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Sheet Metal Engine Mounting Arm Design for 3.3L CEV BS-V

Mr. Gangadhar D. Dukare[1], Mr. RohitKumar Kadam[2]

[1]Assistant Professor of International Institute of Management Science Chinchwad,Pune gangadhardukare@gmail.com
[2]Student of International Institute of Management Science Chinchwad, Pune kadamrohitkumar7@gmail.com

ABSTRACT

Sheet metal engine mounting arm design for 3.3L CEV BS-V, we have designed engine to this vehicle specifically and released development phase. While designing the engine, mounting becomes the most important thing as, it is customer connection. To design this four mounting arms generally made in forging. But due to less costing in this project we had some limitations and this engine has less annual requirement i.e. 600 nos./annum so to reduce costing we have designed this mounting arms into sheet metal, in fabrication.

As Engine mounting requires more strength, endure fatigue and long life we had major challenges, also customer had some mounting location with close tolerance which we have to maintain within range.

Keywords: Engine, Design, Assembly, Process, BSV, Standarad

Introduction

This is 3.3L CEV BS-V Engine design and development. This is being used in concrete mixture of M/s Ajax Engineering. Tear-I engine supplier for this vehicle.

Objectives:

Sheet metal design of Engine mounting arm. (Usually engine mounting arms are in forged design)

Primary Objective

Cost reduction – To reduce Engine manufacturing cost due to low annual demand from customer.

Weight reduction - To reduce Engine weight, we have designed sheet metal mounting arm instead of forged component.

Customer requirement – to shift engine by 20 mm. So we accommodated 20 mm shift in Engine mounting arm keeping same customer mounting location.

Clearance with neighboring components and assembly feasibility in compact space available in engine.

Secondary Objective

CAE analysis results (Customer and operational requirement) - Modal analysis result and strain energy plots.

Manufacturing feasibility - Sheet metal thickness is 12mm, so facing challenges in bending operation and bolt resting face. So we added plates to both side to get resting face to bolt and increase the bending radius.

Literature Review:

ISO standards

General Tolerances as per DIN ISO 2768

ISO-7452-1984 - Hot-rolled structural steel plates - Tolerances on dimensions and shape

IS 16003 (2012): general rules for the specification and qualification of welding procedures for metallic materials

Summary and Research Gap:

Overhang between engine mounting and mounting arm was 78mm, resulting more stress on mounting bolts due to weight of engine and ATS system.

Spacer length between and assembly constrains.

Compact space due to nearby components.

Manufacturing feasibility in sheet metal bending operation.

Research Methodology:

Generative Research Generative research is the creativity phase aimed to generate new part design ideas with concepts. It employs techniques like brainstorming in workshops and CFT team, participant design and innovation activities. Researchers facilitate collective and collaborative meetings/sessions with multidisciplinary cross functional team and actual users to explore generative and innovative solutions, towards development of project through collectivity and brainstorming activities, like mapping, designing and sketching, participants motivate to generate creative ideas. These ideas may include unique communication/interaction & gestures, novel with content-sharing methods, or innovative community-building sessions and feeds Design Research Process It is a iterative and systematic process that leads researchers in creating user-generated and innovative solutions. Overview as below –

Objectives

By clearly defining what is the research objectives? What we want to achieve by research and development? Establish goals, whether its getting customer needs fulfilled, evaluating an current design, or generating new ideas and presenting to customer or for personal own product development.

Literature and review

Conduct a literature review from past experiences and projects to understand existing knowledge with research which one is related to your design objectives. This step helps designer and researcher build existing practical & theories, design and ensures the study that relevant and contribution to the field. Identify Participants Establish the target audience for our research. Recognize user groups, demographics with characteristics pertinent to your aims. Participants may consist of current users, potential users, or particular user segments.

Data Collection

Select suitable methods for data gathering according to your research aims. Methods can encompass interviews, surveys, usability testing or observational studies. Gather both qualitative and quantitative data to achieve a holistic understanding of user behaviors and preferences

Data Analysis

Evaluate the collected CAD data to uncover patterns, themes, and insights. Qualitative data may require coding and thematic analysis, whereas quantitative data can be examined using statistical techniques. Data analysis converts raw information into actionable insights.

Synthesis and Ideation

Integrate the findings from the data evaluation. Determine key insights and user requirements. Utilize these insights as a groundwork for brainstorming and ideation sessions. Partner with designers and stakeholders to create innovative solutions grounded in the research findings.

Prototyping and Testing

Develop prototypes or mockups of the suggested solutions. This could involve digital interfaces, physical products, or service blueprints. Conduct usability testing with actual users to assess the prototypes. Collect feedback to iteratively enhance the designs.

Implementation and Launch

After refining the designs and validating them through testing, move forward with implementation. Create the final product, making sure it aligns with the user insights and design specifications. Release the product or service to the target audience.

Post-Launch Evaluation

Following the launch of the product, continue to gather feedback and perform post-launch evaluations. Observe user interactions, collect user feedback, and evaluate the product’s performance. This feedback loop aids in making ongoing improvements and updates based on user experiences.

Data Analysis & Interpretation:

Criticality,

Overhang between engine mounting and mounting arm was 78mm, resulting more stress on mounting bolts due to weight of engine and ATS system.

Spacer length between and assembly constrains.

Compact space due to nearby components.

Manufacturing feasibility in sheet metal bending operation.

Following actions suggested to team

With respect to previous engine mounting we suggested to make in sheet metal instead for forging.

We have reduced overhang of the arm, to accomplish the desired results in CAE analysis (i.e. Modal analysis result Strain energy plots).

Also, considering manufacturing feasibility and maintaining critical clearance with neighboring components.

Challenges,

Trying to make design in sheet metal instead of forged mounting arm.

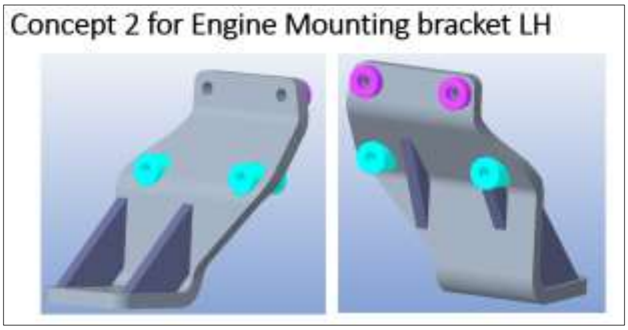
Manufacturing feasibility - Sheet metal thickness is 12mm, so facing challenges in bending operation and bolt resting face. So we added plates to both side to get resting face to bolt and increase the bending radius.

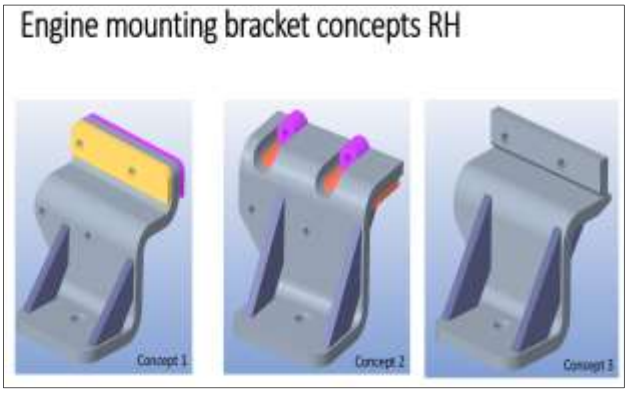
CAE analysis results - Modal analysis result and strain energy plots, to sustain vibration of engine and impacts of vehicle.

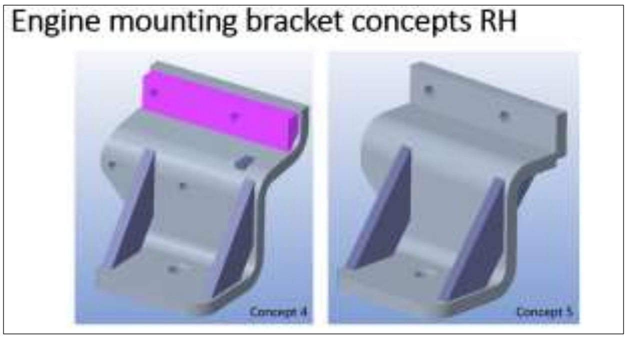
Clearance with neighboring components and assembly feasibility at compact space available near engine.

Customer requirement – To shift engine by 20 mm. We accommodated this change in engine mounting arm. After finalization of design and CAE analysis customer gave this change. So in very short period of time we changed design and get approved from CAE team and customer.

Suggestions & Recommendations:







Engine mounting bracket concepts RH

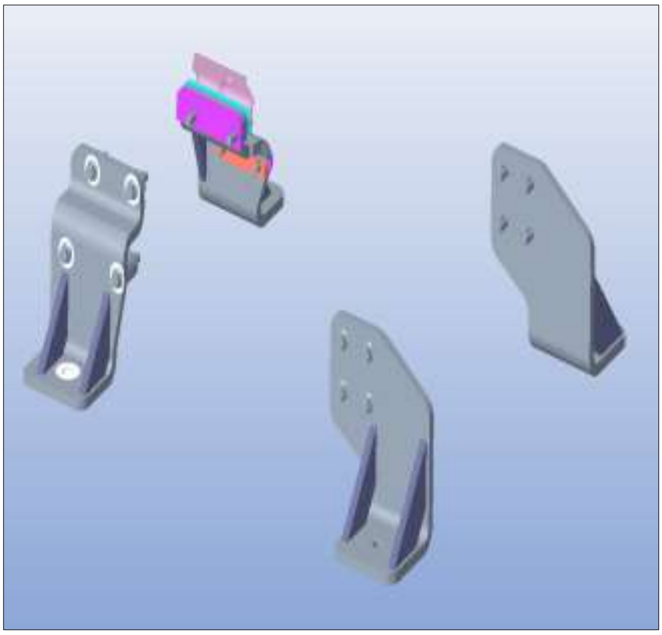
TATA MOTORS

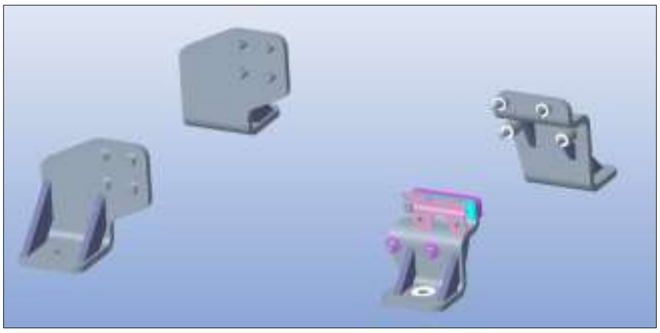
Engine mounting bracket Final concepts

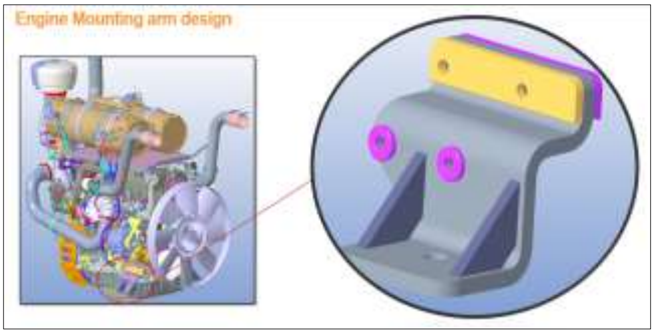
- Concept 1 SENT for manufacturing feasibility

Result:

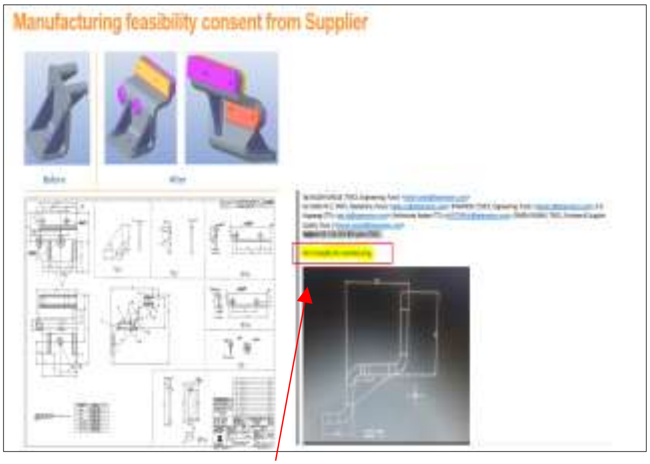
Impact of Work Delivered Engine mounting arm has now more Fatigue Life ≥ 1, 00,000 Cycles. Plastic strain in acceptable criteria (i.e. Plastic strain < 50% of fracture strain) and DV01 design of Engine Mounting Arms meets the durability performance acceptance criteria for SLA loads. Took consent for manufacturing feasibility, from supplier. Fulfilled customer requirement of 20 mm engine shift.







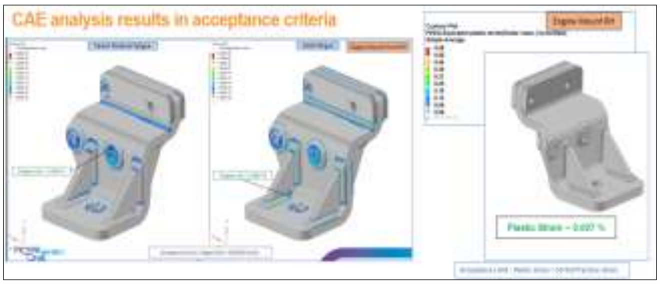
Engine Mounting arm design



Manufacturing feasibility consent from Supplier

Part is Feasible for manufacturing

Findings



CAE analysis results in acceptance criteria

Fatigue life and Plastic strain is in acceptance criteria.

Fatigue Life ≥ 1,00,000 Cycles

Plastic strain < 50% of fracture strain

DV01 design of Engine Mounting Arms meets the durability performance acceptance criteria for SLA loads.


CAE analysis results in acceptance criteria

Design consideration

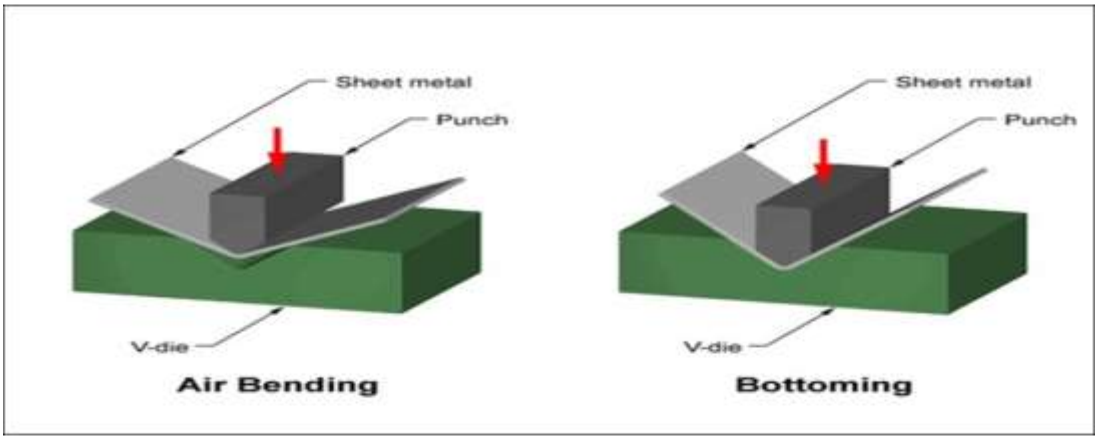
- Sheet Metal Fabrication involves creating parts from a sheet metal through processes like stamping, punching & bending, cutting
- Isometric three dimensional CAD files are transformed into machine programming language, which directs a machine to accurately cut and shape of sheets into the finished part.
- Sheet metal components are recognized for their strength, making them suitable for end-use applications (e.g. chassis, car bodies, various brackets etc.). Parts utilized in low production requirement prototyping and high volume production runs are most cost efficient due to the initial machining setup & the specific material expenses.
- As we know parts are formed from a one continuous sheet of metal, part must maintain a uniform and constant wall thickness. Ensure adherence to design specifications and tolerances that ensure parts closely match with design intent & cutting sheets of metal.

FORMING BASICS

- **Bending**

Bending involves the process in which forces are applied to sheet, resulting in a bend at a designated angle to get the desired product shape. Bends may vary in length according to design specifications.

Bending is applied using a press machine, which can be loaded hydraulic press or manually. Press machines are molds are available in different sizes and lengths (15-250 tons) based on product and process requirements. The press brake has upper tool considered as the punch and a lower tool known as die, between die and punch the sheet is bended or pressed to get desired shape.

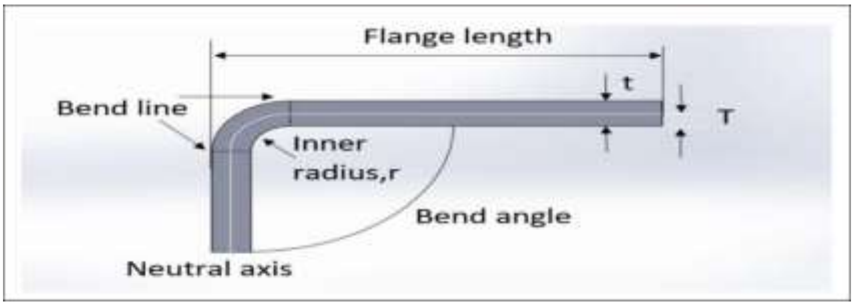


- The sheet is positioned between these two tools and secured by the backstop. The angle of bend is determined by how accurately and forcefully the punch forces the sheet into the die. Depth carefully controlled to achieve necessary bend. The punch and die. Tooling materials include, in order of ascending hardwood, strength, low and high carbon steel, tool/carbide steel. Parts designed for bending are supplied like flat sheet patterns along with bending orders and instruction. Occasionally, bend locations are denoted with bend notches or this notches can be cut to redirect the benders on die and punch where to perform the bends.
- After the laser machine has cut down out the flat sheet, they can be dispatched for bending. A press brake transforms the flat pattern into a bent component.

Critical Dimensions

- The following terminology is commonly used in sheet-metal design and manufacturing. Designers must comply with machinery specifications when producing designs for bending. Bends can be defined by these characteristics. Key metal in computer added drafting (CAD) which include the k-factor and the sheet-metal thickness as well as bend radius. It is very important to confirm that these components are suitable for the tooling that will moved to continumos/mass production. This manufacturing guide offers critical recommendations for effective design practices.
- Bend line –

The curved and straight line on sheet metal surface on both side of the bend, making the end of the flat and curved flange & the start off and above the bend.



- Bend radius –

Measurement from the inner surface of located between the bend lines, to the material bend axis.

- Bend angle –

The angle of the sheet bend that measured between flange of its original position and the bent as well as it included angle created between respected lines drawn from that bending line. It referred to as the in-side bend radius. The out-side bend radius is equal to the in/out side bend radius adding the sheet thickness.

- Neutral axis – The location in the sheet-metal which is not stretched or compressed and maintaining a constant length at certain area.

K-factor

- The position of the neutral axes in the metal sheet is calculated by the ratio of the distance of the neutral axes T to the sheet thickness (t). K-factor varies based on multiple factors like bending operation, material and bend angle etc. is greater than that of 0.25 and does not exceed 0.50

$$K = \frac{T}{t}$$

- Bend allowance –

The length of that neutral axes between the arc length of the bend & the bend lines. The bend allowance added to the flange lengths equivalent to the overall flat length.

- The K-factor is the ratio of the thicknesses of the material and neutral axes. The importance of that K-factor in metal sheet design is significance of the K-factor in sheet metal design
- • The K-factor is needed for calculating flat patterns, as it relatable to the amount of material stretched when the bending process is occurred.
- Side by side, ensuring the value is accurate in CAD software is very important. The K-factor should typically range from 0 to 0.5. To obtain a more accurate K-factor, the average of three samples from bent parts can be calculated by putting measurements of bend angle ,bend allowance, material thickness & the inside radius into the
- Formulae as below

$$K = \frac{180.(\mathit{Bend\ allowance})}{\pi.(\mathit{Bend\ angle}).t} - \frac{r}{t}$$

Outcome – (Parts are released for production and manufactured successfully)

Actual production parts which are assembled on engine and sent to customer. i.e M/s Ajax. Above shown 3303,3304,3305 and 3306 Engine mounting arms assembled.

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2. Material standard
3. Tolerance standard
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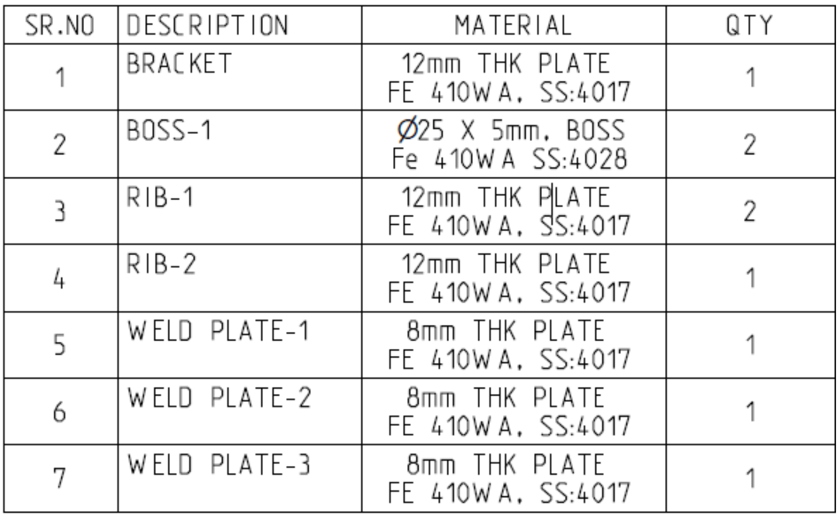
Annexures:

Material specification

Material –



SR.NO	DESCRIPTION	MATERIAL	QTY
1	BRACKET	12mm THK PLATE FE 410W A. SS:4017	1
2	BOSS-1	Ø25 X 5mm. BOSS Fe 410W A SS:4028	2
3	RIB-1	12mm THK PLATE FE 410W A. SS:4017	2
4	RIB-2	12mm THK PLATE FE 410W A. SS:4017	1
5	WELD PLATE-1	8mm THK PLATE FE 410W A. SS:4017	1
6	WELD PLATE-2	8mm THK PLATE FE 410W A. SS:4017	1
7	WELD PLATE-3	8mm THK PLATE FE 410W A. SS:4017	1

Coating/Material protection –

Powder coating - 10 BC-PC10

Surface protection – Black epoxy coating as per SS 7348.

Weld standard as per TS 12145

Design features –

L shape profile with re-enforced ribs

Stress analysis FEA (Finite Element analysis)

Vibration Damping (In customer Scope)