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Research Article

Design and Construction of a Laboratory Rock Cutting Machine

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Abstract

Design and construction of specimen cutting machine was done to assist the researchers to get mineral/rock specimen. In laboratories/mining industries, specimen cutting machines are needed to cut specimen strips, rock specimen, and cores which are used to carry out some tests. This machine basically consists of electric motor, diamond cutting disc with an electric pump for water cooling, pedal guide for vertical cutting safety device to protect against blade brakeage as well as transparent screen guide to prevent dust particles while in use. The machine accepts blades up to 350mm diameter and with the additional clamps rock, core samples and mineral samples can be sliced with a 200mm cut. It has a dimension of 1220mm x 700mm x 1360mm, and weight of 125kg. Electric motor was employed to convert electrical energy into mechanical energy. Electrical motor is powered by alternating current from a central electrical distribution grid. Drilling fluid was provided to improve surface finish and flushing away chips from the cutting zone. The designed machine used electric motor of 380V, 50Hz, 1.3KW at rotating speed of 2800rpm. The designed and constructed cutting machine can be used to cut various materials so as to get specimen and observe the structures.

Keywords: Cutting machines, electric motor, diamond cutting disc, chips, drilling fluid.

INTRODUCTION

Rocks cutting machines were used to cut rocks in different sizes and shapes. They are divided into disc cutter, bar cutters (jibs) and cutters with an annular milling cutter. A rock cutting machine may be chosen on the basis of rock strength, size of produced rocks and the rock saw technology to be practiced. Disc cutters are used when cutting rocks have an alternate compressive strength σ =10–250kgf/cm^2. Rock cuttings machines fitted with circular saws have capacity in mining rock of 4-20m^3/h. The merits of cutting machines with circular saws consist in simple design, reliable operation, and possibility of making cut of a minimum thickness (Rzhetsky,1985).

Universal rock cutting machine is designed for cutting large blocks of marble, memorized, limestone, etc. operating of this machine is up to 6–20m^2 per shift of saw cut in mining marble. The advantage of the machine includes reliable services, high output in cutting strong marbles, correct shapes and smooth surfaces of the cut out blocks demerits are restricted width and height of blocks, marble waste, due to a width of saw-cut of 34–36mm (Rzhetsky,1985). Diamond cutting of wheels 500-300mm in diameter has found wide application in the USA, France where they are used as the cutting element in small size rock cutting machines (Shigley and Mishike, 2001). A number of quarries where facing limestone and marble are mined e.g France presently operate machine felted with thin jibs (25-30mm) with cemented carbide bits. The capacity of the machine mining limestone is up to 5m^2 kerfs area per hour with tool stability equal 1000-1200m^2 of cut area.

To achieve comfortable operations in the laboratories / mining industries, specimen cutting machines are required. It is

suitable for cutting rectangular specimens or squared specimens. Specimen Cutting Machine has a wide area of usage and for this reason its design and construction is necessary.

Specimen cutting machines are used to cut specimen strips which are used to carry out tensile tests on foils. Also, specimen cutter is used for precision cutting of copper, brass, steel or non-metallic materials in cross sections range. A thin abrasive wheel can be used and highly accurate cutting length can be achieved. Cutter machine is widely used in various metallurgical laboratories, cutting variety of metallographic specimens.

Rock / Concrete/Masonry, saw cutting machine can be used to cut rock cores. Concrete cores, stones, building materials and metallic specimens. A smooth finish cut can be made with the machine in either wet or dry operation according to the nature of specimen (Cutters are at extra cost). The specimen cutting machine is designed to cut up to 200 mm (specify the size of deep cut required in the specimen) deep cut in the Concrete, Stones, Tiles, Soft rocks and Hard rocks or any other similar material. To cut metal and easily, you need Plasma Metal Cutting Machines. Use ATE Inverter based Plasma cutting machines for visibly clean cuts. No post-grinding operation, no cleaning. Just cut with the torch and you are sorted.

CONSTRUCTION AND DESIGN METHOD

Manufacturing Process

Manufacturing processes involved the production of different component of the Specimen Cutting Machine Marking out processes were carried out using measuring tape, ruler, scriber, steel rule punch and engineering tri-square. The tape rule was used to measure out the required dimensions while the scriber inscribed points, lines and areas. The engineering tri-square was used to check for squareness of the angle bar and metal plate, that was cut out or welded together. The oxy-acetylene gas cutting flame was used in cutting thick metal plates on the table of the machine to the required dimension.

The hack saw was used to cut the angle iron. Also, the cutting disc was used in cutting sheet and plate metals. The various parts were ground and chamfered for good surface weld.

Parts of the main frame were joined together by first tacking using an arc welding machine, after which the frame (the stand and the water tank hood) was checked for squareness and alignment before proper welding.

The processing machine, the shaft, roller, roller rod, was first center drilled on the lathe and machined to the required dimension. Electric arc welding specification is an area concerned with the particular welding electrode gauge. Electrode having standard wire gauge size of 10 and 12 were used.

Machinery Requirement

These are equipment necessary for the production of the different component of the machines (the rollers, the rollers shaft, shaft of the diamond blade, etc) in the workshop either fabrication or machine tool workshop.

In the machine tool shop, the following machine tools were used: lathe, grinding and drilling machines. While in the fabrication shop, the following equipment were used oxyacetylene gas welding set, arc welding machine, bench vice, hack saw, bending machine and guillotine machine.

Assembling of Machines

These involve bringing together all the manufactured parts to form the machine. Before assembling, the different parts were painted to prevent corrosion and rusting of the exposed parts.

Some of the parts were fastened together with the help of belt and nuts while other parts were welded together. The fastened parts would allow for easy disassembly for maintenance work to be carried out.

Table 1. Cost involved in the manufacturing of specimen cutting machine

S/N	DESCRIPTION	QUANTITY DESIGN	UNIT COST N . K	AMOUNT N . K
1	75mm x 75mm Mild Steel Angle Iron	2	6500	13000
2	1.5mm mild steel sheet	2	8500	17000
3	60mm diameter roller	4	3000	12000
4	Water pump 3 phase h.p 3 phase	1	25000	25000
5	3Hp Electric-motor (2400 r p m)	1	32000	32000
6	40mm diameter mild steel shaft (lo 600mm)	2	4000	8000
7	80mm mild steel round pipe (long 600mm)	2	3200	6400
8	Ball Bearing (diameter 40mm)	2	800	1600
9	Ball bearing (diameter 15mm)	4	400	1600
10	25mm galvanise round pipe	1	3800	3800
11	25mm mild steel flat bar	1	850	850
12	12mm mild steel plate (600mm x 600mm)	1	8000	8000
13	120mm diameter pulley (two-way)	2	3500	7000
14	25mm diameter rod	1	8500	8500
15	75mm x 50mm U- channel	1	10500	10500
16	Helical spring diameter 30, 159 mm long	1	1500	1500
17	Rectangular shape 150 mm long	1	2000	2000
18	Hose	3yards	250	750
19	Switches	2	8000	8000
20	Bolts and nuts	Sum	4000	4000
21	Cutting disc	4	500	2000
22	Grinding gin	2	500	1000
23	Electrode (gauge 10)	1 packet	1500	1500
24	Diamond blade (350 diameter)	1	15000	15000
25	Tap cooler, 314 m	1	1800	1800
26	Paint	2 Cup	1200	2400
27	Labour			
28	Miscellaneous			
29	Total			N195,200.00

Bridge Cutting Machine

This bridge cutting machine is suitable for cutting granite, marble, microcrystalline stone. This stone cutting machine is mainly used for cutting and processing for the marble and granite stone slab.
Diameter of circular sawing blade 350-500mm
Rotating speed of circular sawing blade: 2300 r/min, adjustable
Working table (long x wide) 3200 x 1980 mm
Maximum obliquity of working table 8-85
Rotary angle of frame head 0-90
Rake Angle Cutter 0-45
Rotary angle working table 0-360
Maximum lifting travel of sawing blade 250 mm
Max processing sixe 3200 x 1900mm
Maximum thickness of cutting 0-80mm
Speed of travelling rightward or leftward 0-20m/mm
Speed of travelling frontward of backward 0-12 m/mm

Electronic Motor

An electric motor is an electromechanical device that converts electrical energy into mechanical energy. Electric motors are found in applications as diverse as industrial fans, blowers and pumps, machine tools, household appliances, power tools, and disk drives. They may be powered by direct current, e.g. a battery powered portable device or motor vehicle, or by alternating current from a central electrical distribution grid or inverter. The smallest motors may be found in electric wristwatches. Medium-size motors of highly standardized dimensions and characteristics provide convenient mechanical power for industrial use. The very largest electric motors are used for propulsion of ships, pipeline

compressors, and water pumps with rating in the millions of watts. Electric motors may be classified by the source of electric power, by their internal construction, by their application, or by the type of motion they give.

Effect of Cutting Fluid

Cutting fluid, are used in metal machining for a variety of reasons such as improving tool life, reducing working piels thermal deformation, improving surface finish and flushing away chips from the cutting zone. Practically all cutting fluids presently in use fall into one of four categories:

- Straight oils
- Soluble oils
- Semi-synthetic fluids'
- Synthetic fluid.

Straight oils are non-emulsifiable and are used in machining operations in an undiluted form. They are composed of a base mineral or petroleum oil and often contain polar lubricants such as fats, vegetable oils and esters as well as extreme pressure additives such as Chlorine, Sulphur and Phosphorous. Straight oils provide the best lubrication and the poorest cooling characteristic among cutting fluids.

Synthetic fluids contain no petroleum or mineral oil base and instead are formulated from alkaline inorganic and organic compounds along with additives for corrosion inhibition. They are generally used in a diluted form (usual concentration =3 to 10%). Synthetic fluids often provide the best cooling performance among of cutting fluids.

Soluble oil fluids form an emulsion when mixed with water. The concentrate consists of a base mineral oil and emulsifiers to help produce a stable emulsion. They are used in a diluted form (usual concentration = 3 to 10%) and provide good lubrication and heat transfer performance. They are widely used in industry and are the least expensive among all cutting fluids.

Semi-synthetic fluids are essentially combination of synthetic and soluble oil fluids and have characteristics common to both types. The cost and heat transfer performance of semi-synthetic fluids lies between those of synthetic and soluble oil fluids.

Specimen cutting machine with complete operation for precision cutting of copper, brass, steel. Alloy steel or non-metallic materials in cross sections range. A thin abrasive wheel can be used and highly accurate cutting length can be achieved.

Model Mret-2012 Specimen Cutting Machine

This machine is especially suitable for using in colleges, industries, laboratories, material researching institutes.
A shield is provided which guarantee the safety of operator.

The cooling system with good coolant can take away the heat of cutting so as to protect the structure from being burned. During cutting, the specimen can be adjusted in any angles, which helps to avoid the minor burning when the specimen is cut to fall.

Technical specifications

1. Maximum cutting diameters: 65mm
2. Rotating speed: 2800 rpm
3. Diameter of cutting sand wheel: 250 x 1.5 x 32 mm
4. Power supply: $380V_n$ 3-phase, 50Hz
5. Motor: 1.5 KW
6. Dimension: 87 x55 x12 cm
7. Equipped with 60L cooling liquid tank.

Component:

The machine consists of cutting system illustrating system, lighting system, cooling system, cleaning system, control system.

RESULT AND DISCUSSION

After the construction, the machine was tested to check for required specification. The following test and evaluation were carried out on the machine with positive results.

Performance Test 1
The machine performance was tested by placing talc which is a soft rock on the rotary table tightened to the rotary table with bolt and nut by side and then depressed the pedal.

Evaluation Result

The rock produced is of standard with good shape, size and good surface finish.

Performance Test 2

The machine performance was tested by placing a more harder rock (granite) on the rotary table tightened to the rotary table with bolts and nuts by side and then depressed the pedal.

Evaluation Result

The rock produced is also of substandard with good shaped, size and good surface.

Design Consideration

The following factors were put into consideration in the design.
(a) MATERIAL SELECTION: - very many materials are available today in the engineering field for designing of engineering components and products, proper and accurate selection must be made for this function to play in the entire machine production. Also selection of materials of this machine were based on the mechanical and physical properties of material, putting into consideration the hardness, corrosion resistance, brittleness, ductility, stiffness, creep, toughness or resilience stress elasticity and plasticity of materials.
(b) COST: - the cost of materials used and the amount of space occupied were also kept to minimum. Since local material were used and the size was to the tolerable minimum, the need for unnecessary cost had seen withhold, hence the machine is cheap and readily available for uses in school laboratories and industries.
(c) SIZE AND WEIGHT: - the dimension of the product is to the bearable minimum. Weight of the machine is not too much because it was considered so that the machine can be movable where ever it is needed.

Description of Machine

The specimen cutting machine consist of the working table, standing, rotary table, adjuster (pedal).
Also among the components of the machine is a tensional compressive spring, water tank, diamond cutting blade, rollers, pulley and electric motor.

The adjuster on the other hand is pivoted to the downward vertical cylindrical bar at the centre under the table connected to the pedal is the tension spring which helps to pull the pedal after has being depressed.

The spring is hooked to the bottom still under the working table, the standing frame and part of the working mechanism is covered by metal sheet to protect against damage and by means of beautifying the machine.

The entire machine is 72cm by 100cm and height of 120cm and can be operated by semi skilled operator, the operator can stand using the hands to load and unload the specimen when operation is been carried out using the specimen cutting machine. The machine is capable of cutting a rock at a time it is very economical for a small scale producer because the cost of maintenance is very low and the manufacturing process is considerably low. The designed machine is shown in Plate 1.

Figure 1. Specimen Cutting Machine

Maintenance of the Machine

Maintenance is the act of keeping the machine in good working condition at all time with minimum cost (Nwachukwu, 1994).

There are different types of maintenance operations or culture:

1. Preventive maintenance
2. Corrective maintenance
3. Emergency maintenance
4. Running maintenance

Preventive Maintenance: This is best for effect performance of any machine. This tends to optimize the operation of the machine.

Preventive maintenance goes through the following stages:

i) Inspection
ii) Servicing
iii) Adjustment
iv) Replacement

Inspection: Constant inspection must be carried out on this machine to enable the operator detect fault that are likely to occur. The welded joints should be checked or inspected. The pin joints and other joints on the machine should be checked.

The machine should be inspected for rusting and this could be prevented by painting the machine with lead paint or common oil paint.

Servicing: Cleaning and lubrication of operations should be carried out if the moving parts are not working smoothly, they should be cleaned and greased to avoid failure that might lead to process stoppage, particularly the pin joint.

Adjustment: Any part that needs adjustment should be adjusted and slackened ones should be tightened constantly. Also the spring if slackened should be adjusted.

CONCLUSIONS

The constructed machine is used to cut rock, specimen and samples. Highly accurate cutting length is achieved with the machine. The materials used are locally available with the installation of cooling system that takes away the heat of cooling so as to protect the structure of specimen from being burnt.

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