Mitsubishi L200 Solar Panel Deployment Platform Manufacturing Portfolio

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Group 7

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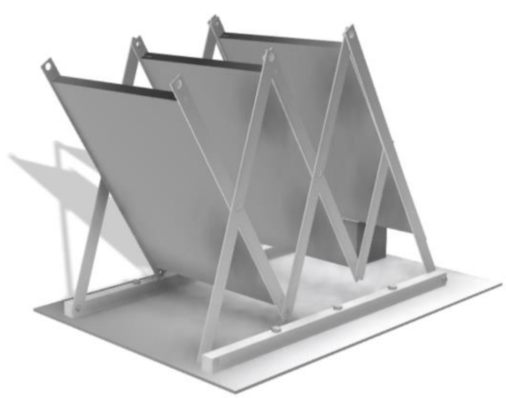

1.0 Manufacturing Considerations

1.1 Workpiece Selection

The chosen bespoke component was a baseplate that acted as a platform for the deployment mechanism. This component securely fastened the scissor lift mechanism to the floor of the truck storage space. Choosing a manufacturing method involved considering the workpiece material, overall cost (requirement 22), precision, design complexity (requirement 7) and production speed. Based on the material selection process in the design portfolio, Low Alloy Steel was chosen to be used for the bars. Thus, it was determined that a workpiece of the same material was suitable for the plate. To specify the dimensions of the stock material, industry-standard plates that are readily available in the market were analysed and compared to the exact base dimensions of the existing lifting mechanism. Since flat sheets have a maximum thickness of 6.35mm [1], they were not considered. The dimensions of the scissor lift mechanism at the base was 1320mm x 823mm, and thus to keep a healthy margin, the intended base plate dimensions were chosen to be 1475mm x 1100mm to allow for any fixtures and clamping, as well as gearbox placement. To reduce cost, the 2000mm x 1250mm x 10mm plate was chosen, due to being the smallest available option which accommodates the scissor lift base dimensions. The thickness of the plate was kept as 10mm as FEA analysis in the design portfolio showed a normal pressure acting down due to the mass having a magnitude of approximately 66MPa which the Low Alloy Steel plate can comfortably resist, considering its high tensile and compressive stress resistance values. Additionally, Low Alloy workpieces are available in different heat-treated conditions for added strength [2]. Ultimately, a 4140 Steel plate workpiece was chosen and sourced.

1.2 Manufacturing Method Selection

Fabrication, CNC Machining, Casting and Forging were considered as manufacturing methods to achieve the required member geometry [7].

Table 1: Manufacturing Method Comparison

Manufacturing Process	Precision	Cost	Material Options	Design Complexity	Production Speed
Fabrication	Moderately High: Accurately carries out cutting, bending, and welding	Moderate: Depends on labour, materials, and equipment	Wide: Metals, plastics, and composites	Moderately High: Can create complex structures and assemblies	Moderate: Varies based on complexity, volume, and workforce
CNC Machining	Very High: Computerized system achieving high precision and tight tolerances	Moderate: Depends on machine setup, tooling, and labour	Wide: Metals, plastics, and composites	Very High: Complex geometries and internal features can be created	High: High machine speed and low complexity of required plate
Casting	Moderate: Dependent on mould quality and materials	Moderate: Depends on machine setup, tooling, and labour	Wide: Metals, plastics, and composites	Moderate: Limited by mould design and parting lines	Low: Mould preparation, cooling time and volume
Forging	Moderate: Dependent on dies, temperature, and material	Moderate: Dependent on tooling, labour, and material cost	Moderate: Limited by forgeability	Low: Limited by dies	Low: Die preparation, heating, cooling, and volume

It is clear from the above comparison that CNC machining is the overall best manufacturing method to achieve good control over surface finish and tight interference tolerances. The tooling material used for the milling process was chosen to be High Speed Steel (HSS) [4] which is comparatively cost efficient, and more tough and wear resistant than Carbides and Ceramics. An outline of the step-by-step machining process is elaborated below [3]:

Workpiece Preparation: Workpiece was closely inspected for any deformations, irregularities, or defects, which were removed. The workpiece was squared, ensuring that it was flat and parallel. The workpiece was securely clamped to the CNC machine's worktable, so that it was properly aligned and rigidly held in place.

Toolpath Generation: CAM (Computer-Aided Manufacturing) was used on Autodesk Fusion 360 to generate the toolpaths necessary for machining the plate. HSS was selected, for its continuous rapid cutting in ferrous materials. The machining operations were also set up, including roughing, semi-finishing, and finishing passes, as well as the fillet machining. No passes were added for depth, as the workpiece had the required depth of the plate. Multiple passes were not added to reduce operation time, since CNC is cost-rated by the hour [6]. Fillet machining was done by replacing the face mill with a 5mm radius tool. The stock was flipped over, and the process is repeated. According to Fusion 360, the estimated machining time was 13 minutes and 27 seconds.

CNC Setup: The required machining and cutting tools were installed into the CNC machine. The work coordinate system was set up and tool offsets were specified to ensure avoiding misalignments. The toolpaths generated in Fusion were loaded into the CNC controller. The specified machining process was then initiated.

Workpiece Inspection: A detailed inspection of the finished plate was carried out for accuracy, dimensions, and surface finish. Then, post-processing i.e., deburring was performed using a 76mm deburring brush on both sides to rule out any imperfections. Finally, an H7 tolerance was used to drill 6 holes to fit M20 x 70mm 45-degree countersunk screws, in order to allow for attachment between the base plate and mounting bars, as shown in the assembly and bespoke component technical drawings. The holes were made using a reamer for its high-quality finish.

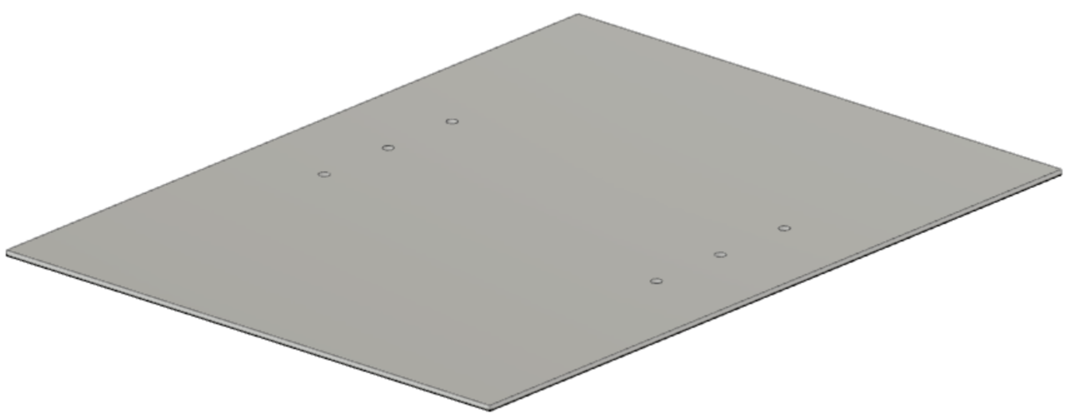

Figure 1: CAD model of low alloy steel baseplate

2.0 Manufacturing Costs

In this section of the analysis, component costs have been considered without their assembly and overhead costs. For this scenario, assembly costs can be excluded because only one bespoke component was considered here. The overhead costs were not considered because of the assumption that a different department incurred this cost. Within component cost, the stock material cost and tooling cost were considered. According to cost estimator CustomPartNet [8], several factors were considered before achieving our component cost result. Considering a run quantity in line with workpiece demand, a defect rate of 5% and a cut charge of $1.50/part, and a selling price markup of 10% the cost per sheet came out to be $3.30/part. Additionally, considering the 13 minutes and 27 seconds of machining time, the cost per sheet rises by $9.70, or £7.77/part to £12.39/part. Within tooling costs, the total comes out to be £164.89 as seen in table 2 for one year of production, assuming all parts are changed once a year. This cost does not consider bulk production for output of many scissor lift mechanisms, which would decrease the cost per unit part. If all Mitsubishi L200 cars have this mechanism, and 64,391 cars were sold in 2022 [9], the tooling cost per part becomes GBP0.0026.

Table 2: Tooling Cost Table

Tool	Model No.	Cost (£)
Scotch-Brite™ Shaft Mounted Bristle Disc BB-ZS, 76 mm, P80 [5]	FN520002620	30.83
RS PRO HSS Twist Drill Bit, 28mm x 291 mm [5]	784-4800	71.40
RS PRO Plain Steel Hex Socket Cap Screw, DIN 7991, M16 x 60mm, 6 screws [5]	193-3425	48.07
4 Flute HSS Corner Rounding End Mills, 5mm fillet attachment [5]	060-280-40050	14.59

In conclusion, the overall cost for manufacturing the baseplate is ~£12.39.

References

[1] Fractory. (2021). Sheet Metal - Materials, Standard Sizes & Forming Processes. [online] Available at: https://fractory.com/sheet-metal/#:~:text=The%20thickness%20of%20sheet%20metal. [Accessed 26 April 2023]

[2] Anon, (n.d.). Heat treating low alloy PM steels | Gear Solutions Magazine Your Resource to the Gear Industry. [online] Available at: https://gearsolutions.com/features/heat-treating-low-alloy-pm-steels/ [Accessed 4 May 2023].

[3] get-it-made.co.uk. (n.d.). CNC Machining Guide | Get It Made. [online] Available at: https://get-it-made.co.uk/guides/cnc-machining-guide#:~:text=The%20basic%20process%20can%20be.

[4] Lee, J. (2021). What Type of Steel is Best for Your CNC Machined Part? [online] Gensun Precision Machining. Available at: https://www.china-machining.com/blog/cnc-machining-steel/. [Accessed 25 April 2023]

[5] My.rs-online.com. 2022. | RS Components. [online] Available at: <https://my.rs-online.com/web/c/engineering-materials-industrial-hardware/anti-vibration-levelling-components/rotary-dampers/> [Accessed 1 May 2023].

[6] Parallel Precision. (n.d.). How Much Does CNC Machining Cost? [online] Available at: https://www.parallelprecision.co.uk/blog/how_much_does_cnc_machining_cost [Accessed 2 May 2023]

[7] Form, D.R. (n.d.). Metal Forming Processes: Techniques, Industries, & Use Cases. [online] blog.dahlstromrollform.com. Available at: https://blog.dahlstromrollform.com/metal-forming-processes-guide. [Accessed 19 April 2023]

[8] Machining Cost Estimator. [online] Available at: https://www.custompartnet.com/estimate/machining/.

[9] BROGAN, G.-M. (n.d.). VFACTS: 2022 sales top the million mark. [online] GoAuto. Available at: https://www.goauto.com.au/news/vfacts/sales-2022/vfacts-2022-sales-top-the-million-mark/2023-01-05/90063.html.