Optimization of Pipe Chamfering: A Portable Approach

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Abstract — Generally, for welding operations in maintenance. And manufacturing we use chamfering machines but still we. Are using manually operated chamfering machines and for. Every operation we have to perform requires human setup. Noise: This manual interference is more time-consuming. Consuming and having more opportunities for physical injuries to occur. Human labor in close proximity to it. The primary objective of this paper is to. Compile a list of all potential approaches for automating the task. Operated chamfering machines to automated chamfering. Machine, enhance efficiency of them and diminishes human. Disturbance during the functioning of the equipment. This paper presents the conclusion of our result. Various previously employed techniques for sharpening chamfers. Machine are talked about. Analysis has is done considering. Exploring Different Methods and Discovering a New Approach Procedure that will be useful for the execution of beveling. Machine by utilizing hydraulic mechanisms. In this endeavor we are. Producing the portable chamfering device. Which can fit in pipes of different sizes, the project will. The main components of the system are divided into two parts, with the first part being the installation of the mounting. The spring-loaded machine should be able to set. The second part of the system is mounted on a variable pipe diameter. And creating the rotating device for grinding the surface. That chambering in various angles should be feasible. The: Machine has been designed with mathematical precision and precision to ensure safety. Cad model is developed for ease of manufacturing.

Keywords: Grinder, Improvement of Chamfering Machine, Precision in Beveling, Minimized Time

I. INTRODUCTION

The industrialization is progressing towards mechanization and digitization. In this era of automation, which is broadly defined as the use of technology to perform tasks that were previously done by humans. Automation of labor through mechanical power. Uses of Production. Chamfering is one of the many. Overview of Pipeline Manufacturing Processes. In: The manufacturing sector has many small-scale enterprises Medium-sized enterprises are those that carry out this activity Operation and as per the requirement or customer. For: Many industrial applications utilize round pipe welding. To be beveled using various tools. This: Manufacturing for large-scale consumption requires time and manpower. Of the sector. To minimize the time consumption and. Energy usage of employee created and. Created: Round Pipe Chamfer Machine.

II. LITERATURE SURVEY

Chamfering is an important machining operation employed. In numerous industries to prepare pipe edges for welding. Increase compatibility, and enhance structural integrity. With: Time, various methods have been evolved to automate and streamline. Automate this process from manual to semi-automated. And automated systems. In the past, chamfering was executed manually by hand. With the use of portable grinders, which involved. A Lot of Effort and Time Invested. Although successful, the result was achieved manually. Chamfering presented issues such as inconsistent quality. End, fatigue, and increased probability of Workplace accidents. The requirement for improved productivity and performance. The invention of mechanized chamfering was prompted by the need for safety. Machines that generated more precise and uniform. Historically, chamfering was performed manually by hand with the use of portable grinders, which involved considerable labor and time. Although successful, manual chamfering presented problems like varying quality of finish, operator tiredness, and higher likelihood of workplace accidents. The need for better efficiency and safety prompted the invention of mechanized chamfering machines that produced more accurate and consistent results. A number of studies have investigated automation in chamfering. Kotkar et al. (2014) presented an automated pipe beveling machine to minimize human interaction, with a view to improving efficiency. Likewise, Liu et al. (2018) discussed the implementation of CNC- based control systems in chamfering, emphasizing how automated systems improve accuracy while reducing human error. Recent developments in industrial automation, such as hydraulic and pneumatic systems, have further enhanced chamfering accuracy and minimized processing time.

Even with these developments, current chamfering solutions remain limited in terms of adaptability to various pipe sizes and portability in small industries. Filling these gaps, this study introduces a portable industrial pipe chamfering machine with an adjustable mounting system and a rotating grinding mechanism. Through the incorporation of a spring-loaded self-adjustment mechanism and a lead screw-driven control system, this design maximizes efficiency while providing consistent chamfering for various pipe sizes.

With its foundations in earlier work and combining advanced automation methods, this research proposes to design an affordable, versatile, and operator-friendly chamfering machine suited to industries in need of precision edge preparation.

III. METHODOLOGY

The designed industrial pipe chamfering machine is intended to improve efficiency, precision, and safety in the process of chamfering.

The machine comprises a number of major components, each of which plays an essential role in providing smooth operation and flexibility in dealing with various pipe diameters.

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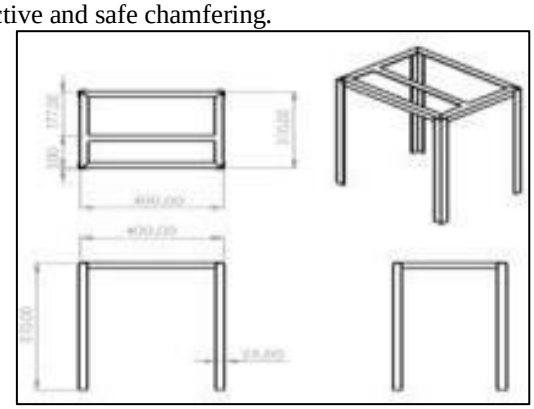
A. Frame

The frame is the main structural support of the chamfering machine, providing stability and accuracy in operation. It firmly holds all mounted parts in position, reducing vibrations and misalignment. Built to last, it offers a firm base for effective and safe chamfering.



B. Chamfering Tool

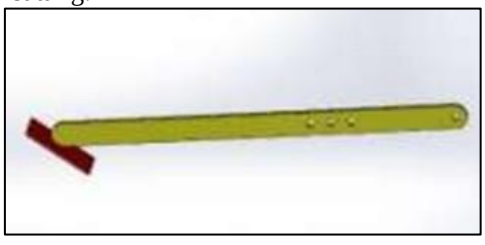
The handheld grinder can be used as a chamfering tool where flexible chamfering is required. It is fixed on a adjustable system allowing for exact material removal through different angles.

C. Lead Screw Mechanism

The lead screw provides exact movement of the chamfering tool over the workpiece. Using concepts of lathe machine operations, this mechanism provides accurate positioning and consistent chamfering.

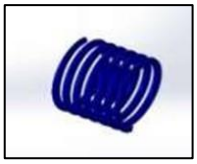
D. Movable Arm

The adjustable arm gives support to the pipe as it is being chamfered. Having a gripper-type system, it holds the pipe firmly in position, resisting vibrations and maintaining uniform cutting.



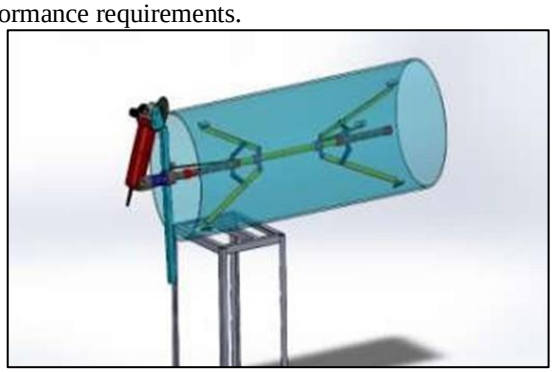
E. Sleeve and Compression Spring

The sleeve mechanism of the spring-loaded type accommodates different sizes of pipes automatically. The compression spring exerts the force required to keep a tight grip and make size adjustments automatic without human intervention.



F. CAD Modeling and Design Validation

A CAD model was created to visualize assembly of the machine, check dimensions, and make it manufacturable. Virtual testing was done before fabrication to assess strength and to ensure that all parts are compliant with safety and performance requirements.



IV. Design Calculations

For guaranteeing the structural integrity, stability, and effectiveness of the chamfering machine, essential design calculations were undertaken:

A. Robot Shaft Design

The shaft accommodates the grinder and its mounting, which necessitates adequate strength and stiffness.

For a given shaft length of 1220 mm and load of 10 kg, the bending moment (M) can be calculated as follows:

- M= W X L
- The shaft diameter= 20 mm
- M = 98 x 586 = 57428 N-mm
- $Z= \pi/32 \times d^3$
- $Z= \pi/32 \times 20^3$
- $Z= 785\ mm^3$
- Induced bending stress:
- σb (induced)= M/Z = 57428/785= 73.15 N/mm^2
- As the permissible bending stress is 270 N/mm^2, the design is safe.

B. Calculation of Spring Force

A compression spring is employed to hold the pipe firmly. Spring dimensions:

- Inner diameter (Di) = 20 mm
- Wire diameter (d) = 4 mm
- Mean diameter (D) = 22 mm
- Outer diameter (Do) = 24 mm
- The spring index (C) is calculated as:
- C = D/d = 22/4 = 5.5
- Using standard equations, the load-bearing capacity
- (P) is:
- P = 439.8N = 44.8 kg
- The force per arm (since three arms are used) is: 40.29N/arm

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C. Bending Stress in the Arm

The arm supports the pipe and may fail under bending.

- Given maximum applied force = 40.29 N, moment
- (M) is:
- $M = W \times L = 40.29 \times 345 = 13900$ N-mm
- Section modulus (Z) is:
- $Z = 1/6 \times b \times h^2 = 1/6 \times 3 \times 18^2 = 162$ mm^3 Induced bending stress:
- $\sigma b = M/Z = 13900/162 = 85.80$ N/mm^2
- Since allowable bending stress is 270 N/mm^2, the design is safe.

D. Bolt Design

The bolt is under rotational forces and tension.

- Given C-45 steel (σ = 420 kg/cm^2) and an M6 bolt (diameter = 5 mm), the shear stress is: $\sigma = P/(\pi/4 \times d^2)$ The calculated stress falls within the acceptable limit, thus a safe bolt design.

E. Load Distribution and Stability

Total machine weight (P) is 40 kg.
The machine is supported on four support angles, and the bending moment (M) is:

- $M = (W \times L)/4 = (392 \times 510)/4 = 199920$ N-mm
- Section modulus (Z) is:
- $Z = (B^3/6) - (b/(6 \times B)) = 1042$ mm^3
- Induced stress:
- $\sigma = M/Z = 199920/1042 = 191.86$ N/mm^2
- As it is below the safe stress limit, the machine is structurally stable

V. Results and Discussion

The industrial pipe chamfering machine was developed, produced, and tested to assess its efficiency, precision, and safety in comparison with manual chamfering. The findings proved that there was a considerable reduction in processing time, accuracy, and operational safety.

A. Reduction in Chamfering Time

The equipment greatly reduced the time required for chamfering a 400 mm diameter pipe from 60 minutes (manual process) to only 20 minutes. The use of a lead screw mechanism and an adjustable chamfering tool allowed for quicker material removal without sacrificing surface quality.

B. Improved Chamfering Accuracy

Manual chamfering tends to leave uneven edges that need extra finishing. The machine developed provided exact and consistent chamfers at all times, enhancing weld preparation as well as structural integrity overall.

C. Enhanced Operational Safety

Conventional chamfering is risky to operators with chances of tool vibrations, sparks, and improper handling. The use of a fixed mounting system and computerized positioning in the developed machine reduced human interaction, lessening the possibility of workplace injuries drastically.

D. Lower Manpower Requirement

The process of manual chamfering is usually performed by three operators—tool operation and two for positioning the pipe. The proposed machine, however, only needs one operator, thus lowering labor expenses and manual labor.

E. Structural Stability and Durability

Load distribution and force analysis validated that the frame and support parts of the machine resisted operating forces without deformation. The movable arm, lead screw, and spring-loaded mechanism worked effectively, accommodating varying pipe sizes without misalignment.

F. Industrial Applicability

Due to a portable configuration, the machine can be transported and applied on site easily. With its versatility for use on a range of chamfering angles and pipe sizes, it can be a universally applicable tool across various industries.

G. Overall Performance Summary

The machine proved to perform better with improved efficiency, precision, and safety while lowering operating risks and manpower needs, thereby being a very useful addition for industrial purposes.

Parameter	Manual Chamfering	Proposed Machine	Improvement
Time per 400 mm Pipe	60 Minutes	20 Minutes	66% Faster
Manpower Required	3 Operators	1 Operators	67% Reduction
Chamfer Quality	Non-uniform	Precise & Uniform	Higher Accuracy
Operational Safety	Low	High	Safer Process

VI. Future Scope

The envisioned industrial pipe chamfering machine has shown notable improvements in efficiency, precision, and safety. Nevertheless, additional research and development can further improve its performance, automation, and industrial applicability. The following future enhancements can be investigated:

A. Enhancement of Automation and Control System

- Incorporating pneumatic or hydraulic systems for more fluid and quicker chamfering operations.
- Using PLC (Programmable Logic Controller) or microcontroller-based control systems to allow automated tool positioning and speed control.

B. Increased Portability and Versatility

- Creating a lighter, more portable version for easier transport and on-site use.
- Designing interchangeable tool attachments to handle different pipe diameters and materials.

C. Increased Functionality

- Adding the machine's capabilities to include beveling, facing, and deburring for wider industrial applications.

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Including automatic pipe clamping and job-feeding systems to minimize manual effort.

D. Smart Technology and IoT Integration

- Applying IoT (Internet of Things) for remote diagnostics and real-time performance monitoring.
- Creation of an easy-to-use digital interface for machine operation through mobile or computer applications.

E. Industry-Specific Modifications

- Improved durability through application of wear-resistant materials and coatings to increase the lifespan of critical parts.
- All these improvements can further enhance the functionality of the machine, increasing its efficiency, flexibility, and worth in industrial use.

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