83	00.24	1.158
Increase In % Ovality	28.52	26.99	30.71	32.51	30.29	28.96	30.08	32.57	30.74	32.91	30.428

Table 5.
Dimensions of Galvanized Steel Pipe and Percentage Ovality after Bending
(Nominal Diameter 21 mm)

Nos.	1	2	3	4	5	6	7	8	9	10	Average
Avg. Dia.	21.31	21.38	21.47	21.17	21.13	21.43	21.37	21.54	21.46	21.30	21.36
Max. Dia	24.61	24.22	24.62	24.54	24.59	24.76	24.63	24.69	24.89	24.79	24.634
Min. Dia	18.41	18.42	18.12	17.50	17.75	18.10	18.07	18.39	17.65	17.95	18.036
Ovality	06.20	05.80	06.50	07.04	06.84	06.66	06.56	06.3	07.24	06.84	06.598
%Ovality	29.52	27.61	30.95	33.52	32.57	31.71	31.23	30.00	34.47	32.57	15.92
Initial %Ovality	01.91	00.80	00.93	01.42	00.34	00.40	00.14	00.00	01.78	00.61	00.79
Increase In % Ovality	27.61	26.81	30.02	32.10	32.23	31.31	31.09	30.00	32.70	31.96	30.583

Table 6.
Dimensions of Mild Steel Pipe and Percentage Ovality after Bending
(Nominal Diameter 18 mm)

Nos.	1	2	3	4	5	6	7	8	9	10	Average
Avg. Dia.	18.28	18.17	18.02	18.35	18.49	18.27	18.28	18.41	18.29	18.66	18.32
Max. Dia	20.34	20.98	20.47	20.95	20.82	20.08	20.84	20.66	20.8	20.71	20.665
Min. Dia	15.74	15.78	15.57	15.99	15.85	15.92	15.80	15.90	16.24	16.13	15.892
Ovality	04.60	05.20	04.90	04.96	04.76	04.88	05.04	04.76	04.76	04.58	04.773
%Ovality	25.16	28.62	27.20	27.02	25.74	26.71	27.57	25.85	26.03	25.54	26.05
Initial %Ovality	02.66	01.38	00.5	01.09	01.64	01.04	00.38	01.42	02.54	02.60	01.48
Increase In % Ovality	22.50	27.24	26.69	25.94	24.10	25.67	27.19	24.43	23.48	22.94	25.08