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Hole Saw-based Pipe Notcher Design: A Cost-effective Manufacturing Solution for 1–3 inch Diameter Pipe

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Abstract

Background: The development of the manufacturing industry demands increased efficiency and precision in pipe joining, a crucial process in machine construction. However, a major obstacle in the field is the manual pipe notching process, which is time-consuming and highly dependent on the operator's skill level, often resulting in imprecise cuts. This inconsistent notching directly complicates the pipe joining process by welding.
Aims: This research aims to design and produce a portable pipe notcher tool based on a hand drill machine for pipes with a diameter of 1–3 inches to improve the quality of perpendicular pipe joints during welding.
Methods: The research method uses a systematic approach which includes needs identification, 3D design planning, manufacturing, and experimental testing.
Result: The design resulted in a tool with dimensions of 980x540x385 mm with smoother and more precise cutting results compared to manual methods. Tests showed significant cutting time efficiencies: Ø1 inch pipe was reduced from 205 to 53 seconds, Ø2 inch from 286 to 75 seconds, and Ø3 inch from 484 to 99 seconds.
Conclusion: This pipe notcher tool design has been proven to increase productivity and produce precise cuts, providing an affordable, appropriate technology contribution to the small-scale manufacturing industry.

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1. Introduction

Efficiency and precision are key in the modern manufacturing and construction industries. One crucial step in assembling machinery and production equipment is pipe joining, which often relies on welding techniques. The efficiency of the pipe welding process is determined not only by the welding parameters but also by the speed and accuracy of the joint preparation process prior to welding (Nelson, 2013). A welding process is needed to join two parts, one of which is arc welding, where the welding process of metal alloys is produced through heat from an electric arc (Pratomo *et al.*, 2020). The quality of a welded joint is largely determined by the accuracy of the initial joint preparation, especially in pipe joints, because small errors at this stage can cause weld defects and reduce structural strength (Althouse *et al.,* 2004; Rampaul, 2003). Precision pipe end preparation is a key factor in improving fit-up quality and pipe welding efficiency (Lobanov *et al.,* 2015). The quality of welded joints, especially in areas requiring high precision, is highly dependent on initial preparation, including accurate pipe beveling. Observations at several small and medium-sized workshops in the West Tulang Bawang region indicate that pipe beveling is still predominantly carried out manually using conventional saws or grinders. The use of these conventional methods often results in dimensional inaccuracies and rough cuts, thus slowing production times (Alfaizt & Fitriati, 2021). This problem directly impacts product quality and workshop competitiveness. In practice, the tube notching process is a critical point that often hinders productivity in small workshops (Nordvall & Tarkian, 2022).

Manual processes depend on individual expertise and are therefore prone to inaccuracy. Manual pipe grinding using a hand grinder tends to produce dimensional variations and inconsistent cut surfaces due to its high reliance on operator skill (Borse *et al.,* 2020). Although pipe notchers are common in large industries, their large size and high cost are obstacles for small workshops. Previous research has developed a notching machine using a sanding belt system, but this was limited to 1-inch pipe diameters (Iswanto *et al.,* 2021). This research offers a novel approach in the design and implementation of a portable pipe notcher based on a hole saw and driven by a hand drill. This tool is capable of handling pipes with diameters of 1 to 3 inches, offering greater portability for small workshops. This innovation aims to reduce production costs without sacrificing the accuracy of the notching results, ultimately improving work quality standards in small workshops. This research also makes a significant contribution to the development of appropriate technology in manufacturing and mechanical engineering.

The objective of this research is to design and manufacture a pipe notcher with diameters of 1, 2, and 3 inches using a hand drill as the main driver. Practically, the results of this research are expected to produce a pipe notcher that can be produced locally at an affordable cost, eliminate the manual notching process that requires the skill of using a cutting grinder, and increase the efficiency of pipe connection time. Thus, this research makes an important contribution to the development of appropriate technology in the fields of mechanical engineering and modern manufacturing.

2. Methods

2.1 Time and Location

The research was conducted from April to September 2025 at Tunas Garuda Polytechnic, West Tulang Bawang. This research method used a systematic approach, with the initial stages of Needs Identification to identify the main problem. The process continued with Design and Modeling, Manufacturing, and Tool Testing. In this research “Tool” and “Product” are the same thing.

Table 1. Research Implementation Schedule

No	Research Activities	Apr	May	Jun	Jul	Aug	Sep
1	Problem Identification and Analysis	X					
2	3D Design & Modelling		X	X			
3	Manufacturing Process (Production)				X	X	
4	Testing and Data Collection						X
5	Analysis of Results and Preparation of Reports						X

Research activities go through the following stages:

a) Field observation

In this phase, we observed the construction process using pipes in the Tunas Garuda Polytechnic workshop and nearby small workshops. Data obtained from these observations included the diameter of the iron pipes frequently used in Tunas Garuda Polytechnic and nearby workshops, which are 1–3 inches. The results of these observations can be seen in Figure 1.

Figure 1. Observation Results: the manual method resulting the pattern is rougher

b) Product design

Create a product design drawing based on the data obtained during the observation. This is followed by a design drawing of the product, which includes the pipe notching tool frame, hole saw cutting blade, and iron pipe clamping system. This design will determine the shape of the components to be used.

c) Preparation of working drawings

The preparation of clear working drawings, including essential elements such as complete engineering drawings with dimensions, tolerances, materials, component details, and assemblies, is crucial in the context of tool manufacturing (Zhou, 2021). These working drawings serve as a guide that helps produce tools with the required accuracy and provides information related to the processes the workpiece undergoes.

d) Manufacturing Product

Based on the working drawings, the material will be processed on machine tools to meet the shapes, dimensions, and tolerances specified in the working drawings. The components are then assembled in a sequential manner, selecting machine elements to create a machine that meets the design.

e) Trial product

After the assembly phase is complete, testing is conducted to ensure the tool functions as expected. This process involves measuring the notch creation time, from pipe preparation to completion of the notch. Tool efficiency is measured based on the time required for each method, which aligns with the design methodology for efficient production (Rachmanudin *et al.,* 2023).

2.2 Tools and Materials

To assemble this tool, a 3-inch diameter pipe and 180x140x5 mm steel plate are used as the base frame to create a sturdy base. This stable base is crucial for precise notching. A handheld electric drill is used as the primary driver for the Pipe Notcher mechanism. The drill's rotation is transmitted through a shaft connecting the drill to the hole saw blade. Additionally, a hydraulic jack is required to provide pressure during the pipe bending process.

2.3 Testing

In this study, testing was conducted to evaluate the performance of a pipe notcher tool by establishing an experimental method to compare the notch creation time of two methods: using a manual hand grinder and using a custom-designed pipe notcher tool. This approach is relevant to previous research supporting the use of design methods that prioritize manufacturing process efficiency and cost (Wijaya & Ernawati, 2021). Explanations regarding the design process and time efficiency have also been widely discussed in the context of tool performance assessment (Sianipar *et al.*, 2023).

3. Result and Discussion

3.1 Design Results

The design of this pipe notcher tool consists of several main components that work together. The main frame serves as a base and support, equipped with an adjustable pipe clamping mechanism for pipes measuring 1-3 inches. The most important part is the shaft, designed to hold the hole saw and connected to a hand drill as a drive. The design can be seen in the 3D image with dimensions of 980 mm high, 540 mm long, and 385 mm wide.

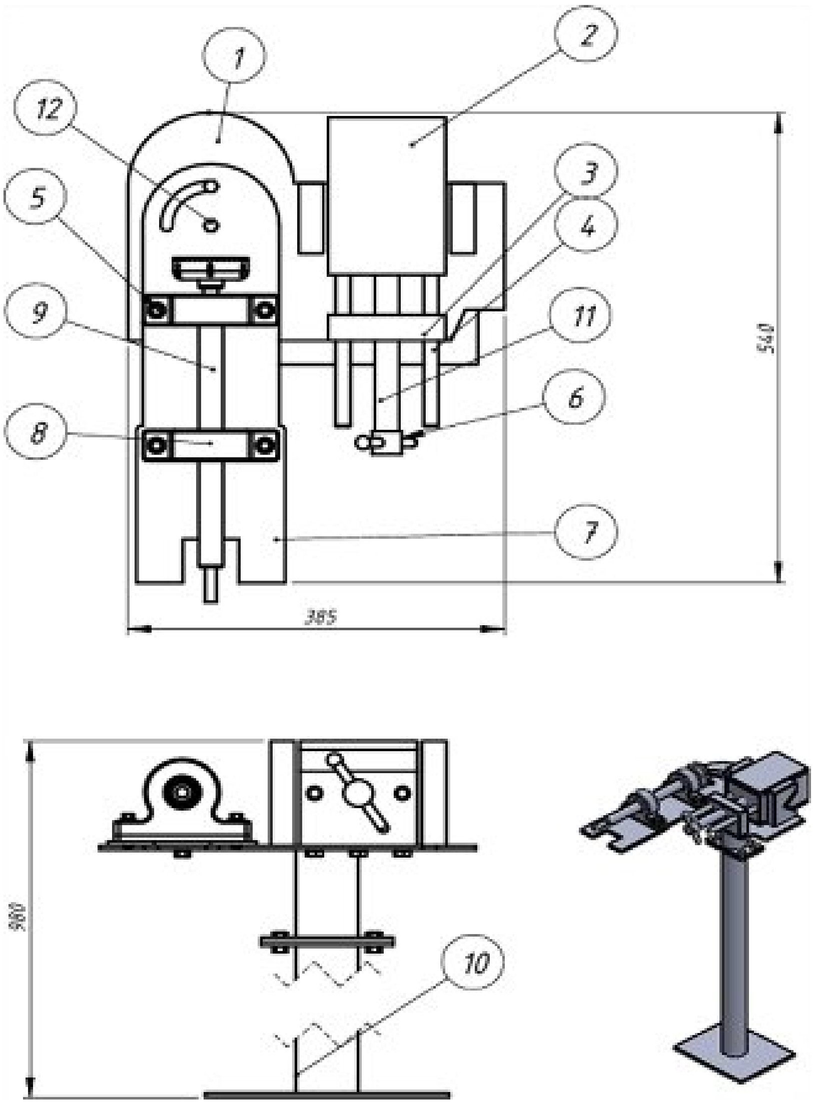

Figure 2. Pipe Notcher Design Results

Tabel 2. Item name of product

Item Number	Item Name
1	Main Plate
2	Moveable Jaw
3	Support Plate
4	Guide Pin
5	Bolt M10
6	Handle
7	Pad
8	Pillow Block Bearing
9	Hole Saw Assy
10	Stand Assy
11	Lead Screw
12	Bolt M12

Figure 1 shows the design results for a pipe notcher, where the end of component number 9 is where the hand drill is installed. This design was realized as a pipe notcher in accordance with the working drawings.

3.2 Manufacturing Results

After going through the manufacturing process and assembly, the tool obtained is as shown in Figures 3 and 4. Once assembled, the pipe notcher is placed in a welding laboratory for testing on 1- to 3-inch pipe joints. The placement of this tool is crucial, given that in modern manufacturing, the use of proper cutting tools is key to maintaining dimensional consistency, smooth surface finishes, and efficient production times (Schlegel, 2023).

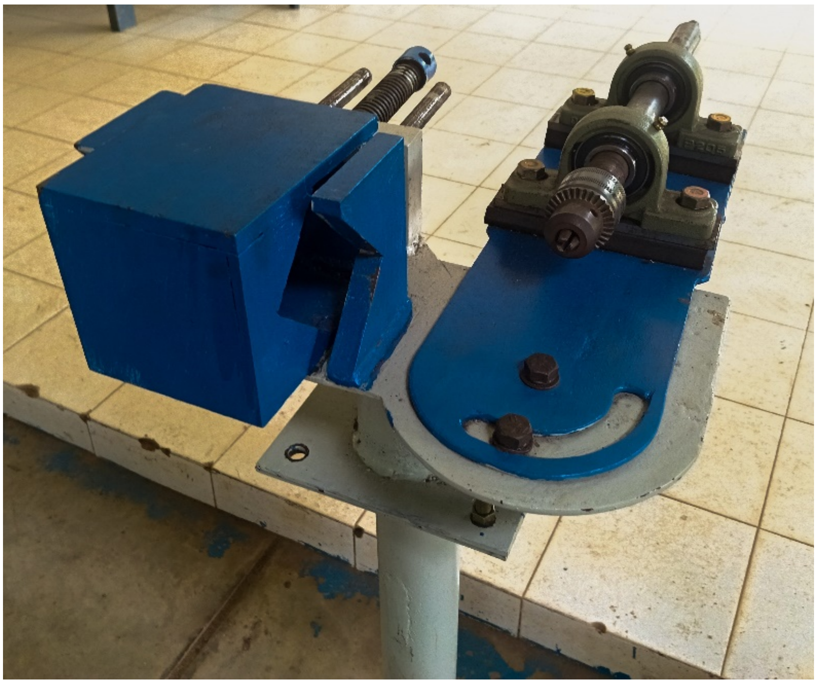

Figure 3. Pipe Notcher Tool

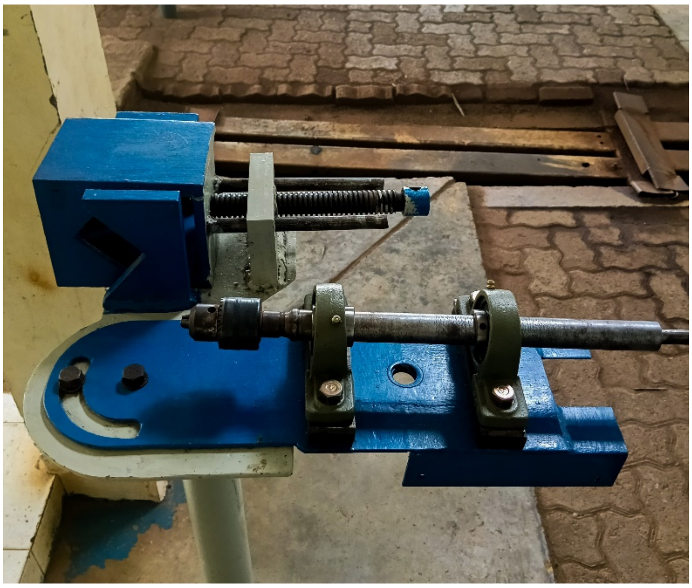

Figure 4. Pipe Notcher tool installed in the Welding Laboratory area.

3.3 Testing Results

The test involved recording the time taken to make the notches manually and using a pipe notcher. The test results are as shown in Table 3 below:

Table 3. Comparison of Pipe Notching Time Using Manual Method and Pipe Notcher

No	Ø Pipe (Inch)	Testing to	Manual Grinding Process		Pipe Notcher Process	
			Time (second)	Average Time (second)	Time (second)	Average Time (second)
1	Ø1	1	218	205	40	53
2		2	191		55	
3		3	206		63	
4	Ø2	1	293	286	70	75
5		2	276		81	
6		3	288		74	
7	Ø3	1	482	484	79	99
8		2	491		129	
9		3	478		88	

The results of notching using a pipe notcher tool demonstrate significant advantages in terms of both dimensional accuracy and cutting aesthetics compared to hand grinding methods. Visually, the cut marks using a hole saw-based pipe notcher produce a smooth, even surface free of burrs, allowing the pipe to be directly connected without the need for additional sanding.

From table 4 it can be seen that tool is able to maintain the consistency of the notch radius with minimal deviation (±0.3 mm), which ensures that the joint gap (fit-up gap) is very tight and uniform (0.3 – 0.6 mm). Good pipe joint fit-up quality will produce a uniform joint gap, thus simplify the welding process and increase the strength of the welded joint (Goodall, 2011). This contrasts with the use of a hand grinder which is highly dependent on the stability of the operator's hand, where the results tend to be uneven, causing a loose joint gap (1.8-3.6 mm), and ultimately reducing the quality and strength of the pipe welding results. Visualization of the pipe notching results can be seen in figures 5 and 6.

Table 4. Dimensions of size and gap of notch results.

No	Target Pipe Diameter (Inch/mm)	Cutting Method	Actual Measurement Result (mm)	Gap (mm)	Cut Surface Quality	Remarks
1	1 Inch (25.4 mm)	Manual (Grinder)	27.2	+1.8 mm	Rough & Jagged	Loose (Difficult to weld)
		Pipe Notcher	25.7	+0.3 mm	Smooth & Uniform	Tight (Very Good)
2	2 Inch (50.8 mm)	Manual (Grinder)	53.5	+2.7 mm	Uneven	Perforated (Gaps)
		Pipe Notcher	51.1	+0.4 mm	Smooth & Accurate	Tight (Very Good)
3	3 Inch (76.2 mm)	Manual (Grinder)	79.8	+3.6 mm	Wavy	Very Loose
		Pipe Notcher	76.6	+0.6 mm	Smooth & Accurate	Tight (Very Good)

Figure 5. Results of notching on pipes: A. Manual B. Using a Pipe Notcher Tool

Figure 6. Pipe Connections: C. Manual D. Using a Pipe Notcher.

Using the data in Table 3, a comparison graph can be made of the length of time required for the pipe notching process using a pipe notcher and a manual grinder.

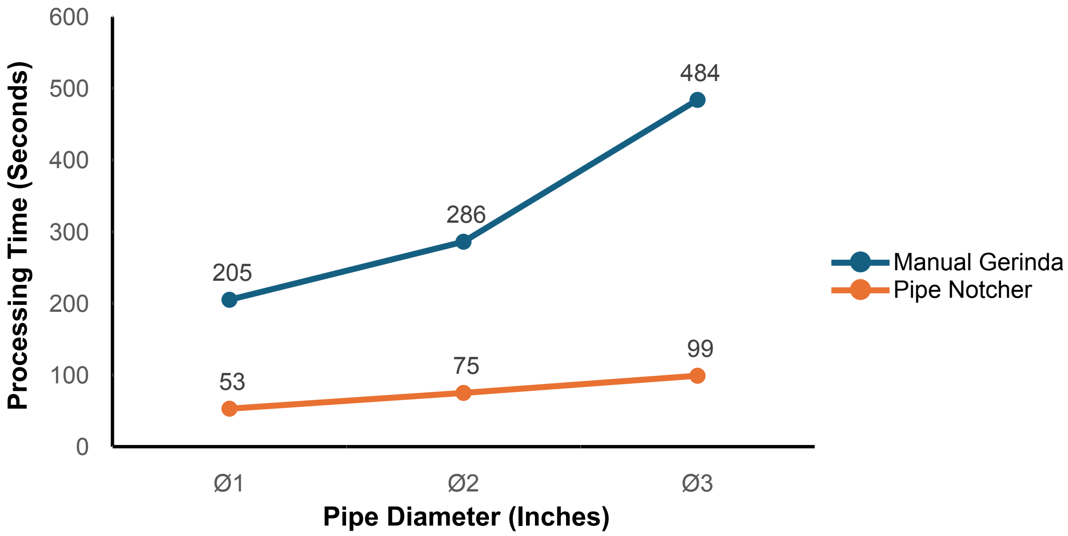

Figure 7. Comparison of notching Time for Diameters 1-3 Inches.

Tests conducted showed that the average manual notching time for a 1-inch pipe was 205 seconds, compared to only 53 seconds using a pipe notcher. Similar results were observed for 2- and 3-inch pipe sizes, where the average time decreased from 286 seconds to 75 seconds, and from 484 seconds to 99 seconds, respectively. The analysis showed that the pipe notcher provided remarkable time efficiency, with a significant reduction of 79% for a 3-inch pipe. The results also demonstrated the effectiveness of the pipe notcher in improving work efficiency and reducing operator stress (Carlan et al., 2023).

The test conditions-maintained consistency in pipe type and diameter, as well as notch depth, helping to ensure the validity of the data obtained. This approach is similar to the method used in automated and manual comparisons in software testing, again demonstrating the superiority of automated methods, which are more efficient and time-saving. Therefore, the results of this time-efficiency test confirm that the use of a pipe notcher can optimize the pipe notching process and bring significant productivity gains in the industry.

Based on these results, the implementation of a pipe notcher tool is highly recommended, as it not only improves operational efficiency but also enhances productivity and safety.

4. Conclusion

Based on the research results, it can be concluded that the use of a pipe notcher significantly increases the speed of the pipe notching process by 79% compared to the manual grinding process. The notching process for a 1-inch pipe takes 53 seconds, a 2-inch pipe takes 75 seconds, and a 3-inch pipe takes 99 seconds. Based on the notching process time, it can improve process efficiency, thereby driving increased productivity.

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