

Research Article

# Design and Development of Blanking and Forming Die for Shock Absorber Mounting Assembly

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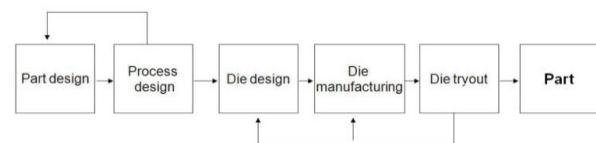
## Abstract

In this paper we have proposed design for blanking and forming die for producing product assembly namely Rear Engine Anti Drive Bracket (R.E.A.D.) as for shock absorber mounting Steering Column of Bajaj Auto rickshaw. For producing part various sheet metal processes were which were blanking, punching, bending etc. were performed. This paper mainly focus on traditional approach of designing die for small automotive stamping part or assembly for small scale industry with improved productivity and flexibility which try to reduced cost.

**Keywords:** Auto rickshaw steering columns, blanking die design, forming die design, R.E.A.D., Stamping part

## 1. Introduction

The designing of stamping dies is a complex process, where various stamping parameters must be defined and calculated. Many inexperienced designers have trouble defining or calculating those various stamping parameters that must be taken into account when designing different stamping die types (Potocnik, D., 2011). Sheet-metal parts have already replaced many expensive cast, forged, and machined products. The reason is obviously the relative cheapness of stamped, or otherwise mass-produced parts, as well as greater control of their technical and aesthetic parameters (Fissha Biruke Teshome, 2014). Sheet metal forming processes are particular manufacturing processes which make use of suitable stresses (like compression, tension, shear or combined stresses) to cause plastic deformation of the materials to produce required shapes. Sheet metal operations are classified in two categories cutting operation and forming operation. In cutting operation work piece is stressed beyond ultimate strength which includes blanking, punching, notching, perforating, trimming, shaving etc. In forming operation stresses are below ultimate strength. There is no actual cutting of metal just contour of work piece is changed to get desired product which includes bending, drawing, redrawing, squeezing (Atharva Bhawe, 2016). In most cases, the stamping product design is always separated from the die and process design, with the latter two being carried out by skillful die and tool makers using and experience-based and trial and error procedure. The stamping product and die development activities have been performed separately and sequentially by designers and engineers, as shown in Fig. 1 (M. Hojny, 2010).



**Fig.1** A traditional process of part development (sequential engineering)

Commercially available CAD/CAM systems are providing some assistance in drafting and analysis in die design process, but human expertise is still needed to arrive at the final design (S. Kumar, 2008).

This paper presents blanking and forming die design for Rear Engine Anti Drive Bracket (R.E.A.D.) as for shock absorber mounting assembly. The assembly consists of R.E.A.D. Inner Bracket, is basically used for reinforcement, to increase the strength of the big bracket and tickli component used to increase the number of threads for the bolt which passes through the tickli. If the tickli is not used then in the 3mm sheet of the big bracket only 1 or 2 threads are possible. With use of tickli the total sheet thickness became 5.5mm and hence numbers of threads were also increased significantly.

## 2. Problem Statement

Design a die for Rear Engine Anti Drive (R.E.A.D) Bracket- A shock Absorber Mounting. R.E.A.D Bracket is assembly of: 1. Big Bracket. 2. Inner Bracket. 3. Tickli.

The material of the component: Cold Rolled Steel Sheet, Shear Strength of the material: 220 N/mm<sup>2</sup>, Tensile Strength of the material: 350 N/mm<sup>2</sup>, Sheet

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Thickness: 3mm for Big Bracket, 2.5mm for Inner Bracket and 2.5mm for Tickli.

Perimeter of R.E.A.D Inner Bracket

**Table 2** Perimeter of R.E.A.D. Inner Bracket

L1	L2	L3	L4	L5	L6	L7
23.5	5.2	30	5.7	20.5	6.5	30.5
L10	L11	L12	L13	L14	L15	L16
2	5.7	30.5	5.2	5	7.3	55
L8	L9					
55	7.33					
L17	L18					
30.5	9					

**3. Blanking Die Design**

**3.1 Area and Perimeter of R.E.A.D. Bracket**

Area of Big Bracket: From the graph the area of big bracket is calculated as  
 = (No. of complete squares × Area of 1 square) + Remaining portion area  
 = (99 × 100) + 3695 = 13595mm<sup>2</sup>  
 The graph scale taken 1:1 with area of 1 complete square is 100mm<sup>2</sup>

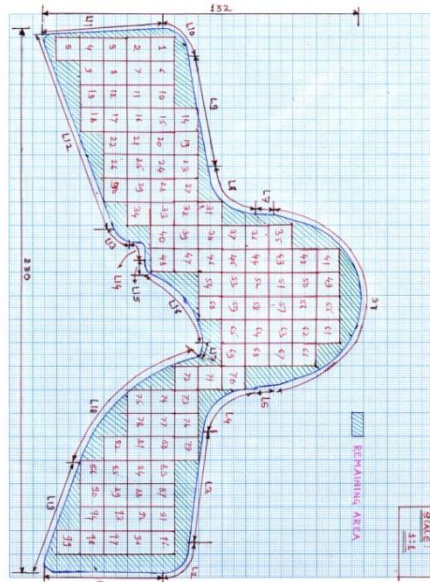
Perimeter of R.E.A.D. Big Bracket:

**Table 1** Perimeter of R.E.A.D. Big Bracket

L1	L2	L3	L4	L5	L6	L7	L8
50	18.6	48.5	34.2	20	113.4	7	34.2
L9	L10	L11	L12	L13	L14	L15	L16
48.5	18.6	50	88	9.3	11.7	5.5	41.4
L17	L18	L19					
11.2	72.5	48.5					

The all perimeter values of R.E.A.D. Big Bracket are tabulated as

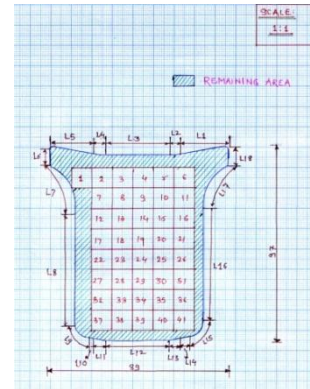
$$L = L1 + L2 + ..... + L19 = 718.47\text{mm} = 719 \text{ mm}$$



**Fig.2** Area of R.E.A.D. Big Bracket

Area of Inner Bracket

From the graph the area of inner bracket is calculated as  
 = (No. of complete squares × Area of 1 square) + Remaining portion area  
 = (41 × 100) + 1792 = 5892mm<sup>2</sup>  
 The graph scale taken 1:1 with area of 1 complete square is 100mm<sup>2</sup>  
 Developed length = Perimeter



**Fig.3** Area of R.E.A.D. Inner Bracket

**3.2 Strip Layout**

R.E.A.D. Big Bracket

From the perimeter calculations and from the graph showing the area calculations,

Total length of R.E.A.D Big Bracket = (A) = 230mm

Total breadth of R.E.A.D Big Bracket = (B) = 132mm

Sheet metal Size = 3×140×1250mm

Front Scrap & Back Scrap:  $a = t + 0.015 \times h = 3 + 0.015 \times 132 = 2.739\text{mm}$  (scaled)

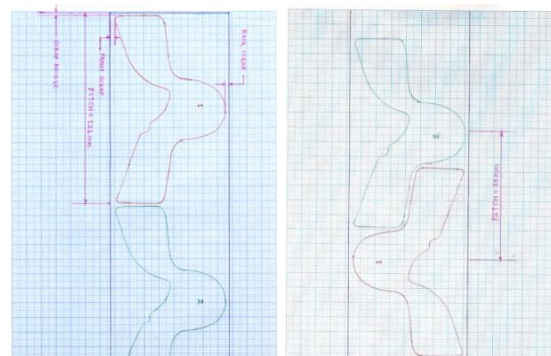
Where, t = thickness of the sheet, h = height of the component

Bridge:  $b = t = 1.65\text{mm} = 2\text{mm}$  (scaled)

Feed:  $s = w + b = 2 + 129 = 131\text{mm}$

Where, w = width of component, b = bridge

The possible layout A and B shown below:



**Fig.4** Strip Layout A (left) & Layout B (right)

**Table 3** Layout Parameter of R.E.A.D. Big Bracket

Layout Parameter	Layout A	Layout B	Layout C
Pitch (distance between corresponding points of successive components), mm	131	88	51
Total length of the sheet (scaled), mm	687.5	687.5	687.5
No. of blanks in one sheet	5	7	13
% Material Utilization	38.84	54.38	58.91

Strip Layout 'C' has more material utilization 58.91% as compared to strip layout 'A' 38.84 % and 'B' 54.38%.

#### R.E.A.D Inner Bracket

From the perimeter calculations and from the graph showing the area calculations,

Total length of R.E.A.D Inner Bracket = (A) = 97mm

Total breadth of R.E.A.D Inner Bracket = (B) = 89mm

Sheet metal Size = 2.5×105×1250mm

Strip layout parameters:

$$a = 2.5 + 0.015 \times 97 = 3\text{mm (scaled)}$$

$$b = 2.5 = 2\text{mm (scaled)}$$

$$s = 2 + 71 = 73\text{mm (scaled)}$$

**Table 4** Layout Parameter of R.E.A.D. Inner Bracket

Layout Parameter	Layout A	Layout B	Layout C
Pitch (distance between corresponding points of successive components), mm	73	64	54
Total length of the sheet (scaled),mm	1000	1000	1000
No. of blanks in one sheet	13	15	18
% Material Utilization	58.35	67.37	73.77

Strip Layout 'C' has more material utilization 73.77% as compared to strip layout 'A' 58.35% and 'B' 67.37%.

### 3.3 Blanking Die Design Parameters

**Table 5** Blanking Die Design Parameters

Die Design Parameter	READ Big Bracket	READ Inner Bracket	Formula
Vertical Force, N	469920	194905.7	$P \times t \times \tau$
% Clearance (C), mm	0.1423	0.1186	$0.0032 \times t \times \tau^{1/2}$
Horizontal Force, N	66912.38	23127.34	$\%C \times V$
Total Shearing Load (T), KN	474.65	196.27	$(H^2 + V^2)^{1/2}$
Press Tonnage, Tones	65	26.62	$T \times 1.33$
Die Thickness (Tr), mm (Rectangular)	35	30	$\sqrt{\frac{3 \times V \times (B/A)^2}{Ft \times 1 + (B/A)^2}}$
Die Margin, mm	42	36	$Tr \times 1.2$

### 3.4 Stripper Plate Design

Stripper plates remove the material strip from around the banking and piercing punches. Severe adhesion of strip to punches is characteristics of the die cutting process. There are two types of strippers, Fixed (solid) stripper and Spring stripper Here Fixed (solid) stripper is selected because of strip Stock is running, low cost and thick material.

Thickness of stripper plate

(READ Big Bracket):

$$T_s = 1/8 \times [w/t + (16 \times t)] = 11.5 + 3\text{mm (resharpening allowance)} = 14.5\text{mm} = 15\text{mm}$$

(READ Inner Bracket):

$$T_s = 1/8 \times [w/t + (16 \times t)] = 9.85 + 3\text{mm (Resharpening allowance)} = 13.85\text{mm} = 14\text{mm}$$

### 3.5 Number of Allen Screws and Dowel Pin

Assuming, Stripping Force = 10% of Vertical Shearing Force

(READ Big Bracket):

$$\text{Stripping Force} = 0.1 \times 469920 = 46992\text{ N}$$

Root Area for Metric Screws

$$A = 0.7854 (D - 1.227 \times P)^2$$

For M16 × 2P Screw,

$$A = 0.7854 \times (24 - 1.227 \times 2)^2 = 346.606\text{ mm}^2$$

(READ Inner Bracket):

$$\text{Stripping Force} = 0.1 \times 194905.7 = 19490.57\text{ N}$$

Root Area for Metric Screws

$$A = 0.7854 (D - 1.227 \times P)^2$$

For M12 × 1.75P Screw

$$A = 0.7854 \times (18 - 1.227 \times 1.75)^2 = 197.378\text{ mm}^2$$

Design Stress for Socket Head Cap Screw Ranges from 80-120 N/mm<sup>2</sup>

Load Capacity at 80 N/mm<sup>2</sup>

$$\text{Load Capacity (READ Bracket)} = 346.606 \times 80 = 29168.50\text{ N/Screw}$$

$$\text{Load Capacity L (Inner Bracket)} = 197.378 \times 80 = 15790.2\text{ N/Screw}$$

Number of Screws:

(READ Big Bracket)

$$\text{No. of Screws} = \frac{\text{Stripping Force}}{\text{Load Capacity}} = \frac{46992}{29168.5} = 1.61 = 2$$

(READ Inner Bracket)

$$\text{No. of Screws} = \frac{\text{Stripping Force}}{\text{Load Capacity}} = \frac{19490.5}{15790.2} = 1.234 = 2$$

Design Stress for Dowel 50-80 N/mm<sup>2</sup>

Number of dowel: consider  $\phi 24$  dowels

(READ Big Bracket):

$$\text{No. of Dowel Pins} = \frac{\text{Horizontal force}}{\text{Area/Dowel} \times \text{Design Stress}} =$$

$$\frac{66912.38}{0.7854 \times 24^2 \times 50} = 2.95 = 2$$

(READ Inner Bracket):

$$\text{No. of Dowel Pins} = \frac{\text{Horizontal force}}{\text{Area/Dowel} \times \text{Design Stress}} =$$

$$\frac{23127.34}{0.7854 \times 18^2 \times 50} = 1.81 = 2$$

Thus we require,

2 Allen Screws of dimensions M16 × 2P,  
Head Dia. = 24mm, Head Length = 16mm, Thread  
Length = 38mm for READ Big Bracket

2 Allen Screws of dimensions M12 × 1.75P,  
Head Dia. = 18mm, Head Length = 12mm, Thread  
Length = 30mm for READ Inner Bracket

2 Dowel Pins: φ24 Size φ18 Size for READ Big Bracket  
and Inner Bracket respectively.

### 3.5 Die Space

$$\text{Length} = A + 2 \times M = 230 + 2 \times 42 = 314\text{mm}$$

$$\text{Width} = B + (2 \times M) + (3 \times \text{Dia. Of Allen Screw})$$

$$= 132 + 84 + 72 = 288\text{mm}$$

$$\text{Die Space} = (314 \times 288) \text{ mm}^2$$

Selected nearest Standard Die set with Die space  
closer to the calculated value

Standard Die Set With Die Space = 400 × 315

### 3.6 Guide Pillar and Guide Bushes

Select standard Guide Pillar Recessed type.

Length of Guide Pillar = 307mm,

Dia. of Guide Pillar = 48mm

Selected 'Standard Guide Bush - Plain Solid type'  
corresponding to standard die space value.

Length of guide bush = 75mm

Diameter of guide bush =

1) Outer Dia. φ<sub>o.d</sub> = 50mm 2) Inner Dia. φ<sub>i.d</sub> = 48mm

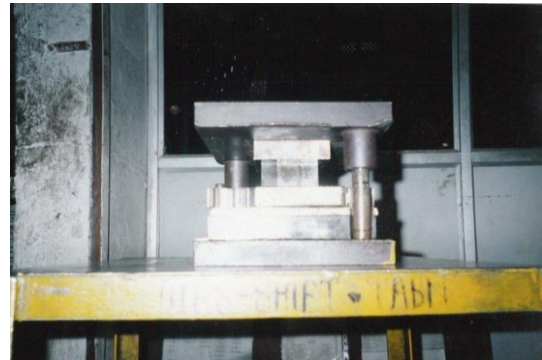
The final assembly of blanking dies design for both Big  
and Inner R.E.A.D. Bracket with respective blank as  
shown in Fig. 5 to Fig. 8.



**Fig.5** Blanking Die of R.E.A.D. Big Bracket



**Fig.6** R.E.A.D. Big Bracket Blank



**Fig.7** Blanking Die of R.E.A.D. Inner Bracket



**Fig.8** R.E.A.D. Inner Bracket Blank

### 3.7 Blanking Die for Tickli

The component TICKLI is merely a rectangular blank of (16 × 22) mm. So it is more economical to outsource this component rather than in house production. Also, it is not a critical component of the required assembly. Slight deviation in the dimension of the component will not adversely affect the assembly.

## 4. Bending Die Design

Bending Force:

$$F = \frac{2.66 \times L \times t^2 \times F_t}{W}$$

Where,

L= Transverse length of bend in mm, T= Thickness of blank in mm, F<sub>t</sub>= Tensile strength in N/mm<sup>2</sup>, W=Width of Channel in mm, F= Channel bending force (N).

Bending Die for R.E.A.D Big Bracket:

$$F = \frac{2.66 \times 85 \times 32 \times 350 \times 0.102 \times 10^{-3}}{26}$$

$$= 2.79 \text{ tones} = 3 \text{ tones}$$

Bending Force = 2989.875 KgF

Bending Die for R.E.A.D Inner Bracket:

$$F = \frac{2.66 \times 90 \times 2.52 \times 350 \times 0.102 \times 10^{-3}}{40}$$

$$= 1.33 \text{ tones} = 2 \text{ tones}$$

Bending Force = 1793.92 KgF

For both the bending dies an 'Ejection Mechanism' is incorporated in order to eject the formed component from the die cavity.



Fig.11 Formed R.E.A.D. Inner Part

Table 6 Bending Die Design Parameters

Die Design Parameter	Read Big Bracket	Read Inner Bracket	Formula
Punch Holder Thickness, mm	32	28	$t_{ph} = 2.25 \times \sqrt{F}$
Die Block Thickness, mm	36	30	$t_b = 2.5 \times \sqrt{F}$
Die Space	400 x 315	200 x 160	---



Fig.12 Forming Die of R.E.A.D. Inner Bracket



Fig.9 Lower Shoe of Big Bracket Forming Die



Fig.10 Formed R.E.A.D. Big Part

#### 4. Die Tryout

Die tryout is a procedure in which completely manufactured die is tested on press using the required tonnage and applying similar working condition.

- 1) This process gives exact information regarding what are the designs and manufacturing limitations of the die under test and how those can be overcome.
- 2) In the absence of this process, limitations in the die cannot be found out and when actual will start, the component produced can have some shortcomings like, excessive work hardening, thinning of sheet metal at specific areas.

These shortcomings will indeed cause poor quality of final product, and also increase in non-productive time and thus resulting in loss in machine and labour hours and ultimately affect productivity. Nowadays, software's are used to determine shortcomings in die design. But these software's are unable to determine the shortcomings at manufacturing stage and hence actual die tryout is very important. Die tryout is

carried out in press shop and the results are noted for each checkpoint in the checklist.

Following are the steps in die tryout:

- 1) Die completion information is given to the press shop from the die manufacturing section and then tool is handed over to the press shop along with checklist.
- 2) Die is then checked as per the checklist.
- 3) Die tryout plan is then prepared in which information about things to be checked is given.
- 4) After die tryout plan, the departmental head of press shop does confirmation regarding availability of press.
- 5) After confirmation regarding availability of press, actual die tryout is carried out on press by making pilot batch production.
- 6) Analysis of the die tryout is then done from which the tryout report is prepared. In case of any shortcomings die is shifted to the die manufacturing section for correction.

Die Tryout Checklist:

Sr. No.	Points Checked	Result of tryout
1	Sheet Loading for both the blanking dies	O.K
2	Blanked component loading	O.K
3	Formed component unloading	O.K
4	Overall size and dimensions of both the blanked components	O.K
5	Overall size and dimensions of both the formed components	O.K
6	Ejection mechanism of both the bending dies	O.K
7	Lubrication of all the dies	O.K

## 5. Assembly of the Shock Absorber Mounting

Assembly of the R.E.A.D Big Bracket, Inner Bracket and Tickli is done by Spot Welding operation. The assembly is used as Shock Absorber Mounting and Is Mounted on the Steering Column of Bajaj Auto rickshaw. The Fig. 13 shows spot welding of the Shock Absorber Mounting assembly and its application on Steering Colum of Bajaj Auto rickshaw shown in Fig. 14.



**Fig.13** Spot Welding



**Fig.14** Application of Assembly

## Conclusions

Design of combined press tool for shock absorber mounting made of sheet metal component has been developed by following the fundamental die design principles. The die for Rear Engine Anti Drive Bracket - A Shock Absorber Mounting is successfully designed and manufactured according to requirements of the company. Therefore newly developed combined press tool is recommended in order to have an improved productivity, improved efficiency, better flexibility, more economical manufacturing process with lower cost of the product.

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