Design And Manufacturing Of Sheet Metal Straightener And Comparing Flatness Time With Hydraulic Straightener By Using Clustering Roller Arrangement.

Dr. Satish More
Prof.
Department of Mechanical Engineering
NMIET
Talegaon dabhade, India

Chinmay Rajendra Joshi
Student
Department of Mechanical Engineering
NMIET
Talegaon dabhade, India

Karan Ramesh Yadav
Student
Department of Mechanical Engineering
NMIET
Talegaon dabhade, India

Mallikarjun Shrishail Hebale
Student
Department of Mechanical Engineering
NMIET
Talegaon dabhade, India

Rahul Kashinath Chavan
Student
Department of Mechanical Engineering
NMIET
Talegaon dabhade, India

Aditya Sheetal Admuthe
Student
Department of Prduction Engineering
VIT
Bibwewadi, India

Abstract— Flatness plays an important role in sheet metal straightener. Sheet metal machine uses to removed curl, gutter, and unwanted bend in product. Straightening machine has been built with number of rollers. Few important factors which are really affect flatness are roller size, pitch of the roller, residual stresses, speed, feed of the material, proper alignment of roller etc. To achieve flatness in the product we have to consider all the factor and work accordingly. We can achieve flatness of sheet metal have size up to 1 – 10mm thickness where on the basis of our research of market no product is available in the same amount so that's why by developing this product, we can achieve more productivity and reduce the cost of project.

Keywords—Flatness, Sheet, Straightening, Roller, Gear, Cluster roller, Material.

I. Introduction

A sheet metal straightener is a vital machine used in the manufacturing and fabrication industry to flatten and straighten mild steel sheets. These sheets often acquire bends, warps, or curls during various manufacturing processes, handling, or transportation. The purpose of a sheet metal straightener is to rectify these deformities, ensuring the steel sheets are flat and uniform, meeting the required quality standards.

The straightening process involves feeding the bent or curled steel sheets through sets of rollers or levelling mechanisms within the straightener. These rollers apply pressure and manipulate the metal to remove any distortions, creating a smooth, straightened surface. The leveler's adjustments, such as roller gaps, pressure, and configurations, can be tailored to suit various thicknesses and types of mild steel sheets.

The key components of sheet metal straightener include: -

1. Rollers or levelling mechanisms: These are the primary components that physically manipulate the metal sheet to remove bends and curls.
2. Frame and structure: The machine is built with a robust frame to support the rollers and withstand the pressure exerted during the straightening process.

- Cluster roller arrangements consist of multiple small diameter rollers in close proximity. This setup allows for more localized pressure application, resulting in precise and targeted straightening of the sheet metal.
- Design and construct a sheet metal straightening system that utilizes a single motor-driven roller configuration, with a focus on simplicity and effectiveness.
- Enhance the precision of the sheet metal straightening process to ensure that distorted and uneven sheets are corrected to meet quality standards.
- Create a cost-effective solution by simplifying the system's design, minimizing maintenance requirements, and reducing setup times. Implement advanced automation and control systems to enable precise, consistent, and efficient sheet metal straightening operations.

Krishna Jadhav et.al [1] in this paper Design and Development of Strip Straightening machine and also provided design calculations of sheet metal and roller for two roller mechanisms.

V.N.Shinkin [2] in this paper present that reduction of curvature and bend is also depend on working roller diameter, distance between two roller named as pitch of roller as well as number of roller. This paper considers detail methodology about determining forces shaft support reaction, bending moment as well residual stresses acting on steel sheet.

Arithmetical method for calculating bending moment, curvature as well as reaction of working roller of straightening machine is proposed and it shown that arithmetical method is better than korolev method.

Markus gruber et.al [3] in this paper working roller intermesh and residual stresses is evaluated to achieve constant flatness.

Ibiye Roberts [4] This paper main goal is to improvement of lever arrangement. Shape correction is very important in industries for achieving more flatness use lesser diameter of roller. In this study using industrial data and validate data with mathematical modal. This paper focus on importance of correct leveler setting.

V.B.Sarode et.al [5] in this paper presented a modification in straightening machine to overcome from the problem of tube not being straightened below 88.9mm due to less contact area because of misalignment and eccentricity of roller and pin. This paper focus on importance of roller engagement and pin because misengagement leads to improper distribution of pressure applying on roller leads to produce uneven bend in the tube. To overcome from this problem in place of changing component author design a pin which is match the center of upper roller and lower roller.

A. V. Barabasha et.al [6] in this paper determining the parameters of sheet straightening takes account of the flexure of the working rollers and its influence, the waviness. The method is based on the combination of a model of sheet straightening and regression equations getting by finite element modeling.

E. A. Maksimov et.al [7] in this paper the mainly focus on parameters such as metal deformation on the rollers during bending process, temperature generation while straightening, etc.

Dr. Biju B [8] in his paper we get design and analysis of straightening mechanism for sheet metal steel bar.

Yi Yali [9] in his paper three roller arrangement of straightening mechanism is given as well as design of three roller arrangement is done. The mechanism of equivalent curvature straightening and standstill-locking after three rolls large plastic deformation is revealed.

Wang Yongqin [10] the paper presents the Evaluation of straightening capacity of plate roll straightener. In his paper straightening capacity of machine or model is proposed and there is a much better consistence when the simulation result is compared with the statistical data.

II. METHODOLOGY

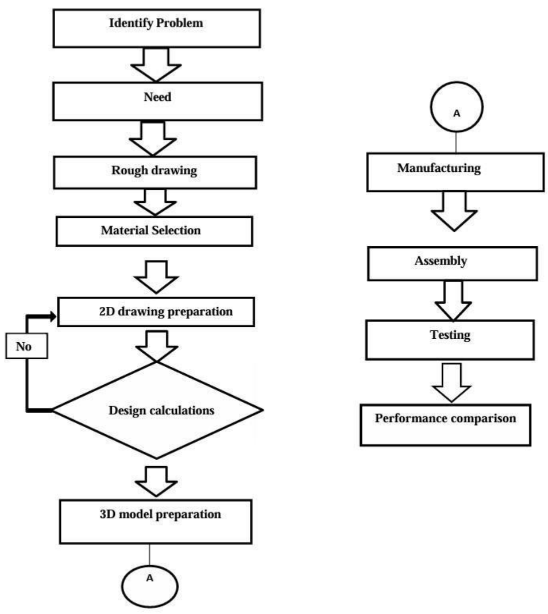

Chart No. 1. Methodology

III. MATERIAL SELECTION

A. EN19 spur gear material

EN19 is a high-quality alloy steel known for its excellent tensile strength and toughness. It's often used in applications requiring high-strength components, such as gears, axles, and shafts. When selecting EN19 steel for use in a spur gear, various factors should be considered:

1. Strength and Toughness: EN19 steel offers high tensile strength and good toughness, making it suitable for gears subjected to heavy loads and high stress.
2. Wear Resistance: While EN19 steel is strong, it might not possess the highest wear resistance by default. Surface treatments like carburizing, nitriding, or specific coatings can enhance the wear resistance of the gear teeth.
3. Machinability: EN19 steel, being an alloy steel, might have a moderate to good machinability, enabling the fabrication of intricate gear teeth profiles. However, it might be more challenging to machine than some lower alloy steels or carbon steels.
4. Heat Treatment: Heat treatment processes like quenching and tempering can be applied to EN19 steel to optimize its mechanical properties. This can help enhance hardness, strength, and wear resistance.
5. Cost Consideration: EN19 steel, being a high-quality alloy, might be more costly compared to lower-grade steels. Consider the trade-off between its performance benefits and the cost involved.
6. Corrosion Resistance: While EN19 steel offers good strength, it might not be highly corrosion-resistant. Therefore, consider the environmental conditions in which the gear will operate and apply appropriate coatings or maintenance to prevent corrosion.

ELEMENT	OBJECTIVE
Tensile Strength	655 MPa
Yield Stress	415 MPa
Elongation	25.70%
Modulus of elasticity	215 000 N/mm²
Hardness	197 HRC

Table No. 1. EN19 Spur Gear Material

B. EN31 roller material

When selecting a material for rollers used in a sheet metal straightener, various factors need consideration. EN31 is a high-carbon alloy steel known for its excellent wear resistance, toughness, and high strength. When applied to rollers in a sheet metal straightener, the following considerations should be taken into account:

1. Wear Resistance: EN31 steel offers good wear resistance, which is crucial for rollers in a sheet metal straightener that continually come into contact with metal surfaces. This helps to ensure longevity and durability.
2. Strength and Toughness: EN31 steel provides high strength and toughness, essential for withstanding the forces and pressures involved in the straightening process without deforming.
3. Surface Finish: The surface finish of the rollers is critical to prevent damage to the sheet metal. A smooth surface, achieved through precision grinding or polishing, can reduce the risk of scratching or marring the metal.
4. Corrosion Resistance: EN31 steel is not particularly known for its corrosion resistance. If the operating environment involves exposure to moisture or corrosive elements, additional coatings or maintenance procedures might be necessary to prevent corrosion.
5. Heat Resistance: Depending on the straightening process, EN31 steel may need to maintain its properties at high temperatures. Heat treatments can be applied to improve its resistance to heat and maintain its performance under elevated temperatures.
6. Cost Consideration: EN31 steel, being a high-quality alloy, might be more expensive. Balancing the enhanced performance benefits with cost considerations is crucial.

ELEMENT	OBJECTIVE
Tensile Strength	750 N/mm²
Yield Stress	450 N/mm²
Elongation	30%
Modulus of elasticity	215 000 N/mm²
Reduction of area	45%
Density	7.8 Kg/m3
Hardness	63 HRC

Table No. 2 EN31 Roller Material

IV. Design and Fabrication

A. Spur gear calculations

Pitch (P) = N / D
= 30/75
= 0.40 mm

Outer diameter (OD) = (N+2)/P
=(30+2)/0.4
= 80mm

Addendum(A) = 1/ P
= 1/0.4
= 2.5 mm

Dedendum (B) = 1.157/P
=2.8925 mm Root diameter (RD) = (N-2)/2
= 30-2/P = 28/0.4 Root diameter = 70 mm

Base circle diameter = D×COS(P*A)
=75cos×(0.4×2.5)
=74.98mm

Circular Pitch (PC) = (3.1416 × D)/N
=3.1416 × 75/30
= 7.854 mm

Module =D / N
=75 / 30
=2.5 mm

B. Roller calculations

Strip tensile strength σ T =440 N/mm^2
σ T =F/a 440=F / L×B
440 =F/200×50 F =4.4×10^6 N

Tensile strength of roller σR =750 N/mm^2 σR = F/A
750 = 4.4×10^6 / (π/4) ×D^2
Dr =76.78
Approximate=80mm

- Assembly View

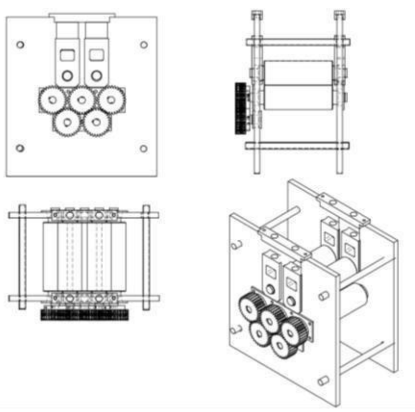

Figure No. 1. Assembly View

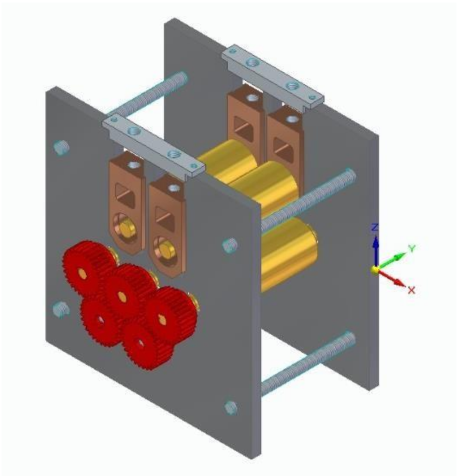

Figure No. 2. CAD Drawing

C. List of components

1. Framing: - Framing is the main structure of the machine which can hold weight of all assembled components.
2. Rollers: - Rollers are used to straight the sheet of thickness up to 10 mm.
3. Spur gear: - Spur gear are used to transmit power from Hp motor to roller.
4. Keyway: - Keyway is used to hold the roller and spur gear assembly.
5. Housing: - Housing is the component used to adjust the distance between upper rollers and lower rollers.
6. Housing Clip: - Housing clip hold M20 boult for adjustment of hosing.
7. HP motor: - HP motor is used to convert electric energy into mechanical energy by using spur gear arrangement.

D. Fabrication

1. Framing manufacturing

- Framing of sheet metal straightener is play an important role, framing is used to mount assembly parts as well as to hole or to stand the machine in proper position.
- Framing is made up of 16 mm thickness to hold the load of whole assembly of machine.
- Framing is cut in proper dimension is done by using laser cutting operation.

Figure No. 3. Framing Manufacturing

- Laser cutting is done by advanced operational machine which has accuracy up to 0.05 mm.
- Laser cutting give accurate surface finish as well as the hole of 47 mm diameter is properly finished as this hole required to fit with standard bearing size.

2. Roller manufacturing

- Roller is made up of EN31 material, manufacturing of roller is done by using advanced automated lathe machine.
- Roller diameter is maintained 80 mm and the 40 mm diameter up to length 16 mm is for free rotation of roller while connected with bearing is provided.
- At the end of roller 20 mm diameter up to length 40 mm is provided to connect with spur gear.

Figure No. 4. Roller Manufacturing

- Keyway slot 6x3x39 mm is provided to roller for strong contact between roller and spur gear.

3. Spur gear manufacturing

- Spur gear is made up of EN19 material, manufacturing of spur gear is done by advanced VMC Machine.
- As per design outer diameter of spur gear is maintained 80 mm and inner diameter is 20 mm, number of teeth is 30.
- Proper finishing of teeth is achieved by using this VMC machine

Figure No. 5. Spur Gear Manufacturing

V. Result

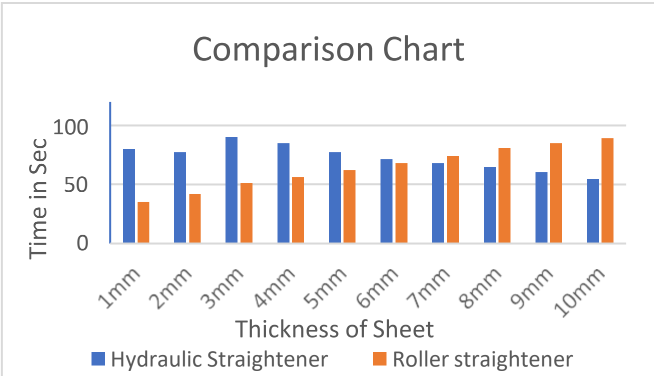

Chart No. 2. Comparison Chart

VI. Conclusion

Sheet metal straightener is able to flat the mild steel strip between thickness 1mm to 10 mm with high precise and in better tolerance. as compare to hydraulic straighter it is able to flat less than 5 mm sheet faster that hydraulic.
With in 3 to 4 pass the sheet will get proper flat as required for further process of sheet metal components.

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