



## Design of 'C' Pillar Punching Special Purpose Machine

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### ABSTRACT

In our country fire accident is a very common phenomenon. Many wealth & lives are fallen in danger. As a developing country we have no Modern technology to solve this problem. Approximately 13% of civilian's death caused by fire are relates to a highway Vehicle. The main sector of fire brigade has a limitation to overcome it, sometimes police military come to the firing spot to help them but this is not enough. We come across various news regarding car's catching fire, car catches fire due to various reasons, like oil or fuel leakage, overheating, defective electric wiring & design etc. In recent there are 28 such cases observing after that Government of India passed motor vehicle Act 2018. According to this fire extinguisher should be install in all commercial vehicles for safety precautions of passengers.

Keywords: Fire Extinguisher, 'C' Pillar Punching Special Purpose Machine, Hydro-Pneumatic Press.

### Introduction

In our country fire accident is a very common phenomenon. Many wealth & lives are fallen in danger. As a developing country we have no modern technology to solve this problem. The main sector of fire brigade has a limitation to overcome it, sometimes police military come to the firing spot to help them but this is not enough. We come across various news regarding car's catching fire. Car catches fire due to various reasons like oil or fuel leakage, overheating, defective electric wiring & design etc.

In recent there are 28 such cases observing after that Government of India passed motor vehicle Act 2018. According to this fire extinguisher should be install in all commercial vehicles for safety precautions of passengers. Fire extinguisher is a real breath of protection when things go wrong with your car. They are extremely important to provide fire protection & also they act as a defence tool. Since we are talking about the use of a fire extinguisher in your car, here are few important points about how it is significant having one installed in the car.

The National Fire Protection Association (NFPA) reports that roughly 30 highway Vehicle fires occur due every hour in the United States.

Approximately 13% of civilian's death caused by fire are relates to a highway Vehicle. Hundreds of thousands of cars fires occur every year claiming hundreds of lives & costing an untold amount of damage. Having a fire extinguisher in your vehicle can help you combat a vehicle fire should it occur. There are several reasons that having a fire extinguisher in your vehicle can help you if a fire occurs.

All commercial trucks, buses & tractors need to have Mandatory fire extinguisher as per the laws of the country. Some vehicle gets the exemption of not having a fire extinguisher as while using a fire extinguisher in vehicles, you need to ensure that it is a location that is easily accessible. When you place it inconvenient place like trunk of the car's, you cannot use it use it immediately. It is also important to securely mount the extinguisher to prevent rolling around or sliding during accident.

## Description of the 'C' Pillar Punching Special Purpose Machine

- **Hydro-Pneumatic Press Cylinder**

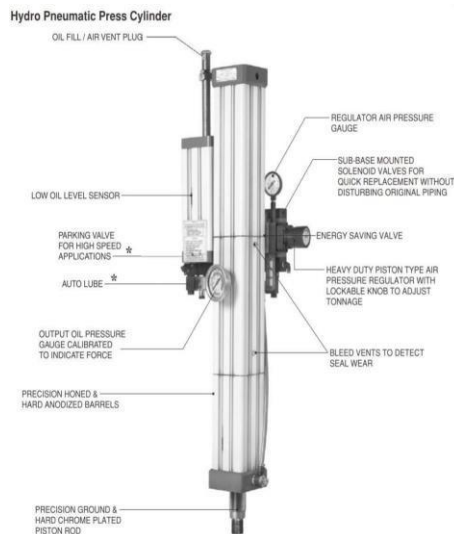


Figure 1: Hydro-Pneumatic press cylinder

- **Operation of Hydro-Pneumatic Press Cylinder**

There are three stages of operation: -

- Initial Low force, large travel, Rapid Approach.
- High Force,

Short travel, Power Stroke, Low Force, Rapid

Retraction.

- In the retracted position air is admitted to ports 'B' and 'D' and exhausted from port 'C' through Valve Regulator Assembly. Port 'A' is also exhausted.
- When an electrical supply is provided, the Approach Solenoid is switched "ON". This causes air to be admitted to port 'C' and air present in port 'D' is exhausted. The output shaft extends rapidly, with a low force due to the air pressure acting on top of the approach piston through port 'C'. The speed of extension can be varied infinitely by adjusting the Flow Control Valve 'F'.
- When the output shaft touches the work piece, the Power Stroke Solenoid is switched "ON". The change over from approach to power stroke depends on the setting of the delay between the two solenoid coils. This causes air to be admitted to port 'A' and exhaust from port 'B'. The Intensifier Piston extends and causes the pressure of the oil in the hydraulic chamber to rise. The intensified oil pressure acts on the Hydraulic Shaft, generating the high force "Power-Stroke". The output force can be varied by adjusting the Air Pressure Regulator 'R'.
- The "POWER-STROKE" is applied for the set time. When this time has elapsed, both the This causes air to be admitted to ports 'B' and 'D' and exhausted from Ports 'A' and 'C'. The Approach and Intensifier Pistons retract rapidly and oil is transferred back to the reservoir.
- The cylinder is now ready for the next cycle.

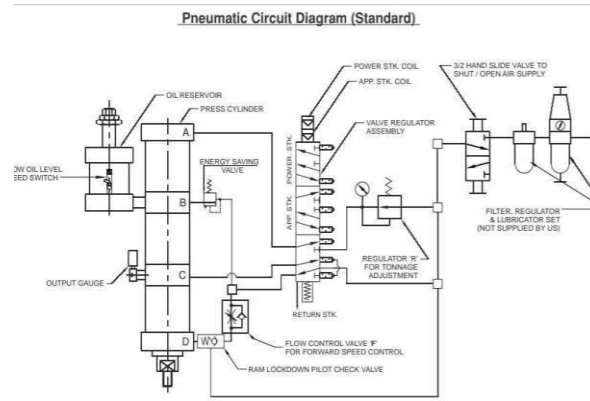


Figure 2: Pneumatic Circuit Diagram

### • **Machine Parts**

1. **'L'-Bracket:** 'L'- bracket supports the main-structures i.e. hydro-pneumatic cylinders. Various components like Top Plate, Guide Bearing, L-N Bearing are supported by 'L'- bracket. The cylinder moves vertically along this 'L'- bracket.
2. **Top Plate:** There are three main plates in C pillar SPM. First one is top plate, second one is middle plate and third one is base plate. Hydro pneumatic cylinders, Guide bearing are mounted on top plate. Also, its guides and supports the bearing mounting.
3. **Middle Plate:** It is in middle of 'L'- bracket. LN bearing, coupler, punch and stripper are mounted on the middle plate. Also, the shock produced when punching is also absorbed by middle plate along with stripper.
4. **Base Plate:** On the base plate, the whole machine assembly is mounted and base plate itself is the strongest part in all. On the base plate, fixtures are placed for placing the work piece for punching operation.
5. **Guide Bearing:** Guide bearings are provided by THK Company. They are mounted on top plate for support. Guide bearings serves smooth linear moment for support guide rod. Also, guide bearings are necessary for vertical moment of cylinder.
6. **Hydro Pneumatic Cylinder:** Hydraulic-press cylinders are expensive and pneumatic press cylinders creates more burr. If we require punching force more than one ton, then we go for hydraulic press and if we require less than one ton punching force then we go for 'Hydro- Pneumatic Press Cylinder'.

Hydro Pneumatic Cylinder is mounted on top plate. Hydro Pneumatic Cylinder is efficient, low cost, light weight, compact and easily maintained. Hydro Pneumatic Cylinder operates on normal air compressor of 5 bar pressure and consumes very low air. 80% of energy is saved by pneumatic press cylinder and 50% of energy is saved by hydraulic press cylinder. Force and speed of operation of hydropneumatic cylinder can be adjusted manually.

In starting, pneumatic press cylinder is used for quick action as travel length of punch is more. Then after hydraulic press cylinder is used for punching the work piece.

7. **Spring Loaded Stripper:** Spring loaded stripper is used to hold the part on fixture while performing punching operation. It is mounted on middle plate. Impact of punching operation is absorbed by the springs attached in spring loaded stripper. Also, it is used to save the punch from over-pressing and under-pressing. In LN bearings are used in spring loaded stripper for smooth operation. Spring loaded stripper have stripper pad made up of nylon for preventing from scratches on work piece.

The spring loaded stripper is used for high ductile material and operation is at large scale. The stripper works faster than the normal stripper, removal of scrap is fast. During the downward stroke of the punch, the stripper holds the sheet until the punch returns to its original position in its return stroke.

8. **Fixture:** Fixture is mounted on base plate. Material of fixture is aluminium. Fixture gives supports and accurate position to the work piece in machine while operation. Fixtures are depends on shape and size of work piece.
9. **Coupler:** Coupler is used for attachment of cylinder and middle plate. It is used for transmitting the linear movement from hydro pneumatic press cylinder to stripper.
10. **Punch and Die:** Punch is attached between middle plate and to spring loaded stripper. Die is mounted on base plate. Material of punch and die is D2 Steel. D2 steel is an air hardening, high-carbon, high-chromium tool steel. It has high wear and abrasion resistant. It is having hardness of in the range of 55-62 HRC. Hence, D2 steel is suitable for making die and punch.

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- 11. Toggle Clamps:** It is placed behind the fixture and used to hold the part of fixture. In toggle clamps pneumatic cylinder of low capacity (50kg to 70kg) are used.
  - 12. Dampener:** It is placed at bottom of the machine. It absorbed shocks and vibrations produced when punching operation is performed. It also used in height adjustment and machine parking.
  - 13. Fork Guide:** Fork Guides are mounted below the machine and used for machine lifting purpose.
  - 14. Castor Wheels:** Castor Wheels are used for moving the entire machine easily from one place to another.
  - 15. Punch out Material tray:** Material which is punched from work piece is collected in tray called punch out material tray. It is situated below the base plate.
  - 16. Blue Board:** All information of machine is given on the blue board.

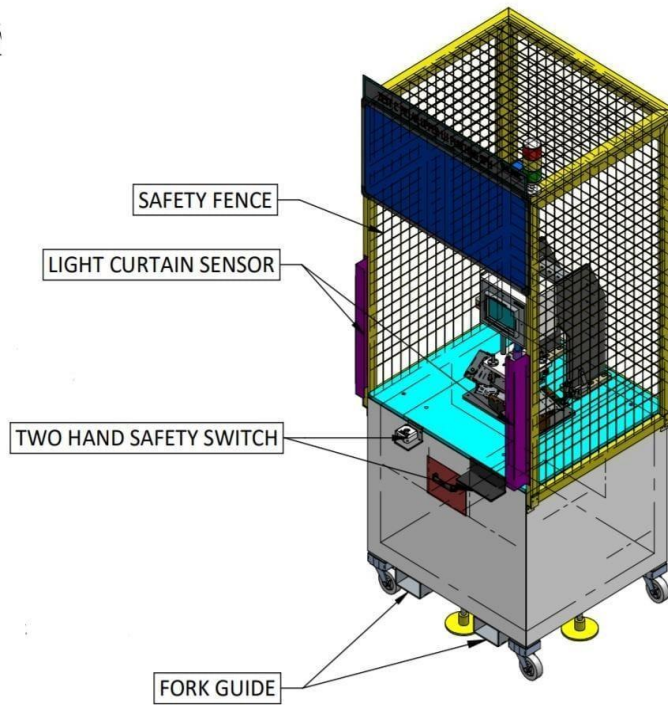
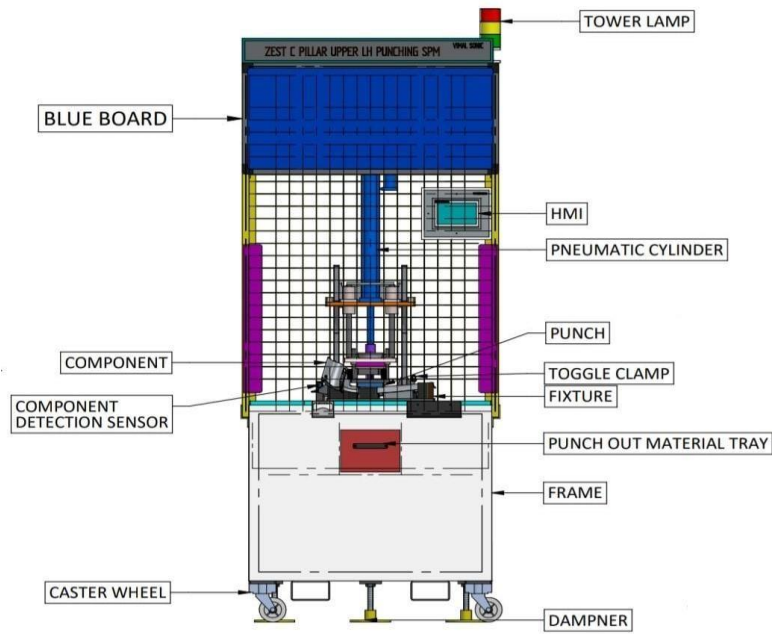


Figure 3: Machine Parts

• **Analysis of stress on Bracket and Work-Piece by Using ANSYS Software**

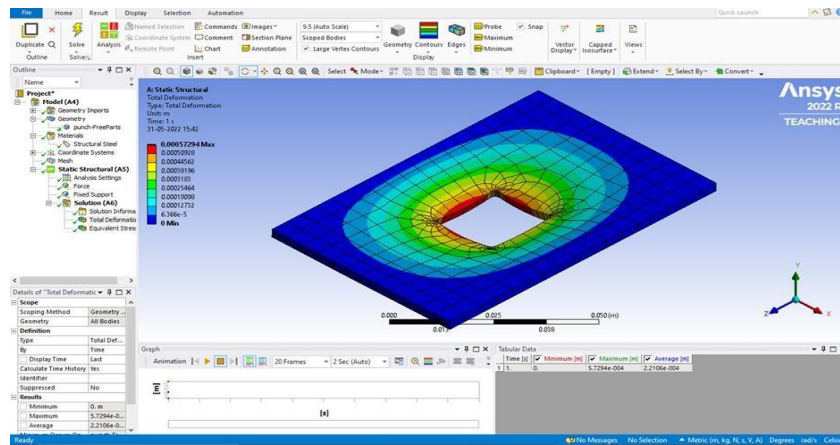


Figure 4: Total Deformation Analysis in work piece

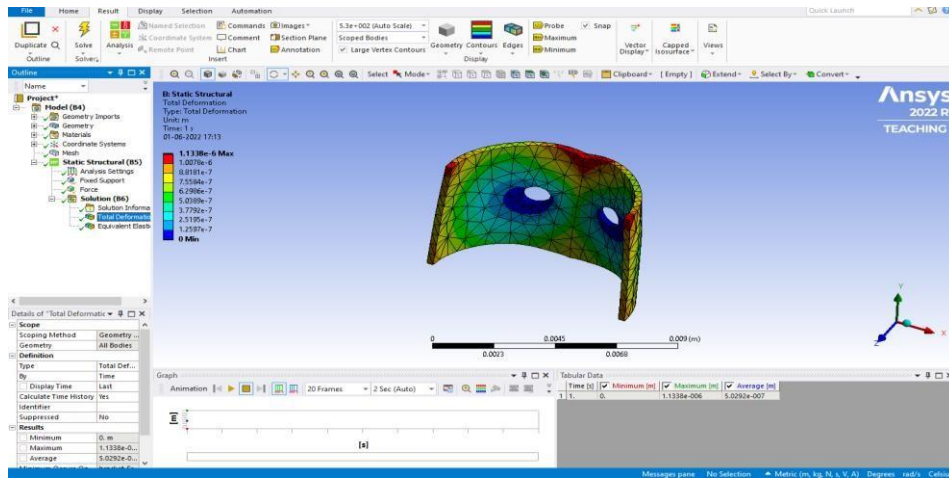


Figure 5: Total Deformation Analysis in Bracket

**3. Data Reduction:**

**Force Calculations**

1. for Punching

$$\text{Punch Size} = \text{Blank Size}$$

$$\text{Die Size} = \text{Blank Size} + (2 \times \text{Clearance})$$

2. Clearance

$$\begin{aligned} \text{Clearance} &= 5\% \times t \\ &= 5\% \times 0.25 \end{aligned}$$

$$\text{Clearance} = 0.125 \text{ mm}$$

3. Maximum Punching Force (without shear)

Maximum Punching Force (without shear) =  $\tau_s$  of PP  $\times$  C. A.

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$$= 20.394 \text{ N/mm}^2 \times 230.12 \text{ mm}^2$$

$$F_{\max} = 4693.067 \text{ N}$$

#### 4. Stress on Punch

Stress on Punch = F / Area of Punch Face

$$\sigma = 4693.067 \text{ N} / 238.065 \text{ mm}^2$$

$$\sigma = 19.713 \text{ N/mm}^2$$

#### 5. Factor of Safety

Factor of Safety = Shear Strength (PP) / Stress of Punch

$$FOS = \tau_s / \sigma$$

$$FOS = (20.394 \text{ N/mm}^2) / (19.71 \text{ N/mm}^2)$$

$$FOS = 1.033$$

**Hence, machine is safe for operation load.**

## 4. Results and discussion:

□ We have designed SPM having Hydro-Pneumatic Press of nearly 1-10 ton capacity which works gradually so that it does not create burrs, scratches on work piece. Also, power is saved 80% through pneumatic and 50% through hydraulic press.

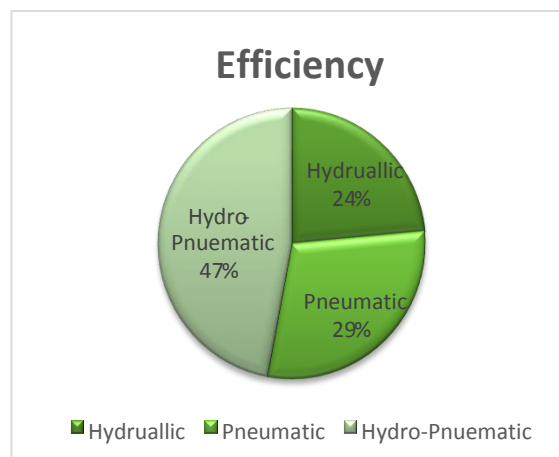


Figure 6: Efficiency of Hydro-Pneumatic Press

□ Maximum force required for punching is 4690N. So, the maximum stress generates at the edge of holes. Also, bracket can hold the FE property while driving car.

□ Hardness of D2 tool steel is reduced due to annealing process. So, we performed heat treatment on the D2 tool steel. So that, its hardness will increase.

□ WSSe can reduce the maximum punching force by giving a shear angle to punch and die.

□ New features like parking feature, two way start switch, inductive sensor etc. in SPM are added for safety of worker.

□ Cost of electricity to punch the 'C' pillar is reduced. The cost of electricity consumed to punch the 'C' pillar is 0.70 pa isa/piece.

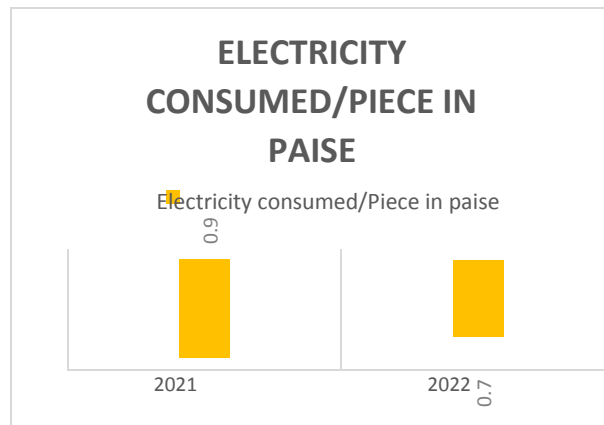


Figure 7: Graph of Electricity Consumed / Piece in Paisa

## 5. Conclusion:

- 1) As we used Hydro-pneumatic press cylinder with renewed sensors and features, we are able to punched 'C' Pillar of car successfully. 2) The analysis of bracket shows bracket can hold fire extinguisher successfully.
- 3) Problem of burr formation due to misalignment and over pressure is solved. As we used parking sensor which senses the position of hydropneumatic press cylinder and inductive sensors for detection of work-piece.
- 4) The maximum punching force required to punch the 'C' pillar is 4693.067N. We can reduce punching force by giving shear of 2% up to 4000N.
- 5) The cost of electricity consumed to punch the 'C' pillar is 0.70 paisa/piece.

Hence, we successfully design the 'C' pillar punching machine.



Figure 8: 'C' Pillar after Punching





Figure 9: Fire Extinguisher

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### Nomenclature

Horse Power		HP
Newton		N
Kilo Watt		KW
Millimetre		mm
Polypropylene		PP
Stress on punch		$\sigma$
Shear Strength of Polypropylene		$\tau_s$
Maximum Force Required For Punching		$F_{\max}$
Pie	$\pi$	
Work Done		W
Thickness		t