Design and Fabrication of Multi-Purpose Cutting Machine with Dust Collector

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Abstract—This paper presents a simple way of designing and implementing multipurpose cutting machine. A concrete saw (also known as a consaw, road saw, cut-off saw or quick cut) is a power tool used for cutting tile, concrete, masonry, brick, asphalt, and other solid materials. It can be a small hand-held cut-off saw, a big walk-behind saw or other styles, and it may be powered by gasoline, hydraulic or pneumatic pressure, or electric motors. The saw blades used on concrete saws are often diamond saw blades to cut concrete, asphalt, stone, etc. Abrasive cut-off wheels can also be used on cut-off saws to cut stone and steel. The significant friction generated in cutting hard substances like concrete usually requires the blades to be cooled to prolong their life and reduce dust. This machine creates substantial amounts of dust during operation. Breathing airborne dust on a regular basis can result in permanent respiratory illness. Reduce your risk by wearing a respirator and capturing the dust with a dust collection system. Here, we are designing a tool to cutting with dust collection application. Here the suction pressure is measured by the vacuum gauge.

Key words: Cutting Machine, Dust Collector, Vacuum Gauge

I. INTRODUCTION

The ceramic tile cutter works by first scratching a straight line across the surface of the tile with a hardened metal wheel and then applying pressure directly below the line and on each side of the line on top. Snapping pressure varies widely, some mass-produced models exerting over 750 kg. The cutting wheel and breaking jig are combined in a carriage that travels along one or two beams to keep the carriage angled correctly and the cut straight. The beam(s) may be height adjustable to handle different thicknesses of tiles. The base of the tool may have adjustable fences for angled cuts and square cuts and fence stops for multiple cuts of exactly the same size. The scoring wheel is easily replaceable. The first tile cutter was designed to facilitate the work and solve the problems that masons had when cutting hydraulic mosaic or encaustic cement tiles (a type of decorative tile with pigmented cement, highly used in 50s, due to the high strength needed because of the high hardness and thickness of these tiles). Over the time the tool evolved, incorporating elements that made it more accurate and productive. The first cutter had an iron point to scratch the tiles. It was later replaced by the current tungsten carbide scratching wheel. Another built-in device introduced in 1960 was the snapping element. It allowed users to snap the tiles easily and not with the bench, the cutter handle or hitting the tile with a knee as it was done before. This was a revolution in the cutting process of the ceramic world.

II. DUST CONTROL

Stones, rocks, sands and clays can contain large amounts of crystalline silica and are used to make kerbs, flags, bricks, tiles and concrete. Cutting these materials produces airborne dust containing very fine respirable crystalline silica (RCS) particles. These particles are small and it is not always possible to see the RCS dust in normal lighting.

There are following ways to reduce or control the dust:
- Wet cutting with adequate water supply.
- If possible, diamond saw blades should be used instead of abrasive saw blades to cut.
- When operating, the operator should always wear personal protective equipment (PPE).

III. LITERATURE REVIEW


This paper presents a simple way of designing and implementing an automatic metal sheet cutting machine using easily available low-cost micro-controllers.

B.P.Numbi, X.Xia and J. Zhang, have presented an “optimization technique for the vertical cutting machine”.

They have proposed optimum methods to reduce the power consumption by varying the conveyor feed flow rate, the vertical shaft impact crusher rotor feed rate and the bi-flow or cascade flow rate.

H. D. Jerro, S. S. Pang, C. Yang, and R. A.Mirshams,”Kinematics analysis of the chipping process using the circular diamond saw blade,”

This paper shows the details about diamond saw blade

B.Nageswara Rao, Dr.J.E.B.Nelson and Dr.B.Balunaik. “Study and Analysis of cutting forces in Granite Machining.”

In this paper the measurement of cutting forces in conventional tools are reviewed and the prototype band saw machine is monitored. Cutting forces in this new process are studied, with measurement of tangential force and feed force under various working conditions.

Åslund, P. and Vomhoff, H. “Method for studying the deformation of a fibre web during a suction pulse.”

In this paper this can show the suction pressure and power of vacuum.

Y. Qiao, H. Bu “An investigation on suction force of vacuum pumps for micro-components.”

In the assembly process of micro-electro mechanical system (MEMS), vacuum pumps are applied to hold micro-components. Viewing through a 3-D microscope, a micro-part of MEMS.
IV. DESCRIPTION OF CUTTING MACHINE AND SELECTION OF CUTTING MACHINE

Mount the cutting wheel. Insert the counter-flange and then tighten with the nut. Align the adjusting bracket in one direction with the cutting wheel and screw tight. Put on the guard hood and fix with the thumb screw and the nut. Fasten the side cover with the self-tapping screws. Insert the straight fence as per drawing.

Following specification are the use in selection of cutting machine.

- Cutting Motor- 750 Watt
- Cutting Motor High Speed- 18 to 20,000 RPM
- Voltage- 100 to 240 V
- Rated Input Power- 400 to 1600 Watt
  
  While cutting any type of tiles this type of machine can be used as well as this machine can also perform an operation on wood, POP etc.

V. CUTTER

A diamond blade is a saw blade which has diamonds fixed on its edge for cutting hard or abrasive materials. There are many types of diamond blade, and they have many uses, including cutting stone, concrete, asphalt, bricks, coal balls, glass, and ceramics in the construction industry; cutting semiconductor materials in the IT industry; and cutting gemstones, including diamonds, in the gem industry.

Diamond blades are available in different shapes:

- Circular diamond saw blades are the most widely used type of diamond blade.
- A diamond gang saw blade is a long steel plate with diamond segments welded onto it.
- A diamond band saw blade is a flexible closed steel band with diamonds fixed (often by electroplating) on one edge of the band.

Cutting with or without water:

Many blades are designed to operate either wet or dry. However, diamond tools and blades work better when wet, and dry cutting should be limited to situations in which water cannot or should not be used.

VI. DESIGN SPECIFICATION OF VACCUM

A vacuum's suction is caused by a difference in air pressure. A fan driven by an electric motor (often a universal motor) reduces the pressure inside the machine. Atmospheric pressure then pushes the air through the carpet and into the nozzle, and so the dust is literally pushed into the bag.

Suction:

This means that it can lower the pressure inside the hose from normal atmospheric pressure (about 100 kPa) by 20 kPa. The higher the suction rating, the more powerful the cleaner. One inch of water is equivalent to about 249 Pa; hence, the typical suction is 80 inches (2,000 mm) of water.

Input power:

Many North American vacuum manufacturers give the current only in amperes (e.g. “6 amps”), and the consumer is left to multiply that by the line voltage of 120 volts to get the approximate power ratings in watts. After 1 September 2014, due to EU rules, manufacture of vacuum cleaners with a power consumption greater than 1600 watts will be banned, and from 2017 no vacuum cleaner with a wattage greater than 900 watts will be permitted.

Output power:

The amount of input power that is converted into airflow at the end of the cleaning hose is sometimes stated, and is measured in air watts: the measurement units are simply watts. ASTM International defines the air watt as 0.117354 × F × S, where F is the rate of air flow in ft³/min and S is the pressure in inches of water. This makes one air watt equal to 0.9983 watts

VII. METHODOLOGY

The cutting machine is designed to perform cutting jobs on small and medium tiles which suit the machine's size. It is intended in particular for use by DIY enthusiasts and craftsmen. It can use the machine to cut wood or metal! Them a chine is to be used solely for its intended purpose. Any use other than its intended use is a case of misuse. The user/operator and not the manufacturer shall be liable for any damage or injury resulting from cases of misuse. All persons entrusted with operating and servicing the machine must be acquainted with the manual and must be informed about the machine’s potential hazards. When selecting a tile cutter, consider the bulk of your job. And the types of materials being cut like vinyl, porcelain, granite, mosaic, marble tiles depending on its thickness and area. This can help you decide the functionality and calculate what you look in for a type of cutter. For comparison jobs using porcelain or ceramic tile.
VIII. DESIGN AND CALCULATION

Cutter

Fig. 3: CAD model of cutter

Dimension And Calculation Of Cutter

Diameter - 110 mm

Machine Speed:
- \( D_1 \) is largest part diameter (initial size)
- \( V \) given in surface feet per minute (SFPM), \( D_1 \) in inches: \( k = 12 \)
- \( V \) given in meters per second (MPS), \( D_1 \) in mm: \( k = 60000 \)
- \( V \) given in meters per minute (MPM), \( D_1 \) in mm: \( k = 1000 \)

Cutting Time:

\[
CT = \frac{(L + A)}{f_z * N}
\]

\( = 0.0152 \text{ min} \)

Material Removal Rate:

\[ \text{Volume Removed} = \frac{\text{Cutting Time}}{\text{Cutting Time}} \times 0.148 \text{ gm/s} \]

IX. EXPERIMENTATION

All operation perform on 8mm size of sheet

For Tiles:

1) The MMR for tile is without vacuum at power 1.10Kw, speed 1300rpm and torque is 7.89*10^{-4}N-m is 0.148 Gm/sec in time 90sec for tile
2) By using the vacuum suction pressure of tile at cutting speed 1330rpm is 8.4 kpa also power and torque obtain is 0.963Kw and 6.91*10^{-4}N-m respectively.

For Wood:

3) The MMR for wood plate without vacuum at power 1.10Kw, cutting speed 1330rpm and torque 7.89*10^{-4}N-m is 0.108Gm/sec at time 90 sec and the dust removed is 9.8gm
4) By using the vacuum suction pressure for wood plate at speed 1330rpm is 7.0Kpa at power and torque is 0.776Kw and 5.57*10^{-4}N-m respectively.

For plaster of Paris:

5) The MMR of plaster of Paris sheet in time 90 sec is 0.098gm/sec, at speed of 1330 rpm.
6) Dust removed at power 1.10 kW is 8.89 gm. by using torque 7.89*10^{-4}N-m
7) With vacuum, Suction pressure obtain at cutting speed 1300rpm & power 0.749Kw is 5.54Kpa and required torque is 5.37*10^{-4}N-m

Cutting Machine and component:-

Become familiar with the names and locations of the controls and features shown below to better understand the instructions in this manual.

Fig. 4: Controls and features (side view).

Fig. 5: Controls and features (front view).

Fig. 6: Dust port location.
**Dust Collection Hose:**
Vacuum hose for use with dust collection system or shop vacuum.

![Vacuum Hose](image)

Fig. 7: Vacuum Hose.

**Vacuum Cleaner:**
On-off switch, Automatic cord winder, Dust bag full indicator, Variable power control, Suction end, Blower end, Flexible hose pipe, Rear wheel, Top hood opening button.

![Vacuum Cleaner](image)

Fig. 8: vacuum cleaner model

Collection issue solved by above design. Many more similar products (like drilling machine, ramming machine, punching machine etc) can be developed at much lower development costs and thereby, making them within the reach of medium and small scale industries.

**REFERENCES**


**X. ADVANTAGES**
- Smooth Cutting
- Harmless
- More Accuracy
- Health efficient
- Eco-friendly
- Less waste material
- Less pollution
- Low Cost maintenance

**XI. APPLICATION**
- Construction Industry
- Automobile Industry
- Process Industry
- Household Application

**XII. CONCLUSION**
For applications on the low end side of technology that do not require very high precisions, low cost automation can be provided using this scheme. These machines are simpler to design and have good accuracy. Along with this, Dust