Design and Development of Sheet Metal Cutting Machine For Circular Profiles

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ABSTRACT— The primary objective of this paper is to design and develop the sheet metal cutting machine for circular profile using continuous piercing operation. In order to obtain circular cutting of sheet of any dimensions, along with adjustable sheet handling setup for getting different size of circular profiles. Which result in more flexible use of machine, reduction in cost and increase in productivity. In many industries the circular profile of sheet metal is achieved by punching machines, CNC machines and by radial drilling machine. In case of small and medium scale industries using separate machines for different sizes of sheet and applications is not possible. This paper deals with design and development of sheet metal cutting machine for circular profiles using piercing operation. Instead of using punch, there is reciprocating single point cutting tool which is operated by Cam and follower mechanism, along with separate adjustable sheet holding arrangement, that enable to adjust the diameter of circular profile. The desire operation i.e., circular profile is achieved by combination of two mechanism, one is reciprocating motion obtained by cam and follower and the second mechanism is used to rotate and hold the sheet.

Keywords—Design and Development, Sheet metal cutting, Piercing operation, Circular Profile.

I. INTRODUCTION

In most of the industries the circular cutting of the sheet metal is done by the Punching Machines and CNC machines. But when it comes to small scale and medium scale industries, use of separate machines for sheet metal cutting for various applications is not possible. Even it is also not possible to use CNC machines due to cost factor. In most type of industries, sheet metal plays a vital role for variety of applications. Affordability is the main factor in case of small and medium scale industries. In order to increase the production rate and profitability, there is a need to reduce the cost for the sheet metal cutting. The use of piercing operation for sheet metal cutting will be cost efficient and affordable to small and medium scale industries. Instead of punch, there is single point cutting tool which reciprocates with help of cam and follower arrangement. This will result in cost effective machine for sheet cutting. Many work have been done to carry out the various operations, for that special machines, tools, fixtures are invented. Some inventor had tried to carry out the Sheet metal cutting operation by inventing different operations or special purpose machines. Merrill L[1]. Ridgway his invention of devices for cutting sheet metal. He developed machine which composed of two relatively reciprocal shearing members which make successive cut in a sheet as fed through the machine. Hans Poersch[2]. S. K. Maiti, A. A. Ambekar, U. P. Singh, P.P. Date, K. Narasimhan, [3], they have evaluated the influence of tool friction, sheet thickness, tool clearance, blanking layout and punch/die size on the sheet deformation for thin M. S. sheet. They give the punch load variation with tool travel and stress distribution in the sheet has been obtained. The results of that indicate a reduction in the tool clearance increases the blanking load.

The blanking load will increases with an increase in the coefficient of friction. The observations obtained are very similar to the case of blanking of component of large size. The sheet metal cutting using piercing operation is the best cost efficient way.

II. DESIGN OF COMPONENTS

a) Cam and Follower Design

A cam and follower mechanism is the mechanism which converts rotary motion into reciprocating motion. It is the main component as it give reciprocating motion to tool. Due to reciprocating motion of tool it will constitute piercing of tool in metal sheet. The arrangement is as shown in fig 1.1

The cam has base circle of 50mm and having stroke of 20mm. The cam is mounted on the shaft. The roller follower which is in contact with cam with help of spring is mounted on the front panel. Follower is also made up mild steel.

b) Sheet Holding Arrangement

The adjustable sheet holding arrangement is mounted on the extended steel bars to adjust the cutting diameter of sheet. Two plate clamped with nut and bolts which can slide over the lower extended bars. The High torque DC motor is bolted to downside plate which rotate the hole Sheet.

On the upper bars same arrangement of plate is mounted which can slide over upper bars. The vertical round bar has ball bearing which will give smooth rotation to sheet. The sheet is hold at centre of circular profile.

III. DESIGN CALCULATIONS

- **Force Calculations:-**

Shearing Force= Length of cut * thickness * shear Strength
where
Length of cut = 10mm
Thickness = 2mm
Considering Aluminum 6061
Shear Strength = 207MPa

Shear force = 10*2*207
shear force = 4140N(required to cut Sheet Metal)
Stripping force = 20% of Shear force
= 0.2* 12420
Stripping force = 2484N
Total Force = shear force + Stripping Force
= 4140 + 2484
Total Force = 6624N

Considering
Inertia Force = m * a
acceleration = v^2 /r
velocity = r * w
Angular velocity = (2 * 3.14 * 1400)/60
= 146.61 rad/sec
velocity = 146.61 * 0.01
velocity = 1.46 m/sec
acceleration = 213.16m/s^2
Inertia Force = 5*213.16
Inertia Force = 1065N

Total Force Acting of Tool
= Inertia Force + Shear force + Stripping Force
= 1065 + 4140 + 2484
=7689N

- **Power Calculation**

Torque = force * radial distance
= 7689 *0.005
= 38.49
Power = 0.967 kW

- **Dc motor calculations**

Holding Force = 49.05N
Motor - Geared
Voltage – 12 volt
Torque – 313.92 N-cm
RPM – 30 rpm
Base Motor – 18000 rpm
Shaft diameter – 6 mm
Shaft length – 30 mm
Weight – 180 gm
Load current – 7.5 A (Max)

- **Material Selection For Tool**

Stress = Total Force on Tool/Area
Area = 10*2 = 20mm^2
Stress = 7689/20
Stress = 384.45MPa
FOS = 4
Selecting Material
AISI D2 steel (Commonly used for piercing operations)
Yield strength =2150 N/mm^2
Poisson's Ratio = 0.3
Young's Modulus = 210000 N/mm^2
Tensile strength = 1736 N/mm^2
Compressive Yield strength = 2150 N/mm^2

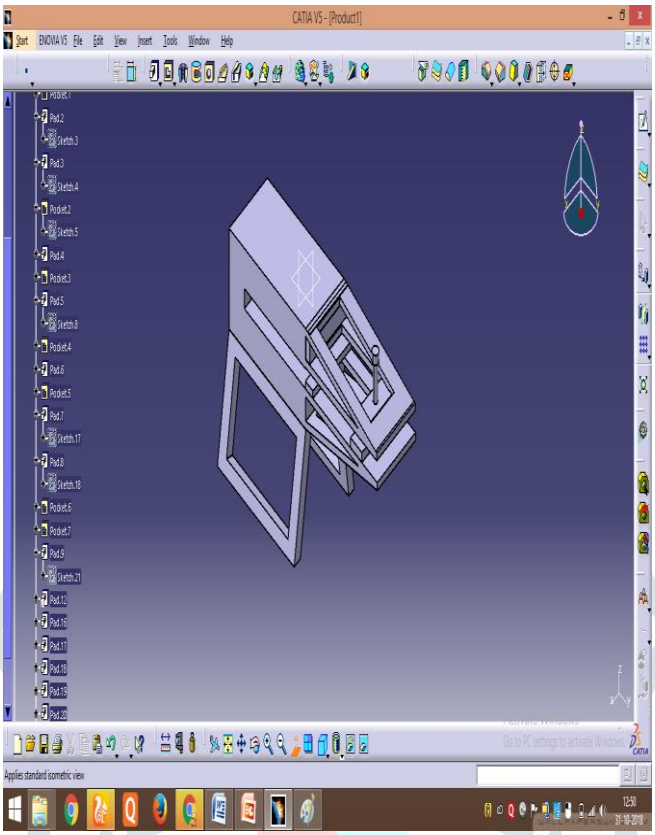

Fig 1:- CAD Model

Fig 2:- Cam and Follower

Fig 3:- Assembled view

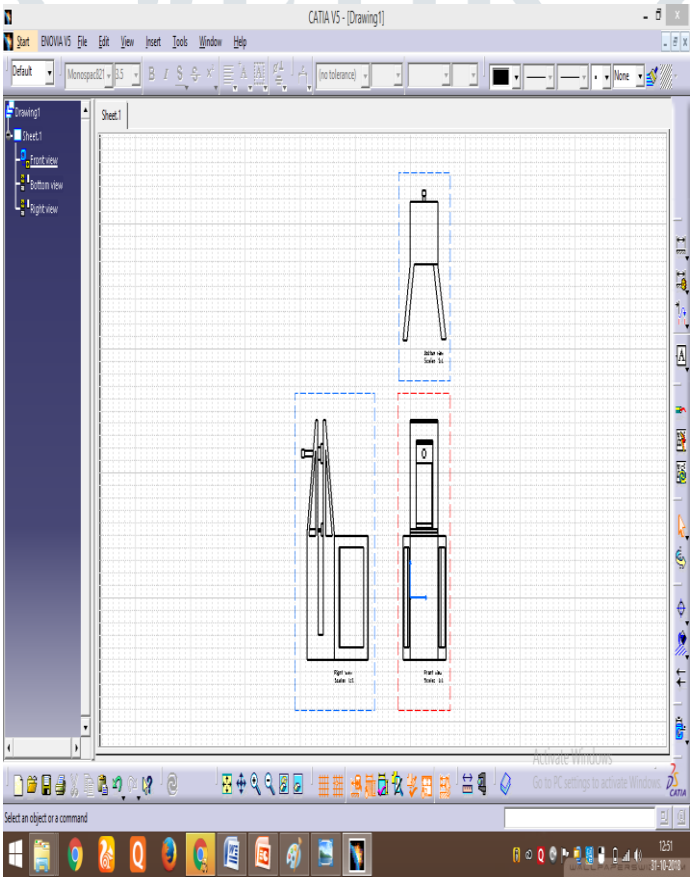

Fig 4:- Drafting of machine

IV. ASSEMBLY OF MACHINE

As shown in the above figures, the cam and follower arrangement mounted on front panel of machine. The cam is mounted on the shaft which is supported by two wall mount bearings one at front panel and second at backside paned.

The shaft is driven by the motor whose calculations are given above with help of belt drive. The motor having speed of 1440 rpm is bolted to the machine at backside.

The front panel is bolted to the frame of machine. The L-Bars are welded to frame for mounting of the sheet holding arrangement. The sheet holding arrangement provide adjustable diameter of circular profile. The tool is attached at the other end of the follower which reciprocated with follower and other tool is fixed at downside of gap provided for sheet movement in frame.

V. CONCLUSION

Taking the recent trends of industries into consideration, there are a lot of growth and advancement in the production technology. But all the advanced automation techniques can be employed to only large scale industries. Small and medium scale industries cannot afford high amount of automation.

Keeping the affordability and accuracy in mind, this paper has been developed for the circular cutting of the sheet metal.

It is a simpler one in construction and its fabrication involves an easy process and its is more economical one. It has been a successful one in its design and fabrication and the further alterations can be easily implemented according to the various working conditions at lesser cost.

REFERENCES:

[1] Strength of Materials by R.S. Khurmi

[2] R.S.Khurmi & J.K.Gupta, (2005) "A TEXT BOOK OF MACHINE DESIGN".

[3] Bhandari, V.B. (1994) "Design of Machine elements", Tata Mc Graw-Hill publishing limited,New delhi

[4] "PSG Design Data Book" (2007), M/s Kalaikadhir achagam, coimbatore.

[5] Thomas Haar, Halstenbek, " Loading Device For A Machine Tool Particularly For Machining Panels of Sheet Metal or Other Materials", 4382395, (1983).

[6] Thomas Haar, Halstenbek, " Loading Device For A Machine Tool Particularly For Machining Panels of Sheet Metal or Other Materials", 4382395, (1983).

[7] S. Aykut, M. Demetgul, I. N. Tansel: Selection of Optimum Cutting Condition of Cobalt-Based Superalloy with GONNS (International Journal of Advanced Manufacturing Technology, Germany 2010) 562 Modelling of Machining Operations

[8] S. Jayabal, U. Natarajan: Optimization of Thrust Force, Torque, and Tool Wear in Drilling of Coir Fiber-Reinforced Composites Using Nelder–Mead and Genetic Algorithm Method; (International Journal of Advanced Manufacturing Technology, Germany 2010)

[9] P. Lim: Optimization of The Rough Cutting Factors of Impeller with Five-Axis Machine Using Response Surface Methodology: (International Journal of Advanced Manufacturing Technology, Germany, 2009)