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"AN EXPERIMENTAL ANALYSIS OF SHEET STRAIGHTENING MACHINE"

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Abstract

In today's world every industry wants quality in their product, accuracy and precision is essential in component to increase production rate. Many industries demand increase day by to achieve flatness in component. To fulfill company needs straightening method is used. Roll straightening method is forming process which is used to remove flatness defect such as waviness, curl, unwanted bend as well to reduce residual stress. Straightening machine having number of rollers, component is subjected to cyclic tension compression deformation for achieving flatness without affecting its dimensional geometry. In this project a 25 roller straightening machine is develop to straighten product. Many straightening machines are available in market but this machine specially develop by considering geometry of product. Mostly in industry straightening is done manually by using hammer but this method is mind-numbing method & time consumable as well as produce unpleasant noise. This paper gives an idea about important factor such as selection of material, roller diameter, and pitch of the roller, roller pressure setting for developing such type of straightening machine. An experimental analysis is carried out by developing straightening machine and this machine is used in industries.

Key word: strip straightening machine, working rollers, flatness, straightener, pressure setting, and methodology.

I. INTRODUCTION

In industry sector an increasing demand of flatness of component and Straightening machine is use to straighten different type of metal object like rope, pipe, plate, angle plate, sheets as well as different shape of component. In this project a part used in engine named as gasket is under bending deformation during shot blasting process in horizontal roller machine as well as improper handling. To achieve Flatness usually Company uses hammer method but this method mind-numbing and production is in large quantity hammer method time consumable so to achieve target as well to fulfill quality requirement designing a system named as **straightener** which is sponsored by SAI AUTOMATION. Straightener can effectively eliminate error like bending, curl, and uneven surface as well as reduce residual stresses. Straightening machine having number of roller, pressure is apply over an upper roller, a component is to be passed between two set of roller. Straightening machine having number of parts like working rollers, bearing, gear, pinch roller, spring, frame, motor, gear box etc.to develop

such type of machine line of action is necessary. This paper gives a brief idea about development of such type of machine.

II. LITERATURE REVIEW

Zhifang liu et.al (1) in this paper authors using curve integration method developed optimization model for plates with varying characteristics. This paper represent importance of working roller intermesh adjustment for levelling of plate, it signify relation between roller intermesh and plate characteristic such as yield stress and young modulus. The optimization intermesh model using nine roller for different plate is solved and compare with production data.

E. A. Maksimov et.al (2) this paper describe about method of arrangement of roller namely horizontal and inclined method. In this paper determining curvature of reverse bending of sheet and intermesh between the rollers by different arrangement of roller. Mathematical model is proposed, and experimental straightening of sheet perform on 7 roller straightening machine, numerical data is compare with experimental data and concluded that proposed model gives acceptable result.

Cui li et.al (3) researcher investigate on deformation characteristic and residual curvature of longitudinal profile plate by elastic-plastic differences. This paper represent connection between longitudinal profile plate thickness and intermesh of working roller as well as effect of thickness, incoming flatness and yield strength on residual curvature. As the plate thickness increases entry intermesh should be reduce from that we can conclude small intermesh selected for symmetrical curvature.

Xiaogang Wang et.al (4) conduct research on combination leveler for medium and thick plate. Geometrical and FEM analysis done on 15 roller combination leveler. In this combination leveler parallel leveling system used include variable size of roller with variable pitch of roller which improve levelling quality and gives leveling strength to the plate. MARC software use for simulation of combination leveler.

Krishna Jadhav et.al (5) presented straightening process for wheel rim for a variety of vehicle. In this paper author present calculation for determining roller diameter for semi operated straightening machine. Presented nine roller system which is commonly used and it also gives an idea about selection of material for different component.

Jong-Bin Lee et.al (6) proposed numerical modelling of roller leveler for thick plate. Using three bending method presented a relation between roller intermesh and curvature. This paper is also introduced correction factor and also represent relation between radius of curvature and stress distribution. MARC software used for FEA to verify the proposed numerical model.

III. METHODOLOGY

Demand of flatness is increasing day by day to remove unwanted bend in product company focus on quality of product. Now a days to achieve flatness straightening machine used. A one of the leading company facing problem in their product during shot blasting process. A below figure shows a product used in engine named as gasket to be flatten. To solve this issue designing an effective straightening machine. A below figure shows a sample bend product for flattening.

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Fig.1 shows an uneven straightening product

CALCULATIONS FOR ROLLER:

σ_t = 565 N / mm^2 ……..Product material

T = 5 mm

σ = 850 N / mm^2 ……Roller (EN24 MATERIAL)

PERIMETER (P) = 2 x {L+W} = 2300 MM

$\sigma_t = \frac{F}{P \times T}$

$_F$ = 6.49 x 10^6N

F = 6.49 x 10^6 + 2.59 x 10^6 …… (Consider 40% FOS)

TOTAL FORCE (F) = 9.08 x 10^6 N

DIVIDE TOTAL FORCE BY NUMBER OF WORKING ROLLER

F = 908.6 x 10^6 N

$\sigma = \frac{F}{A}$

A = 1068.94 mm^2

D = 36.89 mm ≈ 40 mm

IV. EXPERIMENTAL ANALYSIS

Fig 2. Shows strip straightening machine

An experimental analysis is carried out on straightening machine. Above figure shows a twenty five rollers with roller size of 40mm straightening machine with an accuracy of ±0.2 MM which is manufactured in SAI AUTOMATION. All the three component shown in figure are tested over this machine and achieving flatness. In this machine simple gear train system is use for transmitting motion. This straightening machine is fully mechanical operated system. A pressure over pinch roller is given by spring. A function of pinch roller at inlet is to pull the object and removing an error. A reduction gearbox is used in this system with motor.

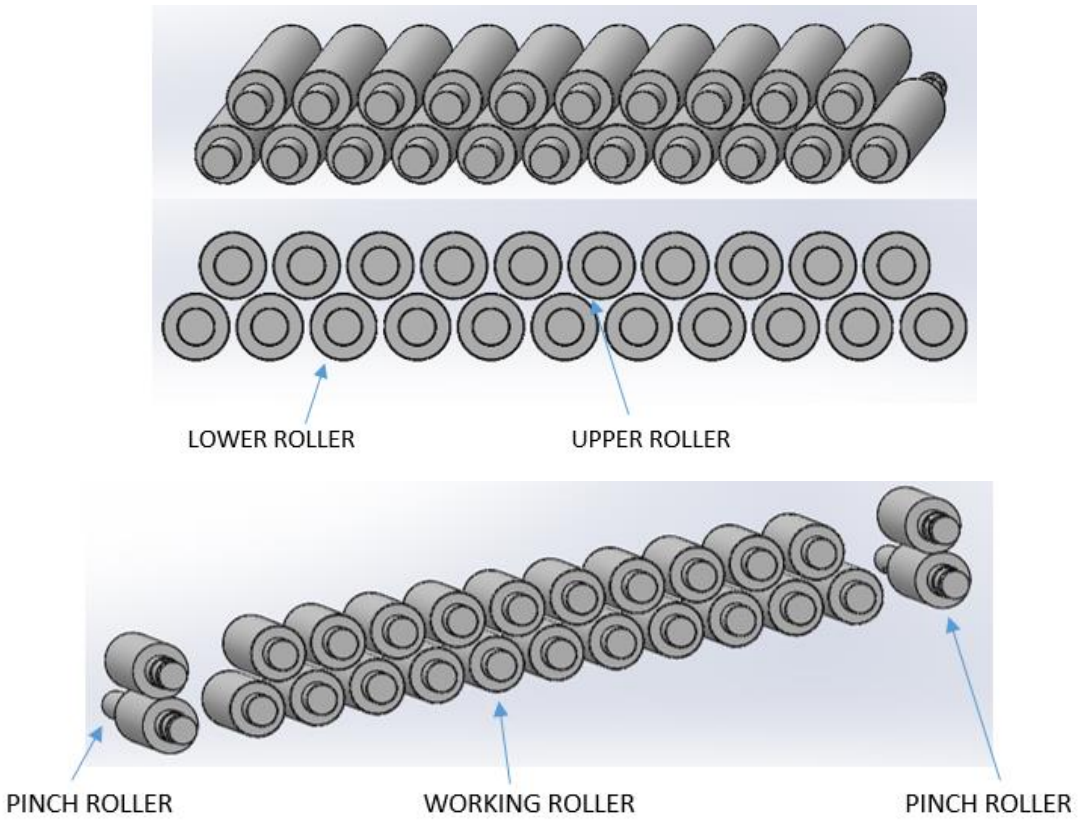

Fig 3 & Fig 4. Shows position of the working roller

Above figure shows position of working roller of straightening machine. This straightening machine achieving flatness by five point pressure system by maintaining an intermesh between upper roller and lower roller. This machine having twenty five rollers from that ten upper roller, eleven lower roller and four pinch roller with maintain pitch distance between rollers.

For straightening purpose to achieve required flatness three number of trial is to be taken in each trial every type of product with a set of twenty number of piece used, in first trial we are using four number spring which is placed at four corner of middle pocket to lift upper roller set and two point pressure setting system at middle of pocket and giving intermesh setting of 0.4mm. From this experiment we can see that from set of 20 almost 5-6 product getting straight and sometime strip is getting bent in upper direction side because of more pressure producing at the middle part.

In trial second, after conducting research we change the position and in this trial we are using four spring to lift middle pocket at middle part and four pressure setting system at each corner of the middle pocket and giving intermesh setting of 0.5mm. By using this setting we conduct trial and we can see that from set of 20 piece 10-14 product getting good response removing a bent of 40 mm but flat strip is not getting flatness, 0.8-1mm deflection in final product.

In third trial, to achieve more accuracy in product and removing a bent we again conduct a research and refers a paper which is related to pressure setting and we provide 2 spring for lifting a middle pocket at required intermesh of roller 0.8 mm and giving five point pressure setting, in this four point at each corner of the middle pocket and one point at centre of the pocket in between two springs using this method we achieve required flatness 0-0.2 mm in all the three product out of 20 piece 18-20 piece getting flatness. From that we can conclude this method is effective and successfully achieve flatness.

No.of trials	Intermesh of roller	Approx accepted product out of 20	Deflection (mm)
Trial 1	0.4	5-6	1+
Trial 2	0.5	10-13	0.7-1
Trial 3	0.8	18-20	0.1-0.2

Table 1. represent summary of all conducted trial

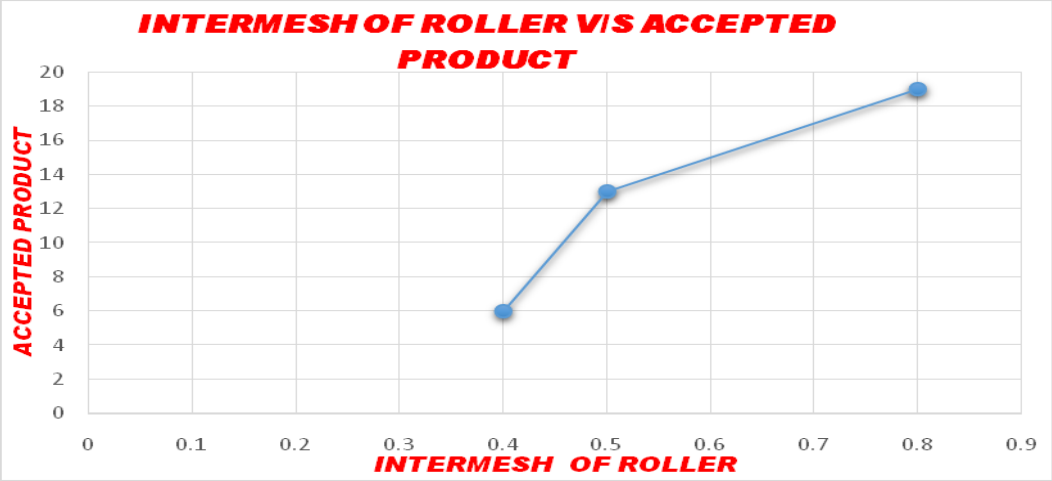

Fig. 5 Represent graph of intermesh of roller v/s accepted product

Above table.1 define overall summary of all the three trial and fig.5 shows a relation between intermesh of roller and number of accepted product in all the three conducted trial. Out of three trial we are getting accuracy in third trial. After that all the three product with a sample of 500 each is to be tested and all the product is within range.

Fig 6. Shows three product after straightening

Fig 6. Shows uneven product after passing between rollers, a part will be in tension-compression condition and at the end require flatness will be achieve. A 500 sample of each component is to be tested in this machine and in single paas achieving required accuracy of 0.1-0.2mm.

After referring a lots of research paper from that it's to be seen that for developing such type of straightening machine we have to study various of parts like roller, power transmission system, bearings, selection of motor and gearbox etc. All the study are interlink with each other during designing one question arise from where should I start first? And similarly this question came in mind of people who start designing such type of machine. To answer the question as well as to save time of people a simple procedure is presented below from referring paper as well as by performing an experimental analysis and getting a good result after conducting a number of trials proposed a methodology

Procedure for developing sheet straightener is given below-

- Determine dimension of component to be flatten, for calculating roller diameter as well as define its material properties of component.
- **SELECT WORKING ROLLER MATERIAL**- A proper working roller material is necessary. Basically EN-8, EN-24, EN-31, die steel material are available. But mostly EN-24material is preferred from economical point of view and easily available for developing a machine. Depending on component material we can select roller material.

- **DETERMINE WORKING ROLLER DIAMETER-** Main component of straightening machine is working roller, determining a roller diameter using below formula,

$$\sigma_t = \frac{F}{P \times T}$$

Where,

σ_t = Tensile stress of component

F = force

P= perimeter of component

T = thickness of component

Using this above formula we can determine force and using this value of force in below formula to determine diameter by considering 40% factor of safety.

$$\sigma_t = \frac{F}{A}$$

Where,

σ_t = Tensile stress of roller

A= area of roller

F = above calculated force + 40% factor of safety

- **DESIGN OF SPRING-** Designing of spring to achieve flatness, we have to apply pressure on roller in radial direction for that purpose generally use spring.
- Determine how much force exerted on roller for straightening, in that consider pressure given by spring as well weight of roller and other component.
- **DETERMINE SPEED OF ROLLER REQUIRED-** Depending on cycle time for straightening a part as well as we have to find that up to which speed we can achieve straightening because straightening factor is also depend on speed of roller.
- **DESIGN OF BEARING-** To transfer motion and reduce friction bearing is used in straightener. First part is according to application select which type of bearing is suitable, generally needle bearing is to be selected to control roller end play, then determine bearing calculation, and select bearing from catalogue.
- **DEIGN OF GEAR-** For power transmission purpose from one roller to another we have to design a gear, spur gear is used because spur gear are cost effective and reliable.
- **DESIGN OF KEY-** Key is an element which is used for connecting transmission shaft and rotating element like motor. For transmitting power we connect gear with roller by using key, in industries mostly square key is preferred.
- **SELECTION OF MOTOR-** Determine how much power is required for straightening machine as well as select which type of motor is suitable.
- **SELECTION OF GEARBOX-** Speed is to be consider as main factor in straightening machine to achieve required speed we have to select gearbox.

- **DESIGN OF CHAIN AND SPROCKET-** Transmitting a power from motor to working roller generally chain drive is used. For that we have to calculate and determine which type of chain is select, number of link required and also design sprocket for selected chain.
- **PNEUMATIC CYLINDER-** For semi-automatic system we can use pneumatic cylinder. Selection of pneumatic cylinder for giving perpendicular motion to upper roller as well as maintaining a gap between upper and lower roller. Intermesh is main property for achieving proper straightening.
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V. CONCLUSION

This paper gives an idea about straightening machine development. In this explaining straightening mechanism along with that gives a brief description about procedure for development of straightening machine, material selection criteria, five point pressure system which is helpful for achieving more flatness as well as how to determine working roller diameter. By conducting three trial at different intermesh as well as pressure setting with maintaining a proper pitch of the roller which may lead to straightening of product. This procedure is proven by experimental analysis with all three component with an approx. of 500 sample and the result state that moderate pressure setting is main factor for achieving required flatness in the component. Using this system we can achieve 40-45 piece/min and this machine is boon for costumer for solving their problem.

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VI. BIOGRAPHIES

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