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## DESIGN AND DEVELOPMENT OF ELECTRICAL SWITCH BOARD (LAMINATED) SLOT CUTTING MACHINE

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**Abstract:-**The electric switch Slot Cutting Machine (SCM) is the special purpose machine used for slot cutting operation on electrical switch wooden board i.e. plywood with laminate and there is a continuous requirement of laminated electrical switch board for electrical shopkeepers. We have to cut the slots for switch/socket on the board as per required dimensions. A very few machines are available in the market to perform this operation and those are little bit expensive. The objective of this work is to design and fabricate electric switch board Slot Cutting Machine (SCM) which would be more economical as compare to traditional slot cutting machine. The performance of SCM is compared with conventional slot cutting machine and comparative study carried out with their functional productive perspective. The SCM machines cuts multiple slots at a time. The results indicate that the SCM had given better, accurate and faster results when compared with conventional slot cutting machine. SCM reduces cost and effort of cutting slots in wooden board to a great extent in batch wise production.

**Keywords -** Switch/Socket slots, slit cutters, driver and driven pulley, stud, electric motor, worm and worm wheel pair, belt drive.

### I INTRODUCTION



There is a continuous requirement of laminated switch boards essential for electrification in construction activity. It has almost consumer item in residential and commercial sectors. There is considerable increase in rural and urban housing. Plywood is generally used for manufacturing of these boards. Wood with required size is cut and assembled into the boards in different sizes 200mm × 250mm, 200mm × 150, 150mm × 150mm, 150mm × 100mm having thickness 3mm to 5mm. We have to cut the slots for switch/socket on the boards for electric wiring as per requirement. Very few machines are available in market to perform this operation and are costlier. In convectional Slot cutting machine, maximum time is

required for loading and unloading the wooden board and tool setting for every single slot. This is idle time, which reduces the production rate. We have introduced a special purpose machine for slot cutting operation on wooden boards. Electric switch board slot cutting machine (SCM) helps to obtain uniform cutting with less human efforts. It can be used for better, accurate, and faster slot cutting operation compared to the Convectional slot cutting Machine.

### II. LITERATURE SURVEY

Electric switch board machine started to use form many decade ago and it is very essential machine for electrical shopkeeper. Various research has been carried out on this machine for manufacturing and production oriented point of view and some of research work described as follows:

Sreejith K., Aravind K., Danie Davis, Farish K.A., George Johnson designed fabricated and experimented the working of Pedal Driven Hacksaw (PDH). PDH is working on Slider Crank Mechanism. The experiment was done using PDH and plywood work pieces. The main parts of PDH are hack saw, reciprocating rod welded to the pedal of a bicycle, flywheel, sprocket and chain drive. The hack saw is connected with the reciprocating rod. By pedaling the bicycle the reciprocating rod moves to and fro, the hack saw will be moving with the rod. The plywood to be cut is placed under the hack saw. [1] Dharwa Chaitanya Kirtikumar designed and developed a

multipurpose machine which does not require electricity for several operations like cutting, grinding etc. This is a human powered machine runs on chain drives mainly with human efforts. But if you wanted to operate this machine by electric power this machine can also does that. It has some special attachment so use both human power as well as electric power [2], C. B. Norris, Fred Werren, P. F. Mckinnon experimented and analyzed the effect of veneer thickness and grain direction on the shear strength of plywood [3], J. Kovac, M. Mikles, Research on individual parameters for cutting power of woodcutting process by circular saws journal of forest science in 2010 [4] , Madekar, K. J., Nanaware, K. R., Phadtare, P. R., & Mane, V. S. Automatic mini CNC machine for PCB drawing and drilling in 2016 [5], Sathyakumar, N., Balaji, K. P., Ganapathi, R., & Pandian, S. R.(2018). A Build-Your-Own Three Axis CNC PCB Milling Machine [6], Dhirajkumar V. Patil, Nitin B. Naikwadi, Nikhil V. Patil, Nayan D. Sonawane, Prof. Kunal U. Shinde, Design And Fabrication of portable PCB Plate Cutting Machine in 2018 [7], Choudhary, R., Titus, S. D., Akshaya, P., Mathew,J.A., & Balaji, N. carried out work on CNC PCB milling and wood engraving machine in 2017 [8], Lo, T. M., & Young, J. S. has been work on improvements of productivity for PCB drilling by laser driller machine during 2014.[9]

**III WORK SPECIFICATION**

Table 1: Laminated wooden boards size

SR No.	Board Size	Number of switches	Number of Sockets
1.	200mm×250mm	6	2
2.	200mm×150mm	5	3
3.	150mm×150mm	3	3
4.	150mm×100mm	2	2

Slot Size: Slot for Switch: 20mm×36mm×4mm, Slot for Socket: 36mm×36mm×4mm

**IV WORKING PRINCIPLE OF CONVENTIONAL SLOT CUTTING MACHINE.**

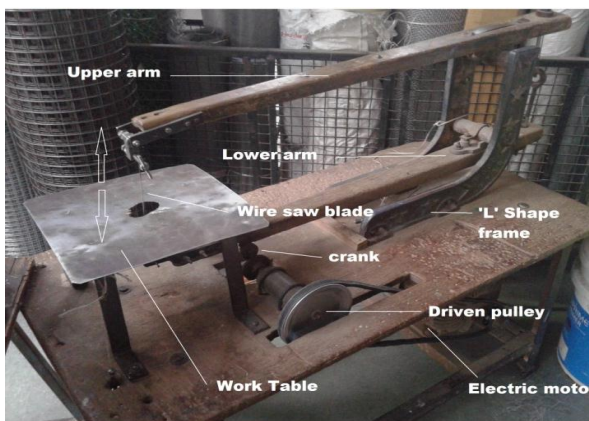


Fig 2: Conventional slot cutting machine

This machine is driven by an electric motor (1 HP) fitted on the base frame. There are two oscillating wooden arms (upper and lower) connected together with the help of molded 'L' shape frame at one side. Wire saw blade is fixed to the ends of the upper and lower arm. Lower arm is connected to crank

which is pivoted to the shaft of driven pulley. As the pulley rotates, lower arm oscillates and wire saw moves in upward and downward direction. Only one slot can be cut by using conventional slot cutting machine.

4.1 Slot cutting operation on wooden board using conventional machine.

a) Marking on wooden board: precise marking is required for accurate cutting operation. It is done by manually for each single slot.

b) Drilling in each slot: Drilling is required to wound wire saw in each whole while cutting operation. Generally φ8mm drill is used.

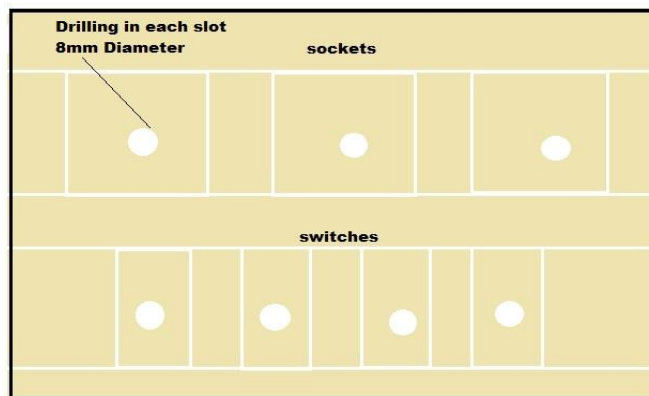


Fig 3: Marking and drilling process

c) Wound the wire saw in each hole for cutting operation (Tool setting).

d) Slot cutting process: Wire saw cuts the slot according to the feed and speed of the oscillating arms. Wooden board is free to move in horizontal direction to obtain desired slot with accurate shape.

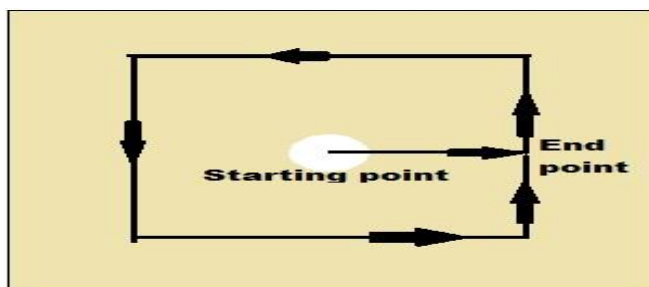


Fig 4: Cutting path generation

**4.2 Average time required for slot cutting operation in conventional machine.**

Table 2: Time required for each slot

Operation No.	Process	Time for each slot(sec)
1.	Marking on board	60
2.	drilling	30
3.	Wire saw wounding & setting	30
4.	Cutting (feed 0.5mm /oscillatio	180
Total time required for each slot =		5minutes

Table 3: time required for one board

SR No.	Board size	No of slots × time	Total time(min)
1.	200mm×250mm	8 × 5	40
2.	200mm×150mm	8 × 5	40
3.	150mm×150mm	6 × 5	35
4.	150mm×100mm	4 × 5	20

**4.3 Cost required for cutting operation:**

Average cutting time for one board= 15 minutes.  
 Electric motor power= 1HP= 0.746 KW  
 Power consumption in cutting operation  
 = 0.746 × (15÷60) =0.1865 kw.hr  
 Electricity Cost = 0.1856×7 Rupees per unit = 1.31 Rupees/board.  
 Average labor cost for one board= 14 Rupees.  
 Average tooling cost for one board= 2 Rupees.  
 Total cost= Electricity cost + Labor cost + Tooling cost  
 = 1.31 + 14 + 2 = 17.31 Rupees for one board

**V ELECTRIC SWITCH BOARD SLOT CUTTINGMACHINE (SCM) USING SLIT CUTTERS.**

Instead of wire saw; slit cutters are used in SCM. These are made up of High Carbon Steel (H.S.S) having diameter 25mm to 32mm with 1mm thickness.



Fig 5: HSS slit cutters

**5.1 MAIN COMPONENTS OF SCM**

The main parts of SCM are slit cutters which are mounted on arbor, spacers, molded frame, electric motor, pulley and belt drive. Drive pulley is mounted on electric motor shaft and it drives the driven pulley which is mounted on the arbor. Slit cutters rotate with arbor and perform cutting operation. The wooden board to be cut is placed under rotating slit cutters.

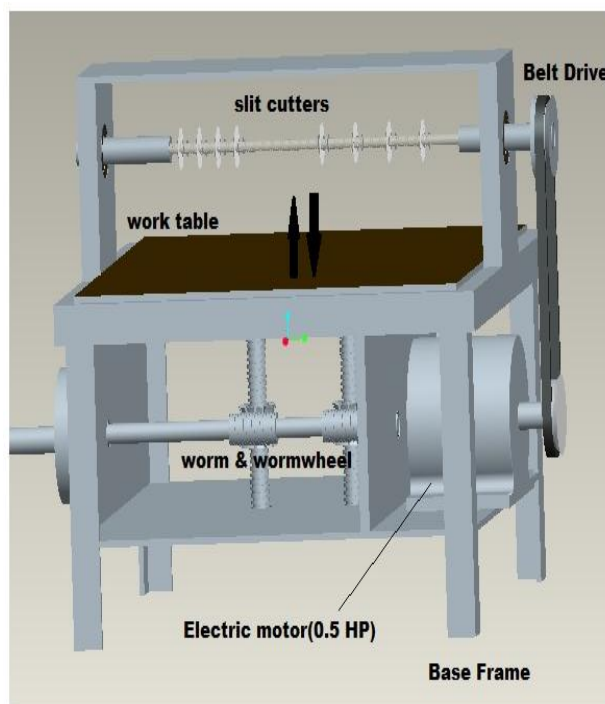


Fig 6: Switch board slot cutting machine using slit cutters

The following table no 4. Shows the detailed parts of SCM machine

Table 4: SCM components

No.	component	Size	Qty
1.	Base frame	450 mm×450 mm	1
2.	Electric motor	0.5 HP	1
3.	Slit cutters	ID= 8 mm, OD= 32mm	8 2
4.	Stud (M8)	Length= 350mm	1
5.	Hollow shafts	ID = 8 mm, OD=20 mm, Length=100 mm	2
6.	Sliding Bearings	ID= 20mm, OD=40mm	2

**5.2 Construction**

Slit cutters having internal diameter 8mm are mounted on the M8 stud (350mm length) using nut and washer. The distance between two slit cutters is maintained by provide spacers in-between them. Stud is screwed into hollow shafts at both ends. Driven pulley is mounted on the one end of hollow shaft. Belt drive is used to transmit power from electric motor to the driven pulley. Work table can move in vertical direction using worm and worm wheel pair at bottom of the table which operates manually.

**5.3 Slot cutting operation on wooden board using conventional machine**

a) Marking on wooden board

Metal sheet templates are used for marking on wooden board which reduces the marking time compared to conventional marking process.

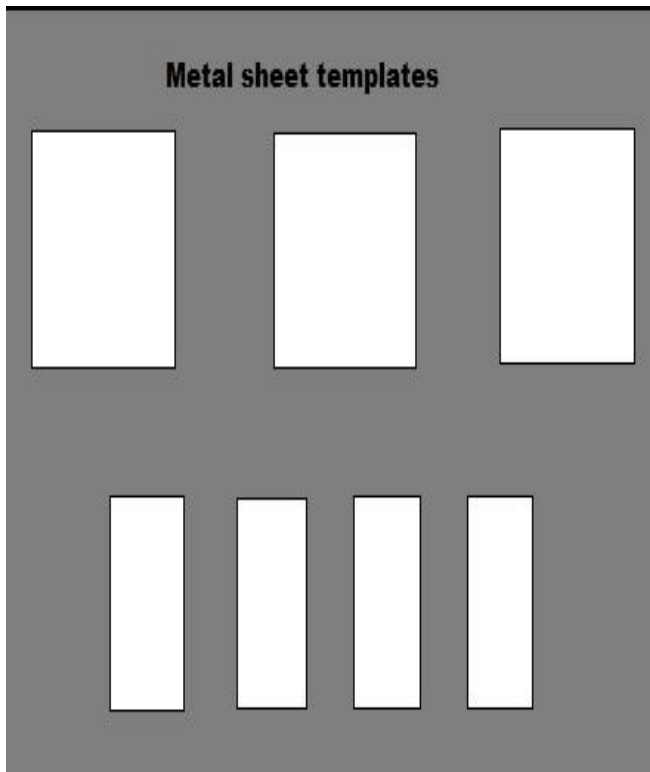


Fig 7: Metallic marking template

b) Working of SCM

Electric motor drives the SCM and belt drive transmit motion from driver pulley to driven pulley. Slit cutters mounted on the stud start rotating in down milling direction to avoid wooden dust spread in front of operator. Vertical movement is given to the table by using worm pairs to provide depth of cut. Slit cutters having 32mm diameter and 25 mm diameter are used to cut corresponding sockets and switches. At time 3 slots can be cut using SCM.

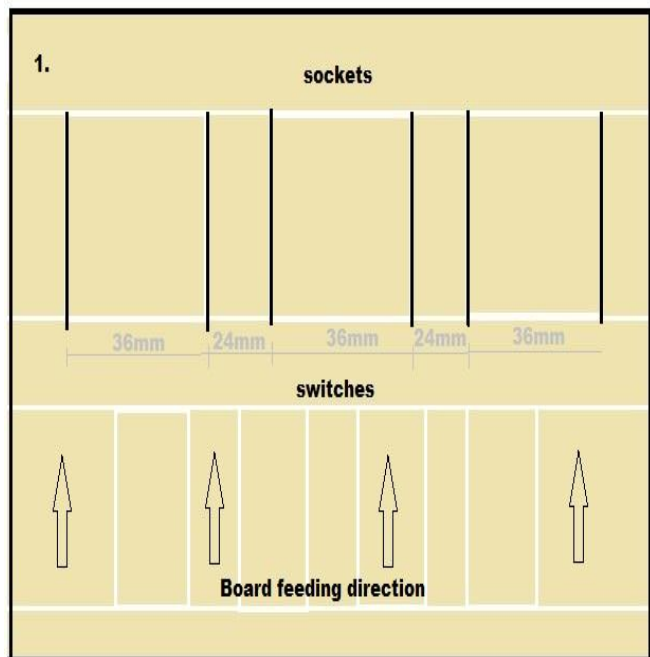


Fig 8: Cutting path generation at first move

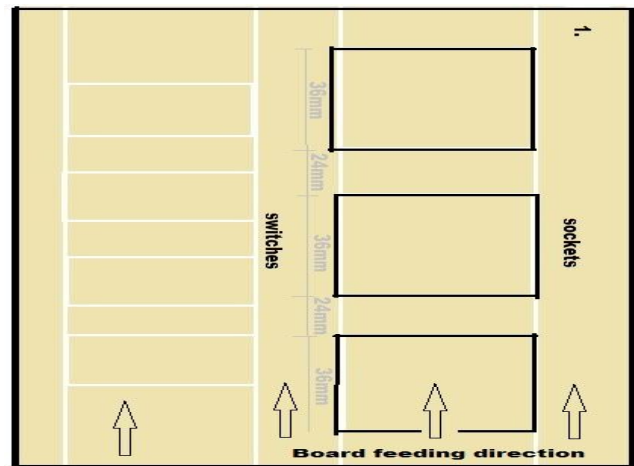


Fig 9: Cutting path generation at second move

5.4 Average time required for slot cutting operation in SCM

Table 5: Time required for one board in SCM

Operation No.	Process	Time (sec) for one board
1.	Marking on board	60
2.	Tool setting	120
3.	Cutting	300
Total time required for each slot =		8 minutes

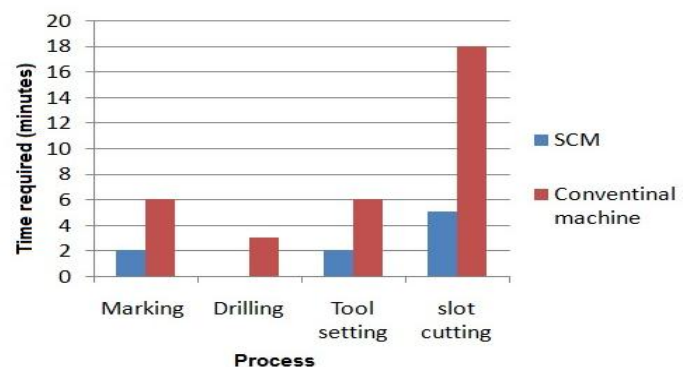
5.5 Cost required for cutting operation

Average cutting time for one board = 5 minutes. Electric motor power = 0.5 HP = 0.373 KW. Power consumption in cutting operation is  $0.373 \times (5 \div 60) = 0.0311 \text{ kw.hr}$

Electricity Cost =  $0.0311 \times 7 \text{ Rupees per unit} = 0.2175 \text{ Rupees/board.}$

5.5.Benefits of SCM compared to Conventional machine

Time: Time required for cutting operation in SCM is less than conventional machine. Marking templates reduces the time required for precise marking.



Graph 1: Time study of SCM and conventional machine

Cost: SCM Machine cost is less than conventional machine. Less labor cost required because of minimum human efforts. In process cost is less because of slit cutter life is more than Wire saw cutter. Electricity cost in SCM is less than



conventional machine. SCM cuts multiple slots which increases production rate. Human effort required in SCM is less than conventional Machine. SCM is portable than conventional machine. Initial tooling cost is more than tooling cost in conventional machine. The 10 Pieces of wire saw is 20 rupees and for the 10 slit cutters is 950 rupees.

#### VI FUTURE SCOPE

This type of machine may converted into the automation with help of robotics and reduces the human efforts. In the automatic machine marking carried out with help of laser and may operate on using micro controllable base operation and we can cut the slot automatically with help of AutoCAD drawing provided to the machine. And in this machine cutting and drilling operation can be synchronize. And also the laser cutting machine can be manufacturing for the wooden board up to 5 mm to 6 mm thickness wooden ply cutting. But only cost of machine may increases. The automatic slot die and punching machine can be design and developed with the some limitation of thickness of play to be cut. Suitable 3D printing machine using Fuse Deposition modelling (FDM) can be developed for the various sizes and attractive creative designs.

#### VII CONCLUSION

The performance of SCM is compared with conventional slot cutting machine; SCM cuts multiple slots at a time. The results indicate that the SCM had given better, accurate and faster cutting slot when compared with conventional slot cutting machine. SCM reduces cost of Manufacturing of single slot cutting board i.e. and its required very less effort of cutting slots in wooden block to a great extent in continuous batch wise production.

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