DESIGN AND DEVELOPMENT OF SLOT CUTTING MACHINE FOR CHOPPER BLADES

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Abstract: In this project a slot cutting machine suitable to cut slots in the chopper blade used in sugarcane harvester is designed and fabricated to suit the needs of the company. Manual operations carried out for making slots in cutting blades used in sugarcane harvesting machines is made automatic. The raw material is clamped to the fixture and is made to come in contact with the running diamond cut off wheels powered up by an induction motor which is used to make the slots. All the components required for the design of the slot cutting machine are placed on a single table.

The project is undertaken to modify the slot cutting method in the industry KG Sugarcane harvesters located in Tirupur. The machine is powered by a 3 hp motor and it takes 4mins to remove slots in one blade, where the past handy method takes about 10min. Each blade consists of 4 slots which cuts one after another by manual feeding with the help of a lead screw energized by a hand wheel. The blade has to be aligned separately for each slot manually. The width of each slot is 16mm. The slots that have been made in chopper blades are used in sugarcane harvesters.

***IndexTerms* – Slot cutting, chopper blades, diamond cut off wheels..**

I. INTRODUCTION

Metal cutting process is a main operation carried out in almost all industries. Normally metal cutting operation is manually operated by hand in medium and small scale industries and so reducing the time required for carrying out the above said operations is required. It also ensures increased productivity with reduced labour cost and time. Nowadays almost all the manufacturing process is going through automation in order to deliver the products at a faster rate due to the increase in demand and lowered waiting time by the customer for the product. In order to remove the gap a slot cutting machine is designed and fabricated for the industry. Even though automation can be achieved in many ways say through computers, hydraulics, motorized, robotics, etc., not all the above said automated processes are required to fulfill one specific automated process in a specific machine. In order to solve this issue a slot cutting machine is designed with only the required automated process as per the guidance and need of the industry. Hence replacement of all manual working habits to full automation is not suitable. Therefore a slot cutting machine is designed which is suitable for the industry which performs their specific work only and it forms an attractive medium for low cost automation. This project is done in the industry and for the industry. This chapter deals with the industrial automated operations with its advantages, limitations and problems faced by the industry, with the objectives and scope of the proposed solution on slot cutting operations for the industry.

1.1 Present scenario

Presently this industry is making spares for many agricultural implements and exclusively cutting blades for machineries related to agriculture. Currently the labours use normal cutting wheels and angle grinding operations to make slots in these cutting blades and it requires highly skilled labour which consumes a lot of time for undergoing the stated operations with the required standards. An idea of designing and manufacturing a slot cutting machine was developed to perform the cutting and grinding operations with the desirable precision and accuracy without depending on the speed and efficiency of the worker.

1.2 Problem statement

Making of slots in the cutting blades is done manually by marking straight lines and fixing it in any one form of job holders available to ensure that the work piece is aligned in the required form and direction. After which it is cut with the help of an angle grinding machine. In order to make a single slot a cutting machine is used to make two straight lines with the required distance as per the specifications. Sometimes the cutting is not accurate, tapered paths are formed which becomes unavoidable.

Even with high concentration and high amount of energy, creation of burrs can't be avoided and this leads to another operation for removing the burrs formed. Only one cut is made in a single operation and this process is done by the labors manually. The speed of the job always depends upon the working capability of the person carrying out the operations.

1.3 Scope of the project

In this project a slot cutting machine is designed and fabricated to carry out the same operations which were done manually in an automated way. By doing so the cost spent on labor and the waiting time of the customer also decreased to a large extent and it was found that a special operation for removing burrs was reduced since no burrs were formed while carrying out the operation in the newly designed slot cutting machine. With the usage of this newly designed machine mass production can easily be achieved which directly increases the efficiency of the plant. It also reduces man power, work load, production cost, production time, material handling time and mainly removes the stress on the worker. This is proved because the number of operations performed was reduced from seven to three with the help of the newly designed slot cutting machine.

1.4 Objective of the project

To design and develop a slot cutting machine suitable to cut slots in the chopper blades used in sugarcane harvesters and to evaluate the performance characteristics.

II. LITERATURE SURVEY

Chihat bohra yisit et al., (2010) made a clear study of belt and pulley drive and reported that pulley system is characterised by two or more pulleys in common to a belt. This allows for mechanical power, torque, and speed to be transmitted across axles. If the pulleys are of differing diameters, a mechanical advantage is realised. A belt drive is analogous to that of a chain drive however, a belt sheave may be smooth devoid of discrete interlocking members as would be found on a chain sprocket, spur gear, or timing belt so that the mechanical advantage is approximately given by the ratio of the pitch diameter of the sheaves only, not fixed exactly by the ratio of teeth as with gears and sprockets. Just as the diameters of gears and correspondingly their number of teeth determine a gear ratio and thus the speed increases or reductions and the mechanical advantage that they can deliver, the diameters of pulleys determine those same factors.

From the study of Fenner Power Transmission UK, 2011 belt and chain drives are used to transmit power from one rotational drive to another. A belt is a flexible power transmission element that runs tightly on a set of pulleys. Chain drive consists of a series of pin-connected links that run on a set of sprockets. This chapter introduces various types of belt and chain drives and presents selection procedures for wedge, synchronous and flat belts and also for roller chains. Belt and chain drives can be used for transmission of mechanical power between two rotating shafts. Belt drives are often cheaper than the equivalent gears and useful for transmitting power between shafts that are widely separated or nonparallel drives.

Marian Dudziak et al., (2016) presented a test result of the quality of timing belt pulley. The quality of the pulleys have a significant impact on coupling timing belt with pulley. This is connected with the problem of the accuracy of movement and displacement. The majority of transport is realized by the use of conveyor belts. Parallel conveyors, manipulators, and electric actuators use movement with timing belts. The accuracy of motion, transmission with timing belt depends on the quality of belt gears, a special quality of pulley.

Hongliang Ren et al., (2017) presented a novel soft actuator with a 3D-printed elastic body based on a fused deposition modelling technique and with tendon actuation based on flexible shafts, which allow push, pull, and twist torque transmissions. The combination of the soft body and flexible shaft furnishes an easy-making, modular and functional unit that possesses softness and enables three degrees of freedom. We derive the kinematics and statics of the actuator based on the assumption of piecewise constant curvature, and identify the parameters experimentally.

Anting Wang et al., (2018) examined the performance of an axially loaded screw shaft pile by designing a model test that installed the screw shaft pile into a sand layer. The pile was subjected to a plate load test, to determine the pile's ultimate bearing capacity. A shaft pile was also installed as a control and subjected to the same test conditions. Digital image correlation (DIC) was applied throughout the test for better examination of the pile's performance. The test results were used to develop a discrete element model, which was used to assess the screw shaft pile's performance at the microscale.

Grzegorz Domeka et al., (2006) conducted a study on manual cutting of materials and stated that the manual cutting process ensures cutting of all kind of textile materials. In comparison with automated cutting, its productivity is much lower and the equipment is much more expensive. The repair and maintenance costs are small. For these reasons, the manual cutting process is widely used in small production units.

Ulrich Werner et al., (2008) stated that the bearing housing vibrations and the foundation vibrations are analysed with and without control system. It could be shown, that without vibration control system the operating speed range cannot be used completely because of resonances, caused by the soft foundation.

Therefore, critical speed areas occur, where steady state operation is not possible. However, with the vibration control system, the whole operating speed range can be used. The aim of the paper showed the capability of using a vibration control system with actuators between motor feet and a soft foundation, for avoiding off limits areas for the operation speed of large induction motor.

III. DESIGN AND WORKING

3.1 Conceptual design

The manufacturing of the component is discussed and the main components used in the design are diamond wheel, steel bench, induction motor, shaft, hub, pulley, belt, fixture, lead screw, hand wheel, bearings, spacer washers and the raw material for the work piece. The steel bench is designed and fabricated based on the size and the number of components that actually sit on the surface of the table. The dimensions of the table are manufactures as per the design. The whole steel bench is made up of mild steel. The mild steel material is cut as per the requirements using normal cutting processes and then it is joined together as per the design requirements and further it is joined by carrying out arc welding. The steel bench serves as the main component or structure of the entire project as it carries all the setups in it also the vibrations caused by the motor and also the tension and vibrations formed during the cutting operations. Hence extreme care was given to the design and the weld point of the steel bench.

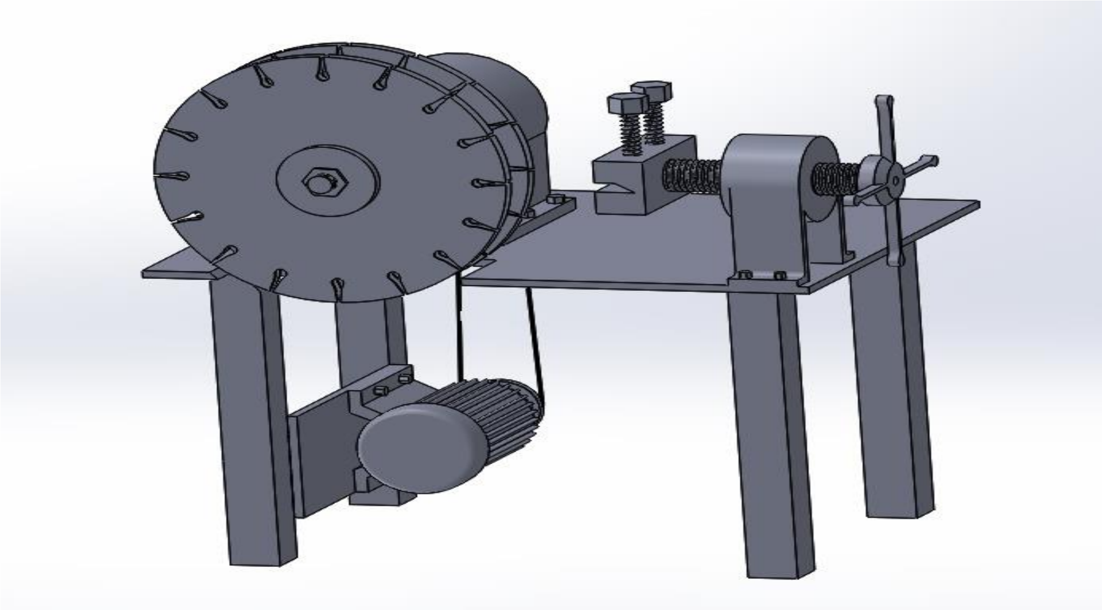

Fig: 3.1 Conceptual design

The purpose of a hand wheel is to move the lead screw front and back which further moves the work piece towards the diamond cutting wheel and away from the diamond cutting wheel. Spacer washer are washers used to ensure that a particular gap is maintained in between two elements. In this case there are totally three spacer washers used and out of which two spacer washers are of the same length and another spacer washer is of different length.

3.2 Working

At first the material EN 48 spring steel is purchased and cutted to its required length. Further the angle is about 10 degree and this is done in anther industry outside. After this the raw material is clamped to the fixture and tightened with the help of screws. The side along which the angle is made faces the opposite of the cut off wheels.

After the work piece is clamped to the fixture the work piece is moved towards the cut off blades with the help of a wheel which is driven manually. This wheel which is in connecting with the lead screw moves the work piece towards the cut-off wheels. The cut-off wheels are then run with the help of a motor as already discussed and this cuts the work piece. There are fur cut-off wheels attached to the shaft of the motor.

These blades are arranged in pairs which means that two cut-off wheels are required to make the slot. The motor is then run and the work piece is moved and for carrying out the cutting pertains. This is the working of the slot cutting machine which cuts the slots in chopper blades of a sugarcane harvester.

Fig: 3.2 Working Model

IV. Result and discussion

Experiments are performed on the diesel engine by varying fuel injection nozzle hole to arrive at optimum configuration. The results are discussed below.

4.1 Slot with manual methods

Set up time for holding of chopper blades	= 30sec
Time taken to single slot in chopper blade through an slot cutter	= 60sec
Total time requires for completing first slot	= 90sec
Total time requires for completing every one slot	= 180sec
Time for adjusting blades to next slot	= 30sec
Total time for making slots in a chopper blade	= 10min12sec

4.1.1 Table for slot vs time

Table: 4.1.1 Manual Slot Cutting

Slot No.	Time in sec
1	180
2	300
3	420
4	540

4.1.2 Graph of slot vs. time

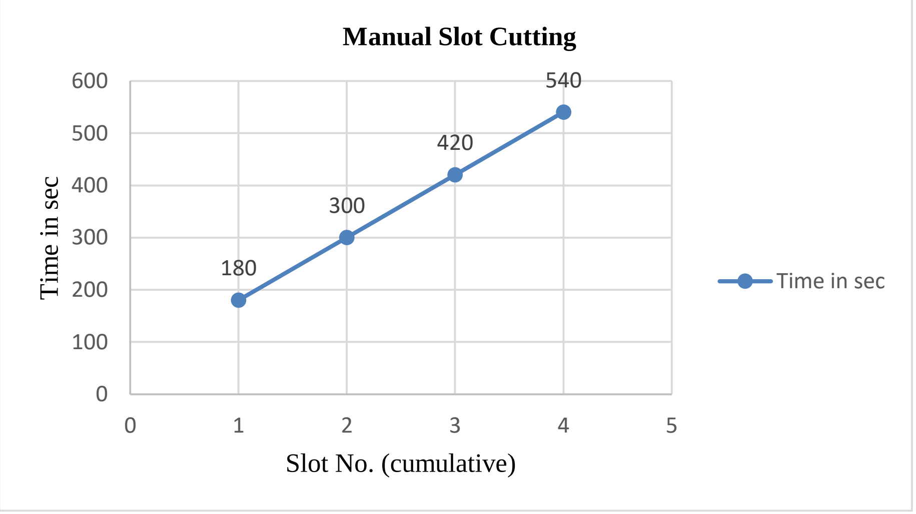

Fig: 4.1.2 Manual Slot Cutting

In this method of slot cutting, at first the chopper blade is holded in the wise and slot has been made by using angle grinding motor. It makes only a single cut but not a slot so the process is again repeated to make a slot. The set up time for the chopper blades is 30seconds, then the time taken make a single slot in chopper blade is about 60sec, the total time requires for completing first slot is 90 sec and the blades are aligned for the next slotting, further every slot is made one after another and the total time requires for completing every one slot is 180seconds. Every single slot takes about 30seconds without the aligning time and finally it takes 10minutes and 12 seconds to make all the slots in workpiece (chopper blades). The graph is inferred that the time is increasing with every single slots.

4.2 Slot cutting through slot cutting machine

Set up time for holding of chopper blades	= 24sec
Time taken to single slot in chopper blade through an slot cutter	= 25.5sec
Total time requires for completing first slot	= 49.5sec
Total time requires for completing one slot	= 45.5sec
Time for adjusting blades to next slot	= 20.5sec
Total time for making slots in a chopper blade	= 3min 17sec

4.2.1 Table for slot vs time

Table: 4.2.1 Slot Cutting Machine

Slot No.	Time in sec
1	49.5
2	95
3	140.5
4	186

4.2.2 Graph of slot vs. time

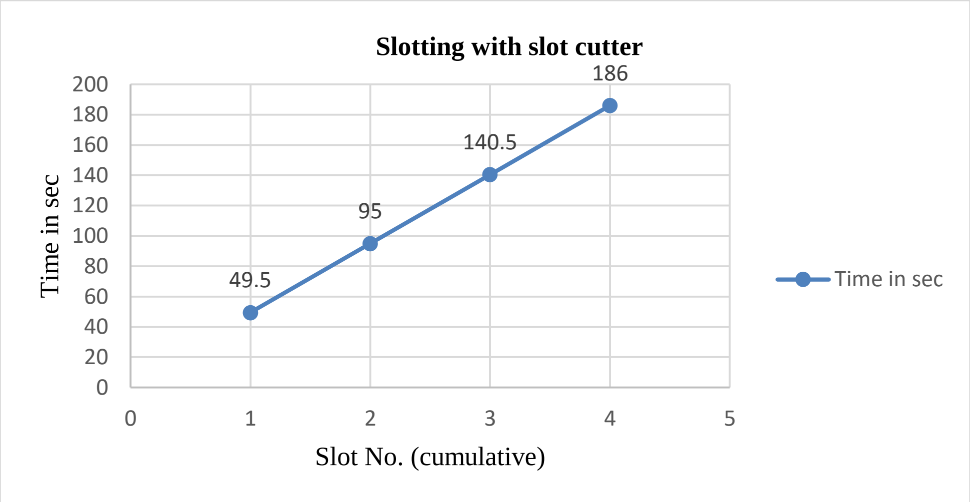

Table: 4.2.2 Slot Cutting Machine

In this method of slot cutting, at first the chopper blade is holded in the fixer and setup arrangements are made, the slot has been made when the chopper blades gets contacted with the diamond cut off wheel. The set up time for the chopper blades is 24seconds, then Time taken to single slot in chopper blade through an slot cutter is 25.5seconds, total time requires for completing first slot is 49.5seconds and the blades are aligned for the next slotting, further every slot is made one after another Total time requires for completing every one slot is 45.5 seconds. Every single slot takes about 20.5seconds without the aligning time and finally it takes 3minutes and 17 seconds to make all the slots in workpiece (chopper blades). The graph is inferred that the time is increasing with every single slots and time is saved when compared to previous handy methods.

V. RESULT AND CONCLUSION

Thus a slot cutting machine was designed and developed for cutting slots in chopper blades used in sugarcane harvester. The cost of machine is ₹ 34300 which is a reasonable price since the productivity is increased with the decrease in the amount spent on labour. The slot cutting through fully manual method takes 3:1 times as long as time consumed in slot cutting machine. The project was completed within the given amount of time and the project ended on a successful note. Skilled labour is not required to operate the machine. The project was completed with keeping in mind all the safety measures that are required while carrying out pertains on the machine.

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