Design of a Rotating Tool for Pipe Flash Removal

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Abstract

This paper presents the design of a rotating tool cutter to remove radial flash accumulated on the outside diameter of pipes due to the upsetting of pipe ends in order to prepare them for external threading. The project was undertaken to assist a manufacturing facility in Calgary, Alberta. The process is to be highly automated in order to allow for easy operation, high production rates and quick integration into the existing manufacturing process. The proposed design consists of a rotating tool housed in a tool holder and chuck assembly. The chuck is powered by an electric motor through a shaft and assembly. The assembly is mounted to a sliding plate that provides the machine with a feed for cutting. The sliding plate, in turn, sits on a vertically adjustable base that allows for height adjustments during changes between pipe diameters. The pipes are held in a place using a pneumatic chuck running on the shop compressed air, with interchangeable jaws. All of the necessary design was performed on all components to ensure that the design is safe and functional. The design concepts have been approved preliminarily by the engineering department of the sponsoring company.

I. Introduction

The design presented in this paper has been done for Prudential Steel Ltd. in Calgary, Alberta. Prudential Steel is a leading manufacturer of pipes of various profiles used in many industries. Their Calgary facility is a fully automated process of pipe production with high output rates and an efficient manufacturing process. They asked us to explore a design challenge that they are facing in one of their facilities. This pertains to a portion of their operation that deals with the process of pipe upsetting. This refers to expanding the ends of a pipe to allow for external threading thus creating a connection between pipes. The upsetting process leaves a flash of material on the pipe outer diameter. This excess material must be removed prior to threading, done by an outside vendor. Right now, the flash removal process is being done manually resulting in large labor costs and loss of man-hours. A design of a fully automated machine that will be able to perform the flash removal operation has been completed for this purpose.

II. The Upsetting Process

Once a pipe has been manufactured, it is taken to a separate mill, within the complex, for upsetting, i.e. using a die and plunger, the outside diameter of the pipe is increased to allow for external threading. This allows for the pipes to be connected together in a pipeline. The process consists of pipe heating, pipe deformation, and flash removal. The pipe is heated to a temperature of about 800°F to soften the pipe material, thus allowing for easier deformation. The heating is done by an induction oven. The heated pipe travels down the conveyor to the plunger location. The plunger has a set of dies that are changed to accommodate the appropriate pipe profile. Once the pipe has been secured, the flywheel in the plunger generates the required force to push the pipe material into the dies, causing desired deformation. As a result, a flash of excess material is created on the pipe at the locations of the die parting lines and the plunger seams.

Two types of flash occur as a result of punching: longitudinal flash, and radial flash. Longitudinal flash is accumulated along the length of the pipe upset. It is removed using a machine that is placed in the next stage of the process, immediately after the plunger application. The machine uses two rollers with protruding tools to remove the excess material. The force is applied using a hydraulic cylinder, which pushes the pipe against the protruding tool tip thus creating the necessary cutting force. Radial flash occurs on the OD around the tip of the pipe. Right now, this flash is being removed manually. An efficient way to remove this flash is the focus of this design. With the rate of production, the costs associated with manual flash removal are high. The proposed design will remove the flash in an automated process with minimum operator involvement.

III. Tool Design

The idea behind the design is that the pipe will remain stationary during the operation while a rotating tool will come into the pipe (workpiece) to do the cutting operation.
The general design (Figure 1) can be broken into three basic components: the rotating tool (including the tool chuck, shaft, bearings, and electric motor), the pneumatic chuck, and the base. The design is highly automated allowing for minimum operator input and keeping the workpiece stable for operation. Each general component of the design assembly will be discussed separately.

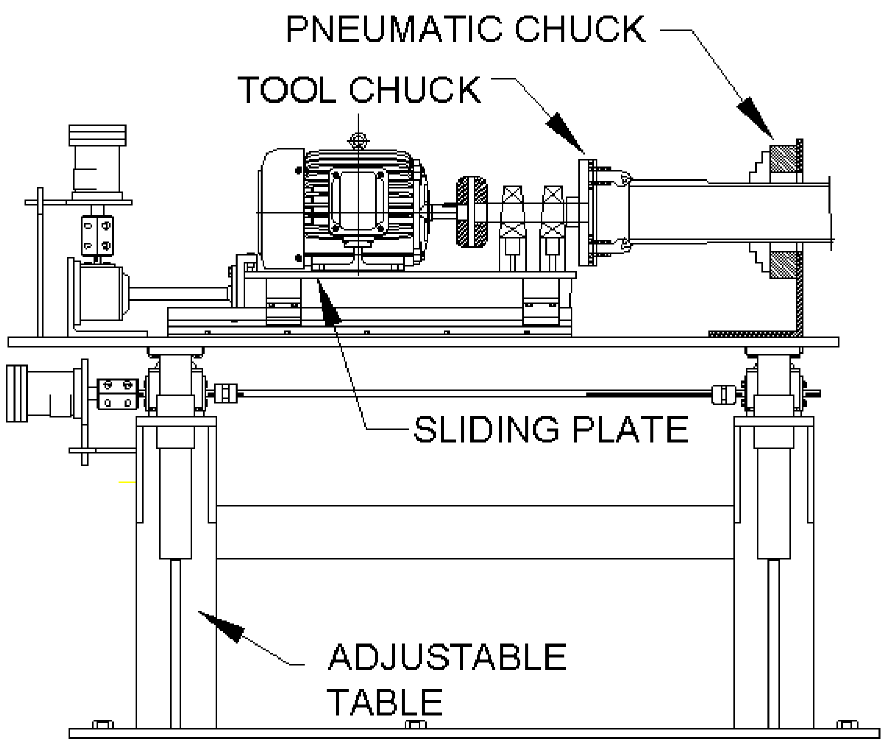

Figure 1: General Design Layout

The Rotating Tool Assembly

The Rotating tool is the heart of the design. This is the component that allows the cutting process to occur.

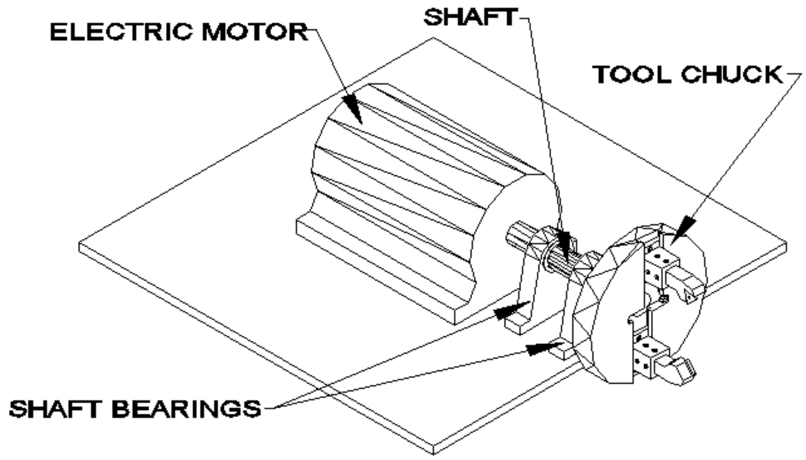

Figure 2: The Rotating Tool Assembly

As seen in Figure 2, the rotating tool consists of several components. The tool chuck is keyed onto the shaft, which is powered by an electric motor. The shaft is supported by two radial and thrust bearings which support the cutting forces during the operation. The entire assembly sits on a sliding plate, which allows for the horizontal movement, thus creating the cutting feed.

The Pneumatic Chuck

A standard pneumatic chuck has been chosen to keep the pipe in place during the flash removal operation. The jaws clamp on the pipe using the shop air pressure, already existing on site. The clamping is activated using a foot pedal. The pneumatic chuck that has been chosen is manufactured by the ITW Workholding Group. The model number selected is the SC 140. The most critical dimension that has to be considered is the diameter of the bore through the chuck since it is required to allow the pipe to slide through prior to clamping. For the chosen model, the diameter is 5.59" which is enough to accommodate the largest pipe diameter. The jaws that are used on the pipe are ordered raw, and are then machined to the appropriate pipe diameter. This means that each pipe size has its own set of accompanying jaws. The replacement of the jaws between the setups is fast and simple. The chuck can be marked for jaw mounting location for each pipe size, making the setup that much easier.

The Base

The last two components outlined in the design layout are contained in the base. First, the top plate enables the horizontal movement of the tool to achieve cutting. The second is the vertical movement of the base. This is necessary because of the various diameters of the pipes being manufactured. When a smaller pipe is introduced the center axis of the pipe drops below the center axis of the tool. This is because the pipe sits on the conveyor, which is not adjustable. Therefore, it is necessary to have vertical adjustment.

IV. Design Calculations and Finite Element Analysis

Finite elements analysis was used to obtain the maximum acceptable defections and to observe the stress distribution throughout the entire tool chuck assembly. Due to the animation capabilities of ANSYS it was also possible to observe the deflection as function of time with varying loads. The solution for the model was obtained and the results were compared to acceptable design limits as well as theoretical calculations.

V. Conclusion

The purpose of this project was to design an automated machine to remove radial flash on pipe OD's and successfully integrate it into the manufacturing process of Prudential Steel. A design was made that can remove the pipe flash with minimum operator involvement and allows for quick operation as well as quick setup times between different pipe diameters. The process will be highly automated, meaning the operator will only have to set the pipe prior to the operation and remove it once it is completed. The actual cutting operation as well as the base table adjustments will be done automatically using hydraulics. The machine was designed to operate safely and in an efficient manner. All of the components of the design have been specified and are included in detail drawings. The project has presented theoretical as well as real-life challenges encountered in industry. It was necessary to take both of these into consideration to ensure that the design will operate safely and accurately in an actual environment. During the course of this design, a constant communication line has existed between the designers and Prudential Steel. As a result, all of the results found in this report have been preliminarily approved pending the detailed inspection of the report itself by Prudential Steel's engineering department

VI. References

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