FMN – IMA
Mathematics at Work
competition winner 2008

The use of Mathematics (Mechanics) in the Testing of an Automotive Engine Component

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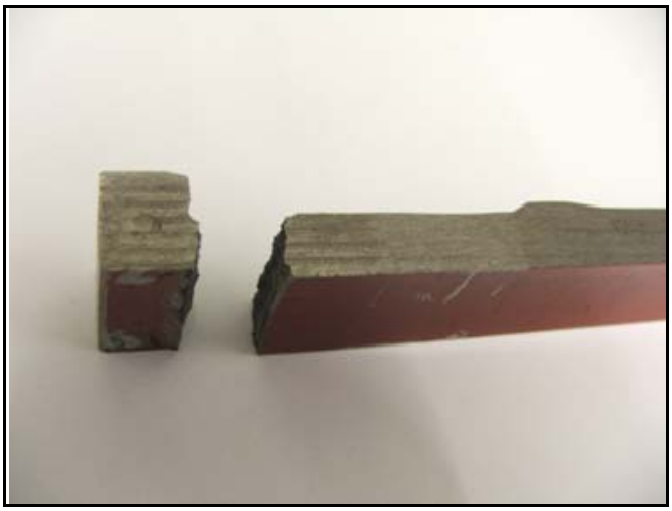
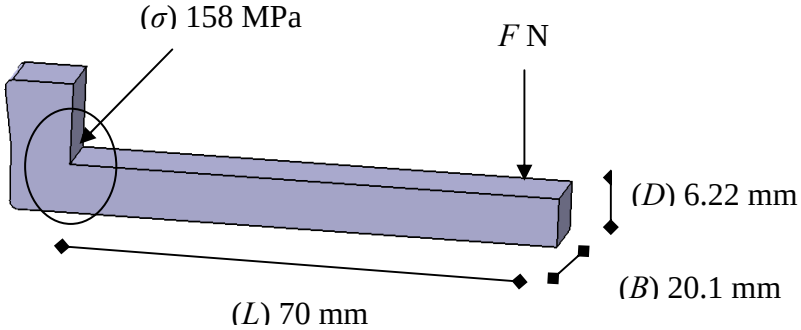
In my YINI placement I have been working under the guidance of Roy Wakeman in the design development and test department at GKN AutoStructures, a manufacturer of automotive chassis components. Throughout my placement the use of different mathematical concepts has been essential.

An example of this involved the test of an automotive engine component for an external company. The component has been failing due to fatigue caused by a repetitive stress in a specific area.



The company for whom the testing was carried out suggested that the area of failure was experiencing a mean stress of 158 MPa. In order to determine the load required to replicate this some calculations had to be carried out.



To calculate the force F:

Start with the bending stress formula: $\sigma = \dfrac{My}{I}$

Where: σ = stress

M = Moment at the neutral axis $= FL$

y = Perpendicular distance to the neutral axis $= 0.5D$ (in this case)

I = Area moment of inertia about the neutral axis $= \dfrac{BD^3}{12}$

Substituting into the formula: $\sigma = \dfrac{12FLD}{2BD^3}$

Simplifying: $\sigma = \dfrac{6FL}{BD^2}$

Rearranging: $F = \dfrac{\sigma BD^2}{6L}$

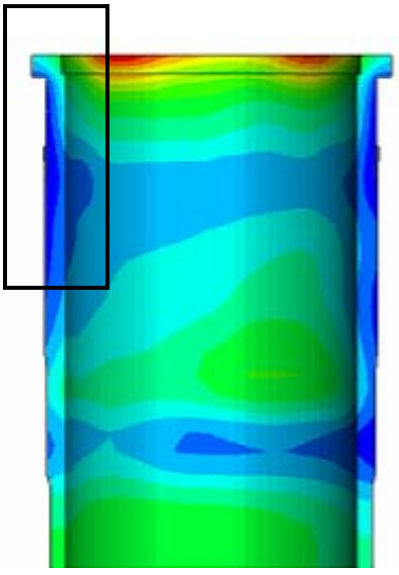
And substituting in the known values:

$$F = \frac{(158\times10^{6})(20.1\times10^{-3})(6.22\times10^{-3})^{2}}{6(70\times10^{-3})}$$

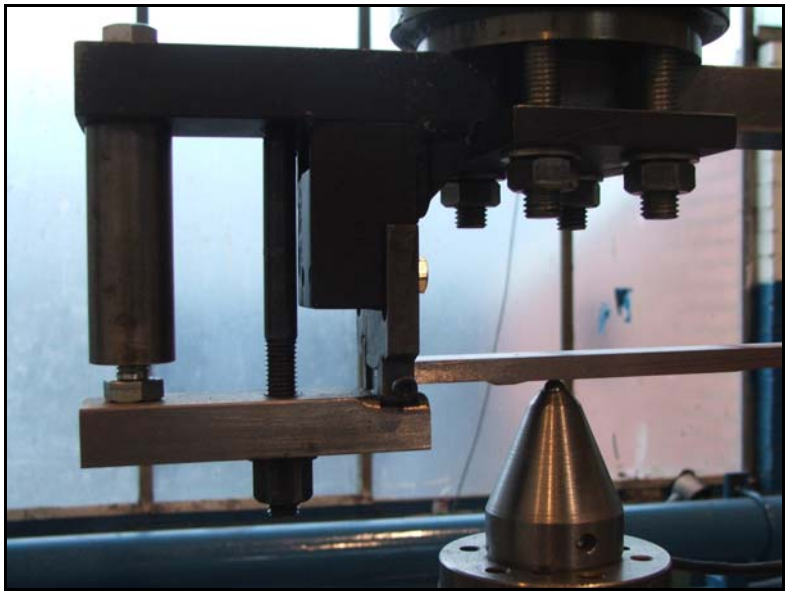
$$= 293 \text{ N}$$

So the force is of magnitude 293 N.

This calculation confirmed that we had the capability to carry out the testing as we could easily apply 293 N in the required format, allowing us to complete a range of computer simulations and physical fatigue tests (see images below).



Stress in component as indicated using Finite Element Methods software



Component testing in progress using actual machinery