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Material Selection Report

Engineering Design and Materials - ACHA4001

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1 Introduction

A comprehensive design specification for an aftermarket, high-grade replacement top bolt for a 2023 M2R 140 rear mono shock is given. Material selection and part manufacturing processes are detailed alongside part requirements, environmental factors, costs, and maintenance.

2 Component Design Specification

2.1 OEM Component Research



Figure 1: OEM Bolt Head.



Figure 2: OEM Bolt Side Profile.

Table 1: OEM bolt metrics.

Metric	Spec
ISO Metric	M10x1.0
Thread Length	12mm
Body Length	40mm
Body Diameter	10mm
Thread Pitch	1mm
Weight	37g
Bolt Head Size (Socket Size)	13mm
Flange Diameter	21mm
Bolt & Flange Thickness	9mm
Part Number	7.010.0450
Material	8.8 Carbon Steel
Coating	Hot dip galvanised (see 2.2)

2.2 OEM Material

Information gathered from the OEM component details the material used as property class 8.8 following ISO 898-1:2013 Mechanical properties of fasteners made of carbon steel alloys - Part 1.

Property class	Material and heat treatment	Chemical composition limit (cast analysis, %) ^a					Tempering temperature °C
		C min.	C max.	P max.	S max.	B ^b max.	
4.6 ^{c,d}	Carbon steel or carbon steel with additives	—	0,55	0,050	0,060	Not specified	—
4.8 ^d		—	0,55	0,050	0,060		
5.6 ^c		0,13	0,55	0,050	0,060		
5.8 ^d		—	0,55	0,050	0,060		
6.8 ^d		0,15	0,55	0,050	0,060		
8.8 ^f	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,15 ^e	0,40	0,025	0,025	0,003	425
	or Carbon steel quenched and tempered	0,25	0,55	0,025	0,025		
	or Alloy steel quenched and tempered ^g	0,20	0,55	0,025	0,025		
9.8 ^f	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,15 ^e	0,40	0,025	0,025	0,003	425
	or Carbon steel quenched and tempered	0,25	0,55	0,025	0,025		
	or Alloy steel quenched and tempered ^g	0,20	0,55	0,025	0,025		
10.9 ^f	Carbon steel with additives (e.g. Boron or Mn or Cr) quenched and tempered	0,20 ^e	0,55	0,025	0,025	0,003	425
	or Carbon steel quenched and tempered	0,25	0,55	0,025	0,025		
	or Alloy steel quenched and tempered ^g	0,20	0,55	0,025	0,025		
12.9 ^{g,h,i}	Alloy steel quenched and tempered ^g	0,30	0,50	0,025	0,025	0,003	425
12.9 ^{h,i}	Carbon steel with additives (e.g. Boron or Mn or Cr or Molybdenum) quenched and tempered	0,28	0,50	0,025	0,025	0,003	380

^a In case of dispute, the product analysis applies.

^b Boron content can reach 0,005 %, provided non-effective boron is controlled by the addition of titanium and/or aluminium.

^c For cold forged fasteners of property classes 4.6 and 5.6, heat treatment of the wire used for cold forging or of the cold forged fastener itself may be necessary to achieve required ductility.

^d Free cutting steel is allowed for these property classes with the following maximum sulfur, phosphorus and lead contents: S: 0,34 %; P: 0,11 %; Pb: 0,35 %.

^e In case of plain carbon boron steel with a carbon content below 0,25 % (cast analysis), the minimum manganese content shall be 0,6 % for property class 8.8 and 0,7 % for property classes 9.8 and 10.9.

^f For the materials of these property classes, there shall be a sufficient hardenability to ensure a structure consisting of approximately 90 % martensite in the core of the threaded sections for the fasteners in the "as-hardened" condition before tempering.

^g This alloy steel shall contain at least one of the following elements in the minimum quantity given: chromium 0,30 %, nickel 0,30 %, molybdenum 0,20 %, vanadium 0,10 %. Where elements are specified in combinations of two, three or four and have alloy contents less than those given above, the limit value to be applied for steel class determination is 70 % of the sum of the individual limit values specified above for the two, three or four elements concerned.

^h Fasteners manufactured from phosphated raw material shall be dephosphated before heat treatment; the absence of white phosphorus enriched layer shall be detected by a suitable test method.

ⁱ Caution is advised when the use of property class 12.9/12.9 is considered. The capability of the fastener manufacturer, the service conditions and the wrenching methods should be considered. Environments can cause stress corrosion cracking of fasteners as processed as well as those coated.

Figure 3: Steel fastener material properties (ISO 898-1:2013 Mechanical properties of fasteners made of carbon steel alloys - Part 1. p. 7).

2.3 Coating

It is likely the OEM component is coated to assist with environmental protection. Although no data can be found on the specific coating of 8.8 class bolts the use of hot dip galvanising is the most used form of corrosion inhibition used in the protection of steel (Zhmurkin, 2009, p. 1). Lab tests should be conducted to further determine the exact coating material and properties.

2.3.1 Cost

A web search of part number provided in table 1 shows a cost of £1.58 per unit to the end consumer.

3 New Product Overview

A high-quality aftermarket replacement for the rear shock top mount bolt for a 2023 M2R 140. The component is to be a 'like for like' replacement with exceptions of material, manufacturing quality and the potential for desirable design additions. The component is to be constructed to specific metrics (table 1) of the OEM part but is to be made to a higher quality, stronger material and be more resistant to elements.

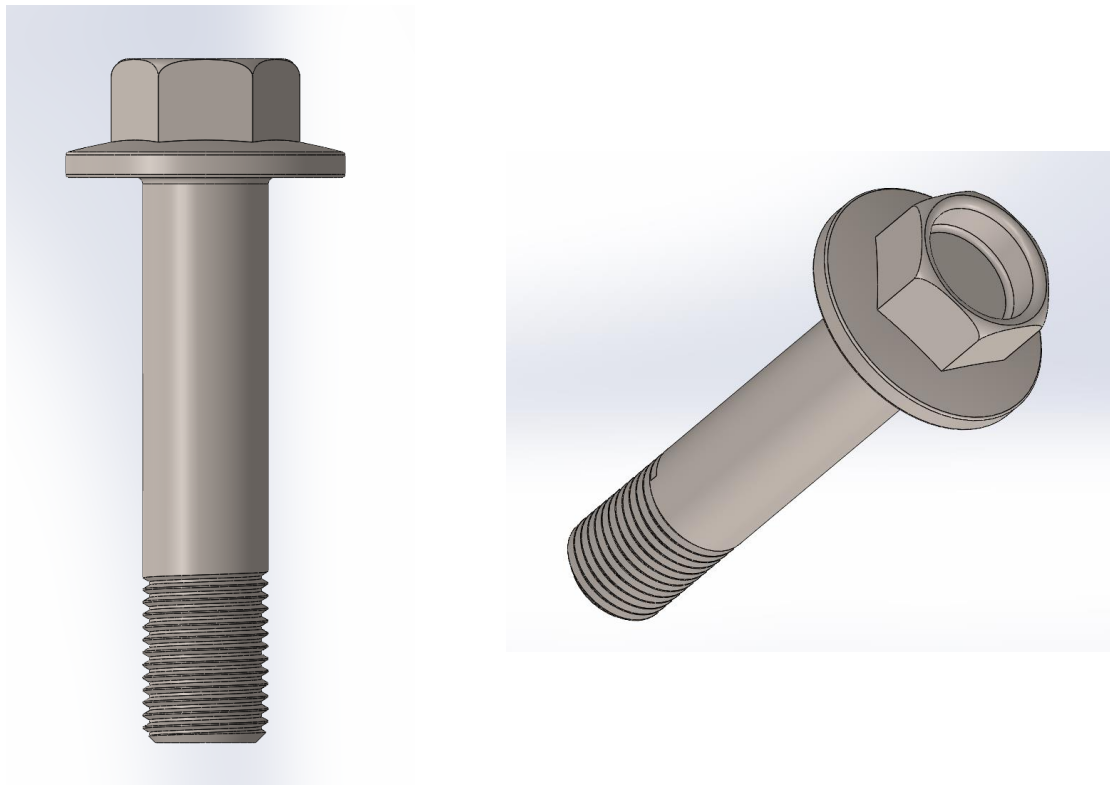
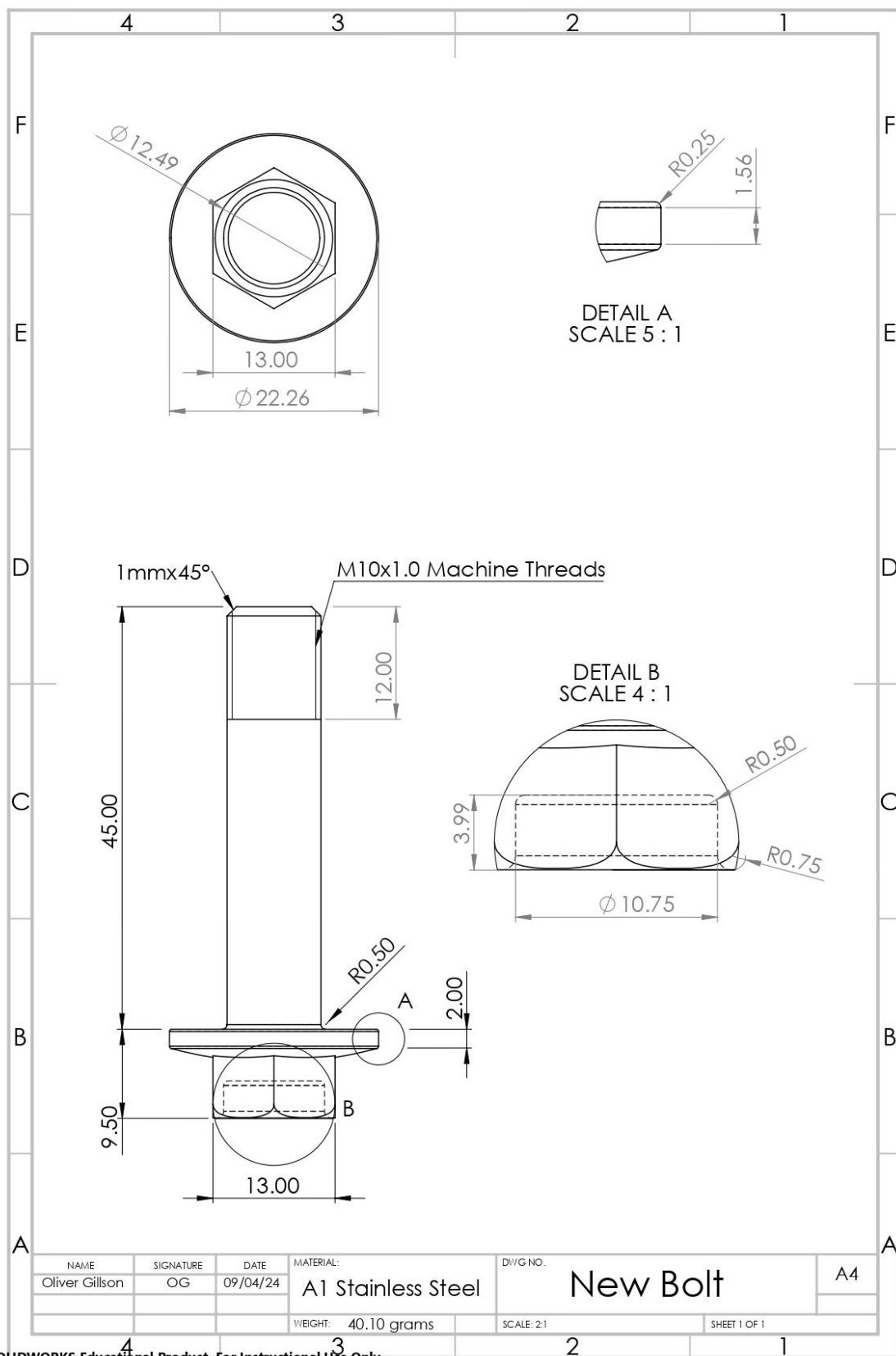


Figure 4: CAD models of new bolt.



SOLIDWORKS Educational Product. For Instructional Use Only.

Figure 5: New bolt technical drawing.

3.1 Component Requirements

Category	Demand/Want	Requirement	Success Criteria	Method of Assessment
Performance	Demand	The part is to perform equal to or better than than OEM.	Superior strength and longevity characteristics. Resistant to wear and elemental corrosion with limited need for maintenance.	Comparative strength and longevity testing. Suitable material selection.
Environment	Demand	Environmental factors do not have adverse effects on the function or longevity of the product. The product will perform equal to or better than the OEM in a range of operating temperatures and weather conditions (wet/dry).	Appropriate material selection to accommodate for wet, dry, hot and cold conditions.	Due material research. Random product testing. Raw material testing. OEM product test to set as a benchmark.
Life Expectancy	Demand	Superior life expectancy to OEM.	Appropriate material selection.	Due material research. Random product testing. OEM product test to set as a benchmark.
Maintenance	Want	Regular maintenance to prevent early failure.	End user maintenance schedule	This is entirely dependant on the end user maintenance schedule however the part is to be produced with limited maintenance in mind. Correct material selection should see part longevity increase and therefore a decrease in maintenance.
Target Product Cost	Demand	Product can be more expensive than OEM but still within suitable range to make it affordable for end user.	Batch manufacturing to bring costs down. Suitable material selection should keep in mind the unit cost.	Comprehensive manufacturing breakdown to determine the per unit cost and a suitable markup applied for end user.
Packaging	Want	Product to be packed in a sealed translucent plastic bag with product specifications written on it.		
Size	Demand	Identical part dimensions to OEM.	Correct measuring against OEM. Accurate CAD modelling.	Random product testing.
Weight	Demand	Equal to or lighter than OEM.	Product is lighter than OEM.	OEM weight as benchmark. Random product testing.
Materials	Demand	Product is stronger, lighter and more resistant to corrosion and wear than OEM.	Product is stronger, lighter and more resistant to corrosion and wear than OEM.	
Product life span	Want	Product should have a life span equal to or longer than OEM.	Appropriate material selection.	Random product testing. Life span will be dependant on end user maintenance and care
Standards & Specifications	Demand	ISO specification threaded bolt	Fits ISO 898 Mechanical properties of fasteners made of carbon steel and alloy steel	Random product testing.
Quality	Demand	Part should be of high manufacturing quality and made from high grade materials.	Limited or no manufacturing marks. High quality finish High quality material	Manufacturing process to be refined to ensure no manufacturing marks are left on end product. Suitable material selection and raw material testing. Random product testing.
Reliability	Demand	Superior reliability than OEM.	High quality material and manufacturing methods	Comparative product testing.
Coating	Want	Product comes with pre applied locktight coating.	Manufacturing process includes coating.	Correct manufacturer selection.
Shelf Life	Want	Long term storage does not adversely effect the product characteristics.	Correct storage methods.	Storage recommendations printed on packaging
Safety	Demand	The product should conform to ISO standards to ensure maximum safety ratings.	Successful stress/strain testing.	Rigorous product testing before release. Random manufacturing tests through the manufacturing line.
Race specification	Want	Holes in bolt head to allow for lock wire.	Holes in bolt head allow for the install of lockwire drilled during manufacturing phase.	
Colour	Want	A range of colours provided	Anodising post manufacturing.	

Figure 6: Design specification table.

This design specification is not exhaustive and should be updated regularly throughout the design and manufacturing process to correctly reflect changes made to *any* aspect of the project.

4 Material Selection

4.1 Material Options

Table 2: Potential material candidates.

Material	Pros	Cons
8.8 Carbon Steel	- Popular, so easily manufactured. - Cheap to produce.	- Subject to corrosion without coating. - Subject to corrosion if coating is damaged. - Coating costs extra. - Lower tensile strength.
A1 Stainless Steel (SAE 303)	- High corrosion resistance. - Corrosion resistant even when damaged. - Highest tensile strength. - More appealing finish.	Slightly heavier than OEM material.
7075 Aluminium Alloy	- Lightest option. - Corrosion resistant	- More expensive than OEM material. - Low tensile strength
Titanium	- Lighten than OEM. - Appealing material - High tensile strength	Expensive per unit

Table 3: Material properties and prices. (Properties are the average value provided by Ashby M. F p.581)

Material	Tensile Strength (MPa)	Cost (Tonne) (\$)	Purchase Link
8.8 Carbon Steel	805	550	8.8mm Carbon Steel
A1 Stainless Steel (SAE 303)	1340	550	A1 Stainless Steel (SAE 303)
7075 Aluminium Alloy	304	1,699	7075 Aluminium Alloy
Titanium (Grade 2)	950	10,000	Titanium (Grade 2)

Table 4: Material costs per unit (weight based off OEM part research (table 1) and CAD model data).

Material	Bolt Mass (g)	Number of Units (per tonne)	Material Cost Per Unit (\$)
8.8 Carbon Steel	37	27,027	0.02
A1 Stainless Steel (SAE 303)	41	24,313	0.02
7075 Aluminium Alloy	20	49,115	0.03
Titanium (Grade 2)	23	43,122	0.23

5 Manufacturing Process Selection

Bolt manufacturing often uses a cold forge process in which rolls of steel wire rod are first cut to length before being passed through a series of stamps that progressively shape the head of the bolt to the required dimensions. The threaded end is cut using the same cold forging method. Samples are taken throughout the run and tested using various measurement tools to ensure conformity (How It's Made, 2014).

The bolts can be heat treated and coated after the manufacturing process to further improve their characteristics (Satisfying Tech, 2024).

[Europressvit](#) are an Italian manufacturer of stainless-steel bolts that has been in business since 1968, they provide a bespoke set of services alongside the manufacturing process that includes heat and surface treatments, packaging, and stock consignment.

6 Conclusion

Stainless steels are a common manufacturing material due to their corrosion resistance and high mechanical strength (Singh, 2022). Simple parts searches for motorcycle spares prove that there is an active market for high quality, weather resistant stainless-steel replacements for multiple makes and models. With this information in mind and considering the material properties detailed in tables 2-3, A1 stainless-steel looks to be the most fitting material for the new product.

Although slightly heavier, which may be a negative for a buyer in a race setting, the stainless-steel bolt holds favourable corrosion resistance and tensile strength properties.

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