DESIGN DOCUMENT: CNG/ LNG GAS INJECTOR RAIL FOR AUTOMOTIVE ENGINES

Provided by Ryan Maudgalya

Scope of work

This document shows the findings and the reasoning behind the design solution given to Hallong international private ltd. (HIPL). The scope of work is to design a rail that allows gas from gas injectors to be combined into a singular funnel of gas along the rail. It must adhere to the dimensions of the HANA H2001 rail type fuel injector created by HANA EMS. Furthermore, some extra specifications were given by Hallong International to satisfy the needs of their fuel system.

Specifications of the design

In order to create a design solution an automotive engine, cummins 6BT AA 5.9L, was provided by HIPL for study and design development. The first step towards developing the design was to find the available space to fit the component. After physical verification, a space of 60 cm of length, 20 cm of height, and 50 cm of breadth was available to fit the component. Considering this available space, the first ideation of the solution was to develop the component with the shape of a rectangular prism. A component with the shape of a rectangular prism has the benefit of withstanding dynamic vibration better and easiness of installation. Moreover the availability of rectangular metal pieces is more available in the market compared to other 3d shapes.

Next, the component will be mounted on a commercial vehicle, such as trucks, which will continuously have shocks and heavy vibrations. As a result, the component must be able to withstand these forces and stay rigid for long after the first installation of the component and related aggregates. Thus a material must be chosen appropriately.

Also, the material from which the component will be machined from must be easily machined and light to allow for rapid production and to not over encumber the overall product. Thus, the type of material must be chosen carefully with these specifications in mind.

HIPL wishes to have extra space along the length of the rail which will allow them to include temperature and pressure sensors if necessary for future upgradation. Thus the dimensions of the design solution must be able to accomodate.

Finally, the design must be compatible with the HANA 2001 rail type fuel injection system as that is what shall be mounted on the component. So the measurements and the spacing of the holes in the mixer must be congruent with the dimensions of the injection system.

Specification considerations

The first specification was addressed by keeping dimensions of 31.8cm x 6.3cm x 3.1cm for the design solution. This allows for all of the attributes and parts of the design solution to be included while reducing the amount of material required to create the product. It also considers the extra length that comes from the fuel injector rail as well as HIPL's specification of the addition of extra length for the inclusion of pressure and temperature sensors.

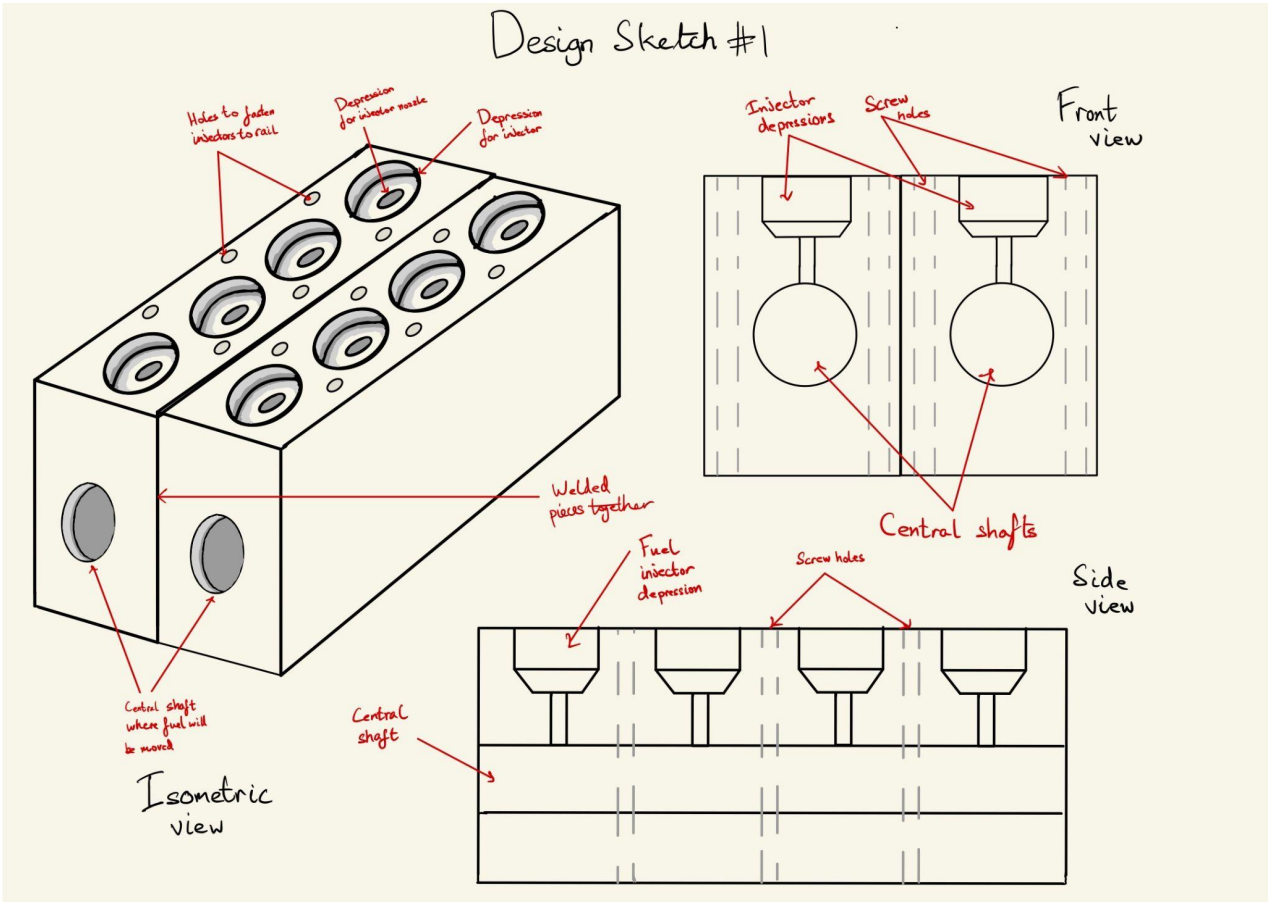
The second specification was addressed by choosing a versatile material, Aluminum 6061-T6, to create the product out of. This material is durable in nature and is good for machining products out of due to its corrosion resistance, versatility and overall strength in the alloy ("Unique Advantages of Aluminum Alloys for CNC Machining"). Furthermore, this addresses the third specification which is to find a material that is easy to machine and create products out of. Aluminum, unlike cast iron, is flexible in nature and can withstand high degrees of torsional vibration making it the best material for the design solution.

Lastly, to ensure that the coordinates of the holes match up with the fuel injector rail, the design solution was created in conjunction with the HANA 2001 rail type fuel injector design drawing to make sure that the design solution will fit. A model of the rail type fuel injectors was also created (as shown in the drawings below) to simulate the fitting of the rail on top of the design solution.

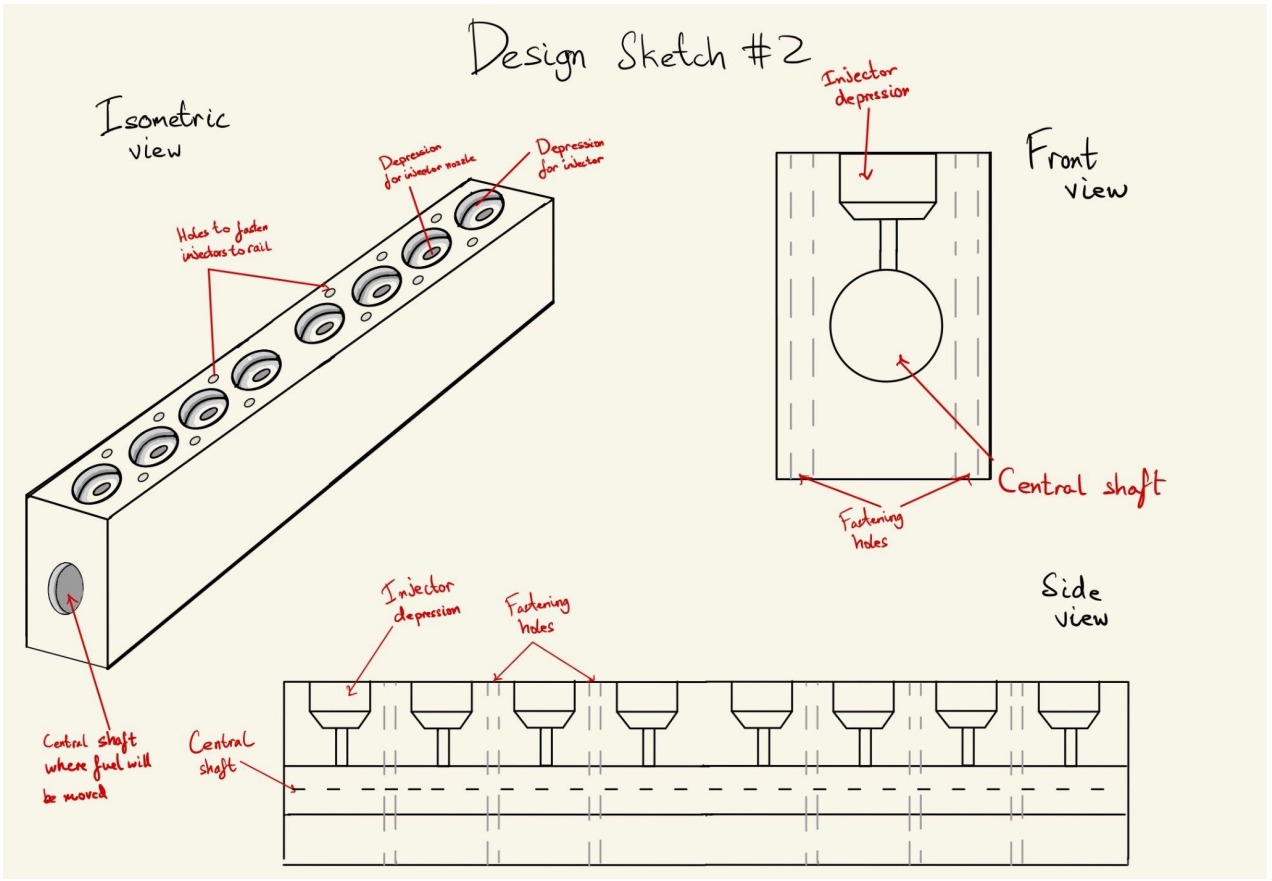
Design Ideation

Before creating the design in fusion, preliminary sketches of the potential design solution were drawn. Afterwards, they were evaluated based on the specifications and sent to HIPL for their thoughts.

Design Drawing 1



Design Drawing 2



Sketch evaluation

Design sketch 1:

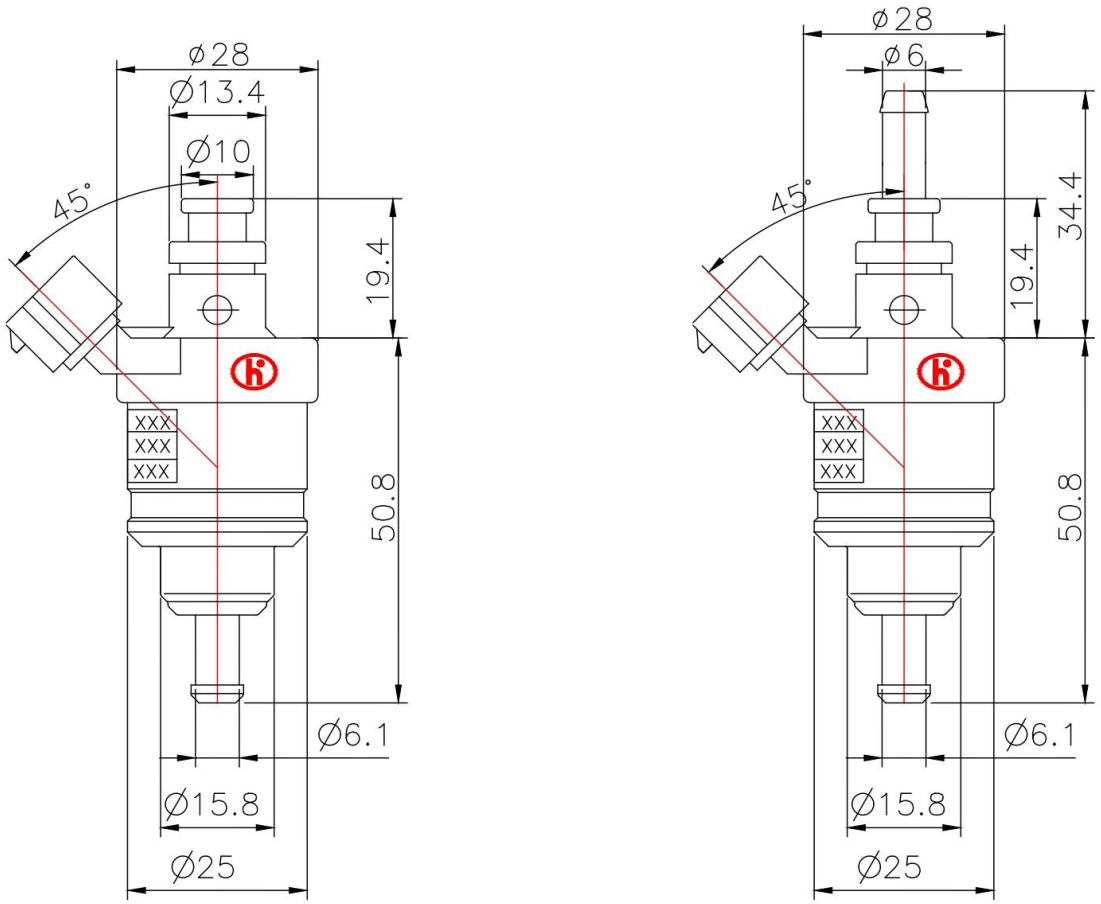
- For the first specification, it should fit as per the requested dimensions as the design features a compact and robust design. This will allow it to sit within the engine properly for use. However, the width of the design may be a problem as it may be too wide for the allotted space.
- The second specification is completely addressed as the material that will be used is Aluminum 6061-T6. However a slight problem with this design is that 2 pieces of aluminum must be welded together. Aluminum itself has quite a low melting point but a high thermal conductivity which makes it particularly hard to weld (Universal Technical Institute). Thus it may be difficult to machine and mass produce these parts without recurring problems and defects.
- The third specification is addressed as the drawing features depressions in which the fuel injectors could sit on. The dimensions will obviously be made in parallel with the H2001 design drawings below however the solution addresses this specification overall.
- As a whole, this design seems to be a bit complex due to the presence of 2 central shafts for the fuel to go through meaning another part will have to be created to homogenize and unify the 2 fuel streams into one creating more room for defects and increased price.

Design sketch 2:

- The first specification is completely addressed by the solution as it should easily fit into the desired dimensions due to the length, width, and height of the design being in tandem with the general guidelines of the first specification. This will allow the solution to sit properly in the engine.
- The second specification is also completely addressed as the material that will be used for the whole component will be Aluminum 6061-T6. Also, due to the fact that the component only features 1 piece, it has no welds so the prior problem will not be faced and the simplistic design will allow an easier and more consistent machining process.
- The final specification is also addressed as this design also features depressions for the injectors to sit on. The dimensions will properly be calculated and incorporated into the final design however the general idea is conveyed from this draft sketch.
- Overall, this design seems much more simpler and easier to create than the previous design allowing for cheaper, faster, and more mass production for the component.

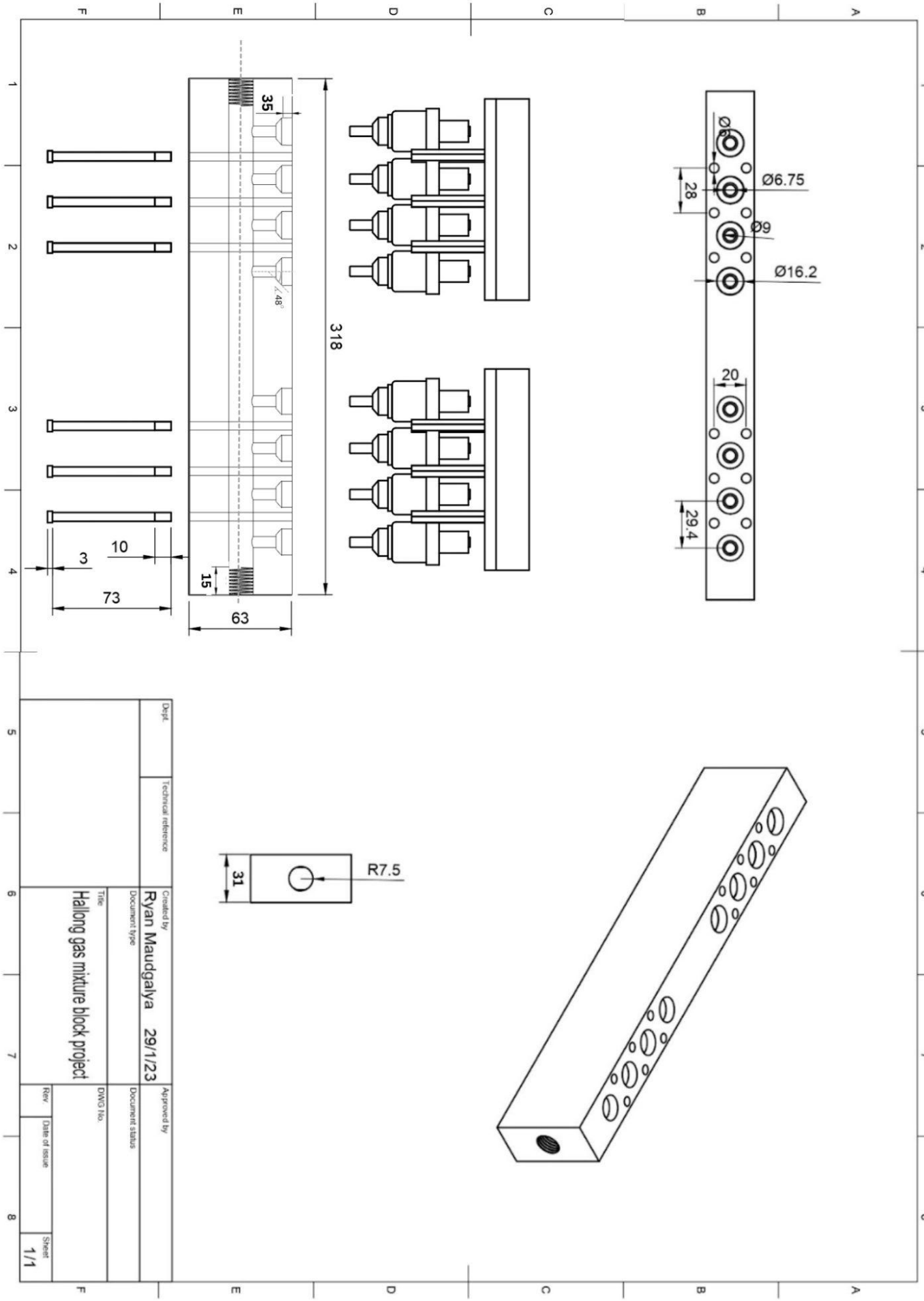
From both of the design sketches, it seems that the second is much more fitting of the constraints of this task and better optimizes the complexity, time, and cost of the component. As a result, the second design will be used to model the final design solution. Also, HIPL approved this design to be fledged out as the final design as well.

Fuel injector drawing (H2001)



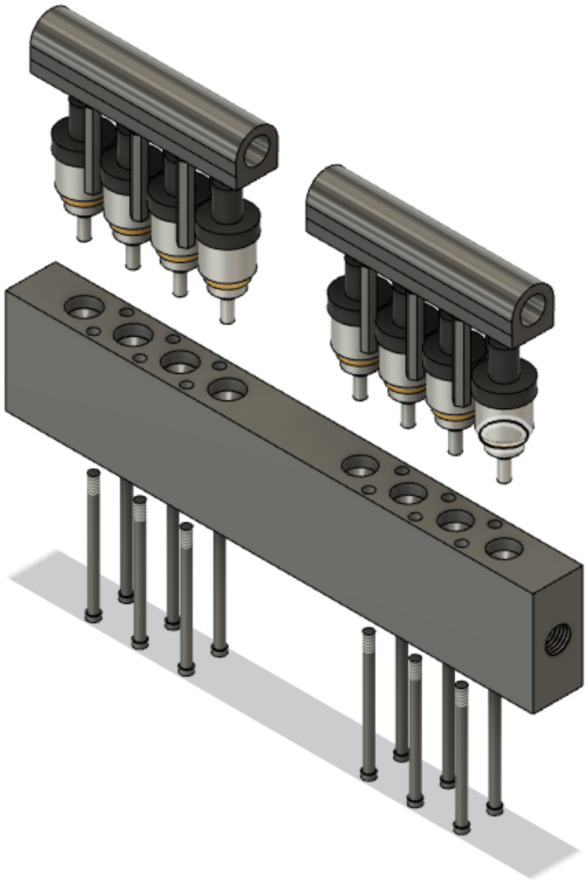
"H2001 - HANA EMS Co., Ltd." *HANA-EN*, http://hanaems.com/h2001/. Accessed 12 Feb. 2023.

Design Solution (All measurements in mm)



(Note all thread depths are 0.42 mm)

3D Model



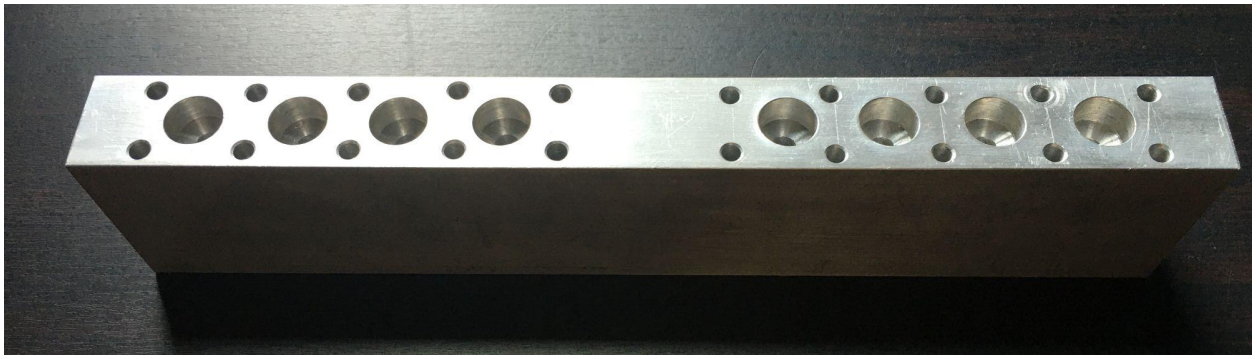
Design methodology

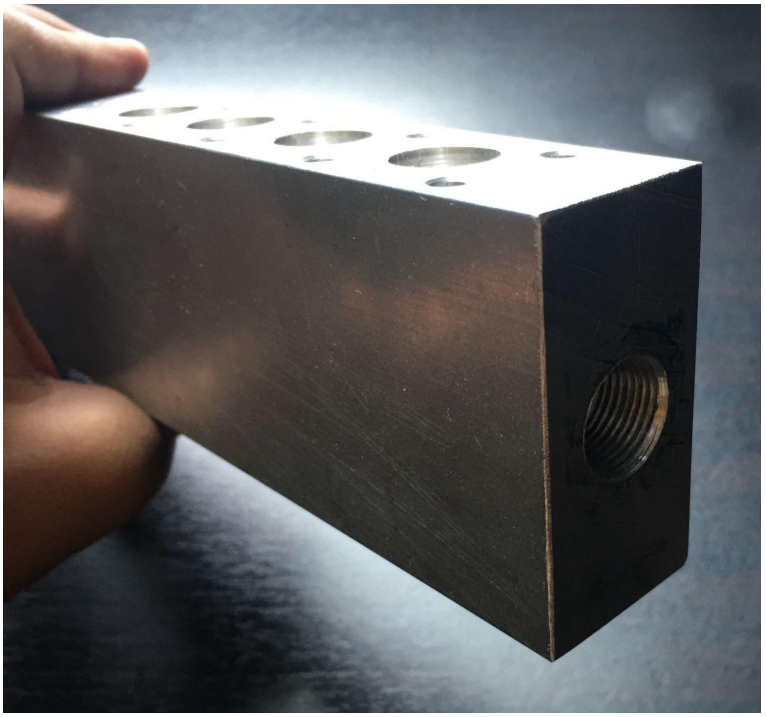
An aluminum 6061-T6 piece must first be machined to the desired dimensions and overall shape as shown in the design drawing. Then holes must be bored into the steel piece in accordance with the design and a cross drill a hole must be bored lengthwise with the necessary thread cutting.

Prototype testing

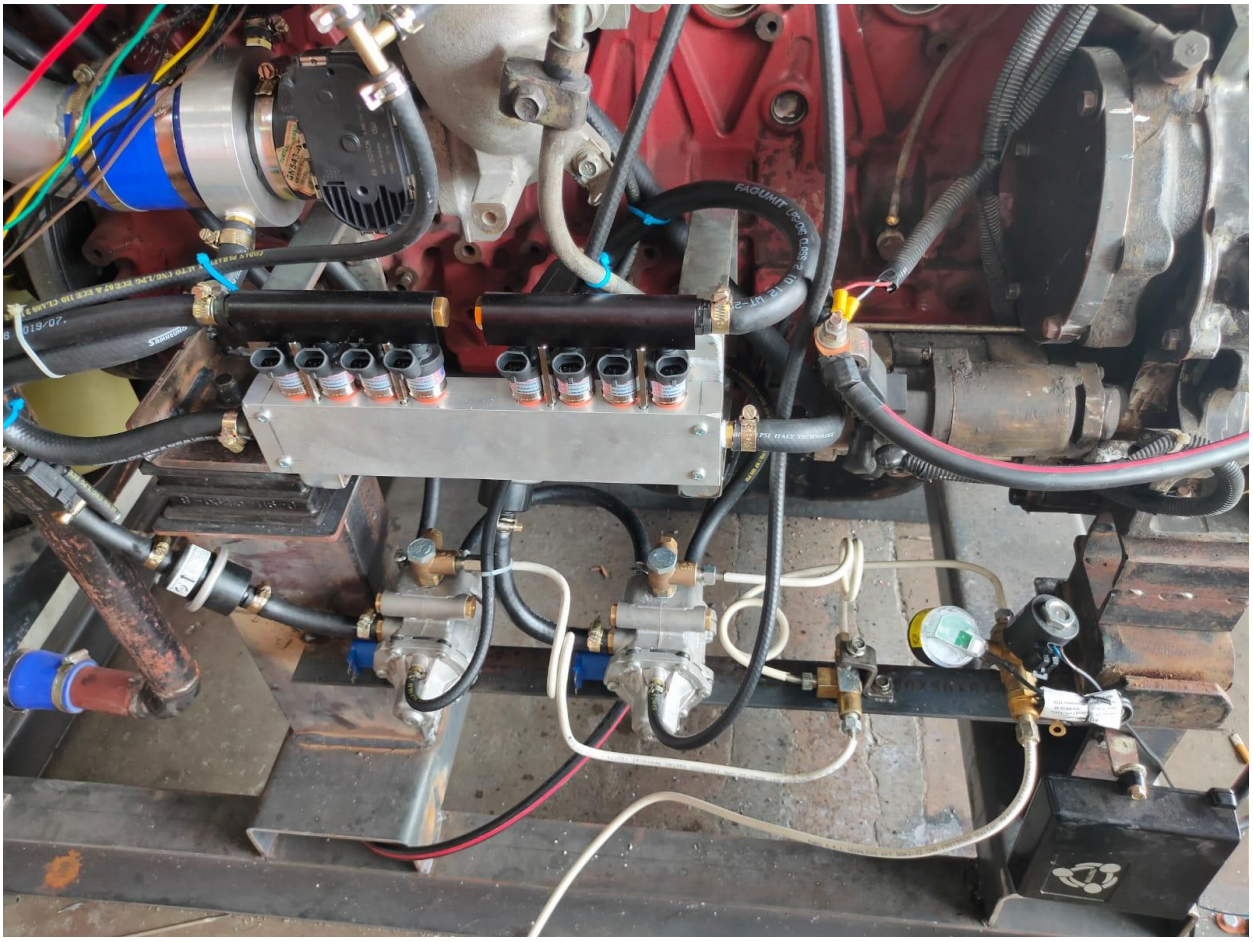
On the basis of the provided solution, a prototype was built and tested as shown below. The model was tested on a cummins 6BT AA 5.9L engine to test the effectiveness of the component as well as the structural integrity of the component when under the normal circumstances of an engine. This prototype was successful during primary testing alongside the whole engine and engine kit as the desired outcome was achieved.

Prototype:





Prototype being used:



Conclusion

In conclusion, the prototype was successful in all aspects specified by the Hallong international group and was successful also when performing government validation. Thus the design was accepted by the company and is now being deployed into more than 300 units in the next year.

Works Cited

"H2001 - HANA EMS Co., Ltd." *HANA-EN*, http://hanaems.com/h2001/. Accessed 12 Feb. 2023.

"Unique Advantages of Aluminum Alloys for CNC Machining." *Fast Radius*, https://www.fastradius.com/resources/cnc-machining-materials-aluminum-alloys/. Accessed 12 Feb. 2023.

Universal Technical Institute. *HOW TO WELD ALUMINUM: THE BEGINNER'S GUIDE*. https://www.uti.edu/blog/welding/aluminum-welding. Accessed 12 Feb. 2023.