Torque Head for Pipe Straightening and Ovality Reduction

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ABSTRACT
In todays world of competition it is mandatory to produce accurate and precise product to enhance its performance. The automotive industries are running faster due to competition in the world of production and automation. Hence, each and every part of vehicle is to be manufactured with accuracy in given time. Silencer is an important part of exhaust system of vehicle; therefore its every component should be manufactured with accuracy. The straightness of pipe used for bike silencer is a key feature for improving structural integrity and enhance emission performance and acoustic performance. The torque head is twist removing and straightening mechanisum.The conventional straightening machine has 3-4 sets of roller and bulky in size which is not convenient for mounting of straightening machine. Similarly for particular diameter of pipe to be manufactured, a separate straightening machine is required. The torque head overcomes the above mentioned problems in which it makes the machine portable and reduces the wastage of time during installing, hence improves the productivity. Also the project can be installed in manually operated as well as automated lines. The full length contact of rollers with work piece straightens it as well as gives better surface finish. And the results shows that torque is able to reduce the ovality of pipe up to 2 to 3%.

Keywords — *Pipe straightening, Ovality, Twist Removing, Set of Rollers, Adjusting plates, opposite angle*

1. INTRODUCTION

Straightening machine has been built with various methods of driving the rolls. Some machine has a separate drive motor for each roll. Irrespective of the manner the rolls are driven it is important that all rolls revolve at the same velocity within about 1 to 2 rpm at maximum machine velocity. The various components and system joint together to form the working straightener, however the most important part of a pipe straightener is the set of work rolls, especially contoured to enable the machine to straighten tube of various diameters. Straightening machine is the finishing machine for the high frequency welded pipe mill line, which is used to straighten the pipes, estimate the stress and bend the pipes after forming and welding. A pipe straightener which uses parabolic upper and lower rollers in combination with hydraulic cylinders which apply pressure between alternate parabolic rollers such that the pipe is moved between the rollers the bends and twists are removed. By adjusting both the rollers(top and bottom) from a right angle with respect to the pipe up to approximately 45 DEG with the upper rollers adjusted in opposite angular relation to the lower rollers, pipe may become readily straightened. Straight pipe exhaust in a high performance exhaust system is such that it produces very minimum back pressure and can hence improve the top end performance of a racing engine. Apart from these headers they would also be fairly straight with perforated pipes lined with dampening materials which convert sound energy to thermal energy.

The pipe for silencer of vehicles are manufacture by cold rolling process, due to respective process of manufacturing the pipe gets twisted and ovule in cross section. Such twisted pipe is not suitable for the silencer of vehicles. The reasons of rejection are:

- Non uniformity in dimensions due to ovule shaped cross section.
- Poor structural integrity.
- Further processing may cause rejection from customer.

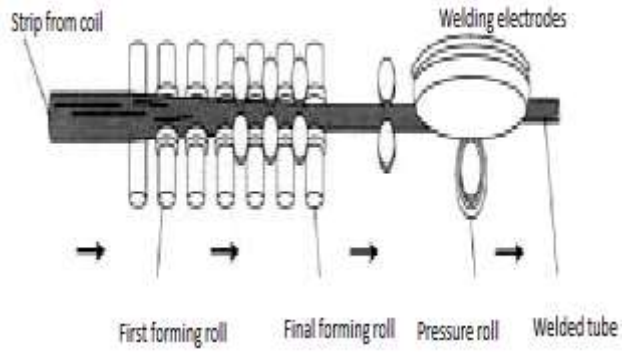

Fig.1. Pipe manufacturing process.

Hence to overcome these problems induced in pipe during manufacturing as well as removing twist, ovality and for straightening of pipe, the Torque Head is introduced which works on following aspects:

- To reduce the number of rollers

In conventional machine two to three sets of rollers are used but in this torque head we have used two numbers of rollers which are in vertically mounted. And we have facility to change the rollers according to the diameter of manufacturing of pipe.

- To make the straightening process portable

The other straightening machines which are bulky and sometimes it is not easy to move that machine from one line to another line. But this torque head i.e. twist removing machine is less bulky compared to conventional machining, which we can move to one line to another line. Also we have less effort to move that machine.

- To reduce ovality for uniform dimension

The ovality increases the non-uniformity in diameter. Due to the ovality the diameter changes at different sections. So to get uniform dimensions we required to removing twist.

- To remove the twist of pipe of varying diameter

In conventional machining system for particular diameter of pipe a separate machine is used for straightening of pipes but in this torque head machine variable diameter of pipe can be straight by using different diameter of rollers.

2. LITERATURE REVIEW

Author A.N.Brown, [1] had described the synergistic effect of the three straightening factors and the applied results of the clarified straightening conditions in actual operation. [6]The tube and pipe industries face many challenges that are requests for tube products in a wider variety of shapes and sizes by the end users, applications which require special materials, and which needs improved product quality from manufacturer to produce high quality tubing in a cost effective and productive way in today's marketplace. Different kinds of facts of manufacturing, processing, design, utilization, quality control, handling, cost and safety in tube and pipe production has been reviewed to present a general idea relating to these issues. Mangat, H.S., Kohli, G.S, [12] The paper experimentally investigate the anisotropic elastic properties of sheet metal and to find the satisfactory correlation between the strip widths, thickness to the diameter of steel pipe. The work has been concerned to investigate the variation in strip thickness, while forming the strip in a rolling mill for constant roller loads as well as constant line velocity.

A sample of 15 tensile coupon tests and 12 full section tests on VHS tubes were carried on . The tested VHS tubes have a diameter varying from 31.8 -75 mm with wall thickness varying from 1.6 -2.0 mm. The non-heat treated tubes were also tested for comparing. The ultimate strength to yield stress ratio of VHS tubes was compared with different cold-formed hollow sections as well as sheet steels and quenched/tempered steels. It has been observed that the VHS tubes fulfilled the material ductility requirement specified in the Australian/New Zealand Standard for Cold-Formed Steel Structures AS/NZS4600 [4]. Gerber [3] studied flattening effect by taking the plastic properties into consideration, although his investigation was relatively elementary. In the research of Kale and Thorat [8], the total energy which was utilized for the mechanical work done in bending, and some energy is stored as potential energy. Michael et al. [10] used the empirical formula to deal with the relationship between that bending moment and the sectional ellipticity of the thin-walled pipe under the plane bending condition.

Christo Michael et al. [19] carried out the a analysis considering the geometric nonlinearity to find out the collapse load equations for a semi-oval cross section under in-plane bending and also internal pressure, and compared them with the present elliptic cross sections to find out the suitability of the two assumed cross sections. However, the data charts as well as empirical formulas obtained from experiments and simulations are mostly targeted for specific vessels under specific conditions, with poor adaptability and portable generalization. Kawaljitsingh Randhawa, [18] Ovality in pipes is undesired phenomenon which should be prevented in early stages to avoid wastage of human power and to save the additional cost of manufacturing. It is also necessary to ensure the roundness of pipes before dispatching because oval pipes cannot be weld properly. For this purpose , expander machine and hydraulic press is useful. Expander is the best way to eliminate ovality from pipes with minimum time taken, minimum strokes and also with maximum efficiency.

K. Kawai, Y. Tatsuki, H. Kudo [5] invented the straightening method proposed for the curved shape near both ends of seamless pipe by using a rotary forming process with three rollers. A helical rolling mill which has three rollers was used in this experiment. The prebend aluminum seamless pipes were straightened under different working conditions. This straightening method will increase the yield of materials during the manufacturing process of seamless pipes. K. Kawai and Satake Y,[2] proposed a rotary straightening method by three rollers in an earlier paper. However, the pipe specimen was bent at the middle position along the axial direction, lb = 250 mm, in the previous experiment.

[20] In the over-bend straightening process of longitudinally submerged arc welding (LSAW) pipes, the cross section tends to be distorted due to the axial curvature variation in the reverse elastic-plastic bending. Based on the minimum work principle, a analytical model of the cross-sectional distortion of the curved pipe with initial curvature in the reverse axial elastoplastic bending is established, and the prediction error is not more than 10% compared with the experimental value of the maximum distortion coefficient. Compared to ovality, the maximum distortion coefficient with a smaller error can be used as an effective parameter of the analytical model to predict cross sectional deformation, suggesting that the circumferential fiber of cross section is compressed in the bending process, and the neutral layer length invariant assumption reduces the accuracy of the analytical model.

The pipe with a deformable cross section, possibly filled with structural foam, is bent in the elastic regime, and deduced the softening moment-curvature relationship applying the virtual work theorem to analyze the contribution of the foam core in preventing instability phenomena. Zhang et al. [15,16] proposed a simplified model of maximum cross-section flattening based on the energy approach, aiming at the continuous rotary straightening process, but the initial curvature was ignored in analytical analysis.

Masakazu Kato, Atsushi Hasegaw [11] invented that it was necessary for this straightener to correct the round bar shape of the product, widening its diameter from 17 to 80 mm more than the conventional diameter .To decide the proper setting of the roll gap, the roll skew angle and the rotation speed of both the rolls of the straightener, a simple 3-point bending model was applied on it , and the inside of the working straightener was observed by an infrared camera.This paper describes the synergistic effect of the above mentioned three straightening factors and the applied result of these straightening conditions in actual operation.

The effect of reducing the thickness on mechanical properties and spinning accuracy were experimentally investigated on 7075-O aluminum tube. A prototype spinning machine was successfully designed and manufactured. It has been seen that with augmentation of thickness reduction; the yield point strength, ultimate strength, crystal refining iand surface hardness, increase. In contrast, it has bad effect on growth of diameter, accuracy of geometry, surface roughness and percentage elongation of spun tube [9]. According to B. Somodi, B. Kövesdi,[17] during the measurements the longitudinal residual stress pattern of the analyzed cross-sections are investigated. The typical values of the residual stress patterns are studied in the function of the yield strength and the geometric properties of the tested cross-sections. The current test results are compared to the results of previous experiments

Jandera et al. [7] measured the residual stresses on one cold-formed stainless steel specimen using X-ray diffraction method. The commonly used method to determine the residual stresses is the sectioning technique, but the X-ray diffraction method enables the direct evaluation of the residual stresses through the material thickness as well. A total of 20 surface and two half through-thickness measurements are executed on the RHS specimen having the geometry of 100 × 80 × 2. The results of the measurements showed longitudinal compression residual stresses in the outer surface of the specimen. The maximum residual stress reached−300MPa in the welded zone and they were quasi-constant in another parts of the specimen.

Ma et al. [14] investigated the residual stress distribution of three different cold-formed specimens with a rectangular (H-series), a square (V-series) and with a circular hollow cross-sections. Residual stresses are measured using the section method. Longitudinal and transversal residual stresses are measured on three specimens with a cross-section geometry of H200 × 120 × 5 (rectangular), V120 × 120 × 4 (square) and S139 × 6 (circular). Based on the test results the membrane and bending stresses are separately determined for the rectangular and square hollow sections. Both test results proved that the maximum bending residual stresses can reach 80% of the material yield strength. The maximum value is measured next to the corner zone. According to A. V. Kale, H. T. Thorat [13], this work targets at design, development,

fabrication and use of equipment, this will produce pipe bends with better quality without sacrificing simplicity of existing equipment.

3. FINITE ELEMENT ANALYSIS

The basic idea behind the FEA method is to divide the body or region into a finite number of finite elements, connected by nodes, and obtain an approximate solution in terms of the temperatures at these nodes. These elements may be various dimensional it can be 1-D,2-D 3-D,. In this case, we are using FEA to evaluate and cheak the dimensions of some important parts of torque head like: 1]Horizontal plate,

2]Vertical plate

3]Shaft.

1. Horizontal plate

Horizontal plate is located between square block and vertical plate. Horizontal plates are used to adjust the center of torque head.

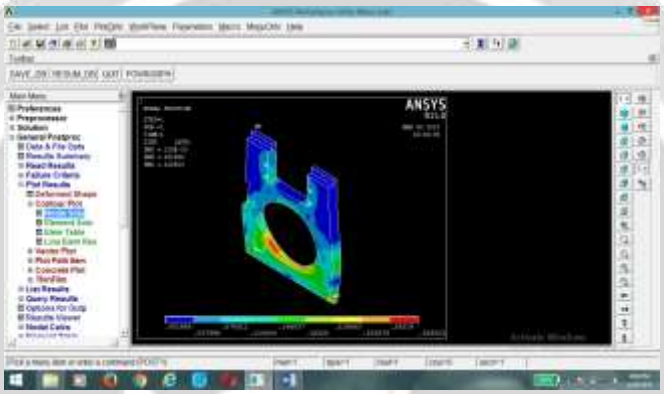

Fig.3.1: Stress Intensity in HSP

Horizontal plate is taken as 310mm× 250mm×24 mm. It is made up of Mild steel with theoretical allowable stress of 280GPA. And after using ANSYS, it gives analytical stress of 95GPA which is favorable and hence design of plate is safe for plate dimensions 310mm× 250mm×24 mm.

2. Vertical plate

Vertical plate is connected between vertical supporting plate and horizontal plate. It is used to adjust the pipe at center.

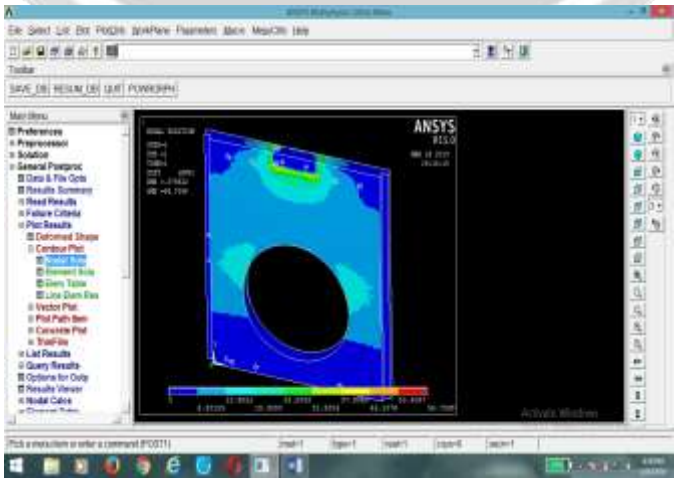

Fig.3.2: Stress Intensity in VSP

Vertical plate is taken as 352mm× 312mm×22 mm. It is made up of Mild steel with theoretical allowable stress of 280GPA. And after using ANSYS, it gives analytical stress of 145 GPA which is favorable and hence design of plate is safe for plate dimensions 352mm× 312mm×20 mm.

3. Shaft

Shaft is a power transmitting element.

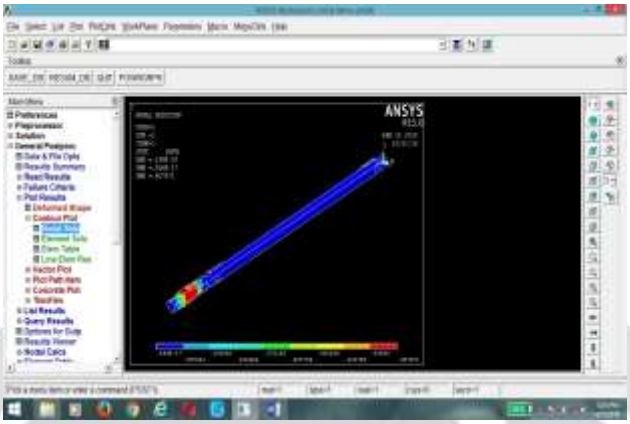

Fig.3.3: Stress Intensity in Shaft

Shaft is taken as 500mm length and 20mm diameter. It is made up of Mild steel with theoretical allowable stress of 280GPA. And after using ANSYS, it gives analytical stress of 55GPA which is favorable and hence design of plate is safe for plate dimensions of 500mm length and 20mm diameter.

4. CONCLUSION

With the help of newly developed Torque head machine, we can conclude that:

[1] We can adjust the center of pipe on a single torque head by giving the sliding plates adjustment which were not present in previous mechanism.

[2] This newly developed Torque Head machine has helped to cure the ovality of the pipe more accurately by using adjusting roller pair.

[3] By using adjustable roller pair, different size and shapes of pipes like circular, rectangular, square can be straighten on the same machine.

[4] Thus the machine has reduced the time of production, hence it is more efficient.

[5] The machine requires less floor space.

[6] Thus, it is concluded that the newly developed Torque Head machine is capable of reliably reducing the torque and ovality using more expensive machines, but at a fraction of the cost.

[7] On the basis of results, we can conclude that depending upon thickness and radius of pipe the ovality of pipe decreases by 2-3% within the tolerance limit.

[8] Also from FEA analysis, it is proved that the assumed dimensions and material selection is safe.

5. FUTURE SCOPE

The work has been real challenge to execute as there was many practical and cost problems. The torque head has great future scope for various applications like cold rolled, long components. The constraint of this device lies is slightly higher cost but advantage lies in its simple design and easy handling.

1) To reduce weight of torque head we can use medium carbon steel instead of MS Bright.
2) We can use sensors and actuations to avoid hourly checking of pipe ovality.
3) The project can be installed for manually operated line or even automated to improve productivity.

4) The full length contact of rollers makes this machine suitable for straightening and polishing to improve surface finish while being straightened.
5) Wide range of pipes that can be processed ranges from 25mm to 85 mm diameter.
6) 25-30 mm: For bikes.
7) Above 35 mm: For cars.

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