



Mass Optimisation Of A connecting Rod

Utilising Composite Materials

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Introduction

Powertrain development is vital to succeed in the automotive industry due to the demand for smaller engines with higher specific output and efficiency to meet tougher emission standards. Greater efficiency and higher specific output is achieved by more efficiently transferring force from combustion to the rotational motion of the crankshaft, thus, the force transferred through the piston to the cylinder walls needs to be reduced. One way to reduce the friction is to reduce the mass of the connecting rod which is typically overengineered.

Aims

The project was based on a Ford 1.6 GDI engine and had four main objectives with the overall aim to ascertain whether a carbon fibre connecting rod optimised for mass is a suitable replacement for the standard steel connecting rod.

Objectives

1. Reverse engineer a 1.6 Ford GDI connecting rod
2. Reverse engineer a titanium Pankl rod
3. Perform tensile testing on UD carbon fibre to ascertain material properties
4. Design a connecting rod suitable for manufacture from carbon fibre

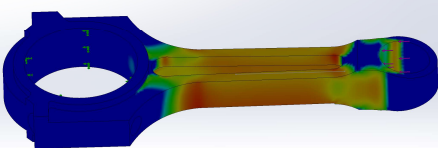


Figure 1 Safety factor plot



Methodology

Cylinder pressure data from the GDI engine was used to calculate the forces that the connecting rod is subjected to throughout its lifecycle. The forces were used to calculate the compressive and tensile stresses which are used to calculate:

- Static and fatigue Safety factors
- Displacement from compression
- Displacement from tension

The connecting rods was modelled in Solidworks and analysed using finite element analysis utilising the maximum forces calculated in Excel. This analysis was completed using:

- Solidworks
- Siemens FEmap

Carbon fibre coupons were tested in tension using a Denison test machine. Unfortunately the machine wasn't calibrated therefore the material properties calculated were incorrect. Multiple tests were performed to obtain a manipulation value, these tests include:

- Aluminium fitted with strain gauges
- Hounsfield dog bones
- Image analysis software

A bladder mould carbon fibre connecting rod was designed and FEA conducted using:

- Solidworks
- Design Studio

Table 1 connecting rod calculations

Connecting rod		GDI	Pankl
Material		4340 steel	Ti6Al4V Grade 5
UTS	MPa	745	1000
youngs modulus	MPa	200000	110000
Safety Factor		2.95	3.96
Comp dist	mm	0.169	0.307
Stretch	mm	0.050	0.091

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Results

Material properties, safety factors, displacements for both connecting rods are displayed in table 1.

Table 2 shows the reduction in friction from reducing the connect rod mass.

Table 2 friction

	Total friction	Friction / °	Reduction %
100% Mass	80640.35	112.00	
90% Mass	80223.05	111.42	0.52
80% Mass	79805.76	110.84	1.04
70% Mass	79388.47	110.26	1.56
60 % Mass	78971.17	109.68	2.09
50% Mass	78553.88	109.10	2.61

Table 3 displays the average Youngs modulus, after the extension value was divided by 2.5. this reduction factor was ascertained as an average from the GOM correlate image analysis software shown in figure 2.

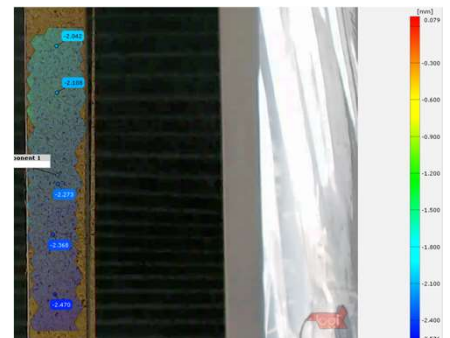


Figure 2 GOM Correlate

Table 3 Youngs modulus

Fibre orientation	E (Gpa)
0°	142
90°	30
Ez comp 0°	160

Conclusions

Using the cylinder pressure data it was possible to successfully reverse engineer both connecting rods and analyse the effect of mass reduction on friction.

From the research conducted its known to be possible to reduce mass by the manufacturing the connecting rod from carbon fibre, unfortunately due to unforeseen circumstances it was not possible to get to the manufacturing stage. Therefore it was not possible to work out the cost to manufacture.