DESIGN AND FABRICATION OF HOT WIRE CUTTER USING NICHROME 24 TO CUT MOTOR WEDGE BUNDLES

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Abstract: Hot wire cutting is a process in which a heated wire is used to melt and cut through a material.It is a versatile technique that can be used tocut a wide variety of materials, including foam, plastic, wood, and metal. The design and fabrication of hot wire cutters is a relatively simple process and canbe done using a variety of materials and tools. Thebasic components of a hot wire cutter are a power supply, a heating element, and a wire guide. The power supply provides the current to heat the wire element. The heating element is typically made of a high-resistance metal, such as nichrome or nickel-chromium alloy. The wire guide is used to guide the wire element along the desired cutting path. The power supply can be either AC or DC. AC power supplies are more common, as they are less expensive and easier to find. DC power supplies are more efficient, but they are also more expensive. The heating element can be purchased pre-made, or it canbe fabricated from scratch. If fabricating the heating element from scratch, it is important to choose amaterial with a high melting point and a high resistance to corrosion. The wire guide can be made from a variety of materials, such as metal, plastic, or wood. The important thing is that the wire guide canto withstand the heat of the wire element. Once the components have been selected, the hot wire cutter can be assembled. The first step is to attach the wire element to the power supply. This can be done using a variety of methods, such as crimping, soldering, or welding. The next step is to attach the wire guide to the wire element. The wire guide should be attached ina way that allows the wire element to move freely along the desired cutting path. Once the hot wire cutter is assembled, it is important to test it to make sure that it is working properly. To do this, simply turn on the power supply and heat the wire element. Once the wire element is hot, try cutting through a piece of material.

Keywords: Hot wire cutter, Heating element, Wire guide & Power Supply

Introduction

The design of a hot wire cutter will vary depending on the intended use. However, there are some basic design principles that apply to all hot wire cutters. First, the wire guide should be designedto minimize friction. This will help to prevent the wire element from overheating and breaking. Second,the wire guide should be designed to allow the wire element to move freely. This will help to ensure that the wire element cuts cleanly through the material. Third, the power supply should be rated for the current required by the heating element. If the power supply is not rated for the required current, itcould overheat or fail. The fabrication of a hot wire cutter can be done using a variety of tools and materials. The following is a basic overview of the fabrication process. Select the appropriate material sfor the wire element and wire guide.

1. Cut the wire element to the desired length.
2. Attach the wire element to the power supply.
3. Attach the wire guide to the wire element.
4. Test the hot wire cutter to make sure that it is working properly.

Once the hot wire cutter is fabricated, it can be used to cut a variety of materials. The cutting processis relatively simple:

1. Heat the wire element to the desired temperature.
2. Guide the wire element through the material to be cut.

Literature Review

Design and Fabrication of Hot wire cutter for cutting foam Author- J.P.Davim1, R.S.Figueria1 Published- 2007. This paper describes the design and fabrication of a hot wire cutter for cutting foam. The cutteris designed to be used in a variety of applications, including the cutting of **foam insulation, packaging,and prototypes.** The cutter consists of a heated wire element that is guided through the foam to be cut. The heat of the wire melts the **foam**, creating a clean and precise cut.

Design and Fabrication of Hot wire cutter for cutting plastic Author- H.K.Tonshoff – 2012. This paper describes the design and fabrication of a hot wire cutter for cutting plastic. The cutter is designed to be used in a variety of applications, including the cutting of plastic signs, displays, and packaging. The cutter consists of a heated wire element that is guided through the plastic to be cut. The heat of the wire melts the plastic, creating a clean and precise cut. The cutter is controlled by a power supply, which allows the user to adjust the cutting temperature.

Design and Fabrication of Automatic Plastic Pipe Cutting Machine Author- Y.Y.Nandurkar, S. S. Akant and S. L. Bankar Published- 2018. The Automation of processes plays a crucial role in improving the overall productivity of Industry. The main aim is to improve the overall productivity by decreasing the manpower cost, utility cost and improving quality and quantity of production. Quality of production is improved by making the manual cutting operation fully automated ensuring the repeatability of the process with accuracy and precision. This ensures elimination of human error and monotonous work. Quantity of production is improved by avoiding manual delays and achieve quick response time of machine. It also focuses on optimum use of power provided for cutting operation.

Problem Statement

The manufactured wedges of 3 meters are bundles as hundreds and allowed for cutting into different lengths using motor assisted cutting machine by a labor. The major problems faced by the industry here are,

- Larger area occupied by the system,
- Frequent malfunctioning of Controller and the microchip.
- Wear of Cutting blades which cost around 3600 per blade.
- Usage of specially designed motor with two capacitors to produce high torque increases the power cost. Wear of V-Belt drive which is coupled with the motor.
- Enormous amounts of chips, wastage, dust are released during cutting.
- Labor fatigue as he cuts around 10000 wedges per day using this heavy motor assisted cutting machine.

Proposed System

Hot wire cutters overcome the issues mentioned in the following ways:

- ✓ **Wear of Cutting blades which cost around 3600 per blade:** Hot wire cutters do not requirecutting blades, which eliminates the need for costly blade replacements.
- ✓ **Usage of specially designed motor with two capacitors to produce high torque increasesthe power cost:** Hot wire cutters require less torque to operate than traditional cutting machines, which can lead to significant power savings.
- ✓ **Wear of V-Belt drive which is coupled with the motor:** Hot wire cutters do not require V- belts or other mechanical drives, which eliminates the need for maintenance and replacement.
- ✓ **Enormous amount of chips, wastages, dusts are released during cutting:** Hot wire cutters can be designed with dust collection systems to minimize the amount of chips, wastages, and dust released during cutting.
- ✓ **Labor fatigue as he cuts around 10000 wedges per day using this heavy motor assisted cutting machine:** Hot wire cutters can be automated to reduce the amount of manual labor required for cutting operations. This can help to reduce labor fatigue and improve productivity.

Design Calculation

To design a hot wire cutter, we need to calculate the following:

- The resistance of the wire element.
- The power required to heat the wire element.
- The current required to heat the wire element.
- The voltage required to power the wire element.
- The temperature of the wire element.
- Selection of wire material.
- Selection of wire diameter.
- The size of the power supply.
- The size of the wire guide.
- The size of the frame

Power Supply Calculations

TEMPERATURE (IN CELSIUS)	T1 = 205 C		T2 = 316 C		T3 = 427 C		T4 = 649 C	
WIRE DIAMETER (IN MM)	0.27	0.51	0.27	0.51	0.27	0.51	0.27	0.51
OHM PER FOOT (OHM/FT)	5.286	1.6710	5.286	1.6710	5.286	1.6710	5.286	1.6710
R (WIRE LENGTH*OHM PER FOOT) (IN OHMS)	2.643	0.8355	2.643	0.8355	2.643	0.8355	2.643	0.8355
V (WIRE TEMP*R)	2.8544	1.84645	3.7266	2.4229	4.5724	2.8407	6.6339	4.2610
I (WIRE TEMP) (IN AMPS)	1.08	2.21	1.41	2.90	1.73	3.40	2.51	5.10
P (V*I) (IN WATTS)	3.0828	4.0806	5.2545	7.0266	7.9102	9.6583	16.6512	21.7314

Sample Calculation:

Assuming Wire Length = 6 Inches (15 CM Approx)
Taking ohm per foot for 0.27 and 0.51mm from table,

Calculating Resistance:
R = Wire length (in foot) * Ohm per foot
R = (6/12) * 5.286
R = 2.643 ohm (for 0.27mm wire)

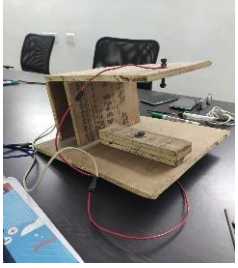
Calculating Voltage and Current:
We have **V = (Wire temperature * Resistance)**
Where wire temperature is the current flow for that temperature which is also taken from the table.
Therefore,
V = 1.08 *2.643
V = 2.8544 Volts (for 0.27mm wire @205 degreeCelsius)
I = 1.08 Amps (for 0.27mm wire @205 degreeCelsius)

Calculating Power:
P = V*I
P = 2.8544 * 1.08
P = 3.0828 Watts (for 0.27mm wire @205 degreeCelsius)

Observati

onsTrial

1:
Coupling 12W mobile charger with positive and negative terminals of Nichrome wire.



Result Obtained:

We were able to obtain an output temperature of range 55-58 degree Celsius and this temperature was able to cut the bundle of 30-35 wedges by taking a time around 60-70 seconds.

Trial 2:

To increase the temperature, we used SMPS which can increasethe output current to 3 amps.

Result Obtained:

We did not get desired temperature rather this method leadsto failure of Nichrome wire.

Results of different wires:

- ✓ Nichrome of Gauge 29 = Broke into half after certain point.
- ✓ Nichrome of Gauge 24 = Melted itself after certain point.
- ✓ Stainless-Steel of thickness 1.2mm = The capacity of SMPS is insufficient to heat the wire.

Trial 3:

We now coupled the 27W mobile charger with the positive andnegative terminals of Nichrome Wire.

Input:

Wire diameter = 0.27mm

Length of the wire = 100mm

No. of wedges = 6 to 10

Results Obtained:

This power was able to produce current around 5 amps whichturned out to be better than previous trials.

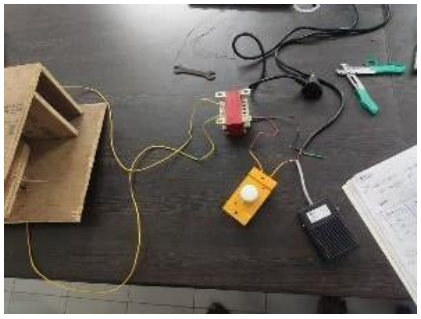
Output:

- ✓ Temperature obtained = Around 70 to 75 degrees Celsius.
- ✓ Time taken to cut the bundle = Around 30 seconds.

Trial 4:

Finally, to control and regulate the Current, Voltage and the Temperature we built a circuit using a **Transformer, Dimmer Switch, and a Pedal Switch.**

Circuit Image:



Components Used:

1. TRANSFORMER:

   INPUT = 230V AC SUPPLY

   OUTPUT = 0-12V, 5A.

2. DIMMER SWITCH.
3. FOOT SWITCH.
4. NICHROME WIRES OF DIAMETER 0.27,0.51 AND 0.8MM

Observations:

I.

INPUT:

1. WIRE THICKNESS = **0.27 MM**
2. WIRE LENGTH = 6 INCHES (APPROX.)

OUTPUT:

CURRENT(A)	TEMP (C)	TIME (S)	
		6”	4”
1	44	14	8.5
1.5	55	10	7
2	60	7	4.7

II.

INPUT:

1. WIRE THICKNESS = **0.51 MM**
2. WIRE LENGTH = 6 INCHES (APPROX.)

OUTPUT:

CURRENT(A)	TEMP (C)	TIME (S)	
		6”	4”
3	50	13	9.15
4	58	8.5	6
5	85	6.5	4.1

III.

INPUT:

1. WIRE THICKNESS = **0.8 MM**
2. WIRE LENGTH = 6 INCHES (APPROX.)

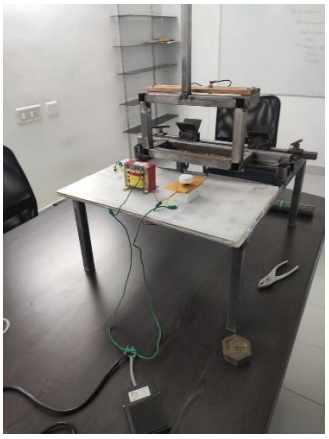
OUTPUT:

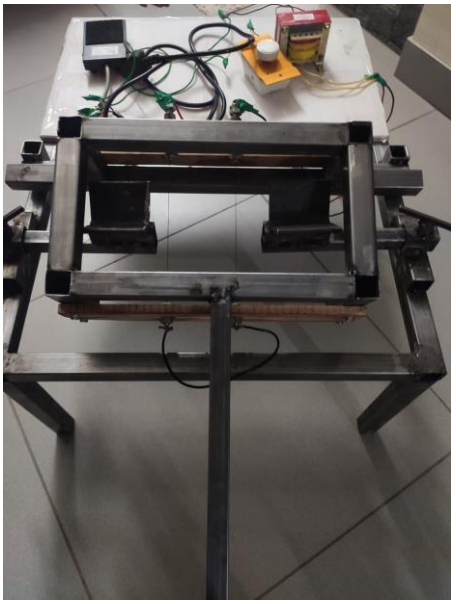
CURRENT(A)	TEMP (C)	TIME (S)	
		6”	4”
5	44	13	9.6
6	62.5	10	7.3

Result:

From the above experiments, we can conclude that the **Nichrome wire of 0.51mm (Gauge 24) operating at 3 to 4 Amps of Current** can give the optimum cut.

Fabricated Model:





Working Principle

The wire element is the heart of the hot wire cutter. It is the wire that is heated by the power supply and that melts the material being cut. The diameter of the wire element will depend on the thickness of the material to be cut and the desired cutting speed. A thicker wire will be required to cut thicker materials or to achieve a higher cutting speed. The power supply provides the current that heats the wire element. The voltage regulator keeps the voltage at a constant level, and the current limiter limits the current to a safe level. The wire guide guides the wire element through the material being cut. It should be made of a material that can withstand the heat of the wire element, and it should be designed to minimize friction between the wire element and the material being cut. The cutting frame holds the wire element and wire guide in place. It should be made of a material that is strong and stable, and it should be designed to allow the wire element to move freely. Safety switch, cooling fan, and dust collection system are all optional components, but they can help to make the hot wire cutter safer and more efficient.

Advantages:

1. **Clean and Precise Cuts:** Hot wire cutters produce clean, precise cuts without chipping or tearing, making them ideal for delicate materials like foam, plastic, and thin wood.
2. **Reduced Dust and Waste:** Unlike mechanical cutting methods that generate dust and debris, hot wire cutters melt the material, minimizing dust and waste production.
3. **Minimal Operator Fatigue:** Hot wire cutters can be automated or semi-automated, reducing the physical strain on operators from extended cutting tasks.
4. **Cost-Effective Operation:** Hot wire cutters generally have lower energy consumption and maintenance costs compared to traditional cutting machines

Applications:

- ✓ **Foam Cutting:** Hot wire cutters are widely used in the foam industry for cutting foam insulation, packaging materials, and prototype models.
- ✓ **Plastic Cutting:** They are also commonly employed in the plastics industry for cutting plastic signs, displays, and packaging components.
- ✓ **Metal Cutting:** While not as common as cutting other materials, hot wire cutters can be used to cut thin metal sheets, particularly in jewelry making and prototyping.

Conclusion:

Hot wire cutters have emerged as a valuable tool in various industries and applications due to their versatility, precision, and cost-effectiveness. Their ability to cut a wide range of materials without generating excessive dust or waste makes them an attractive alternative to traditional cutting methods. Additionally, their automated or semi-automated capabilities can reduce operator fatigue and increase productivity. As technology advances, hot wire cutters are likely to gain even wider adoption and play an increasingly important role in various manufacturing processes.

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