Motorcycle’s Chassis Analysis

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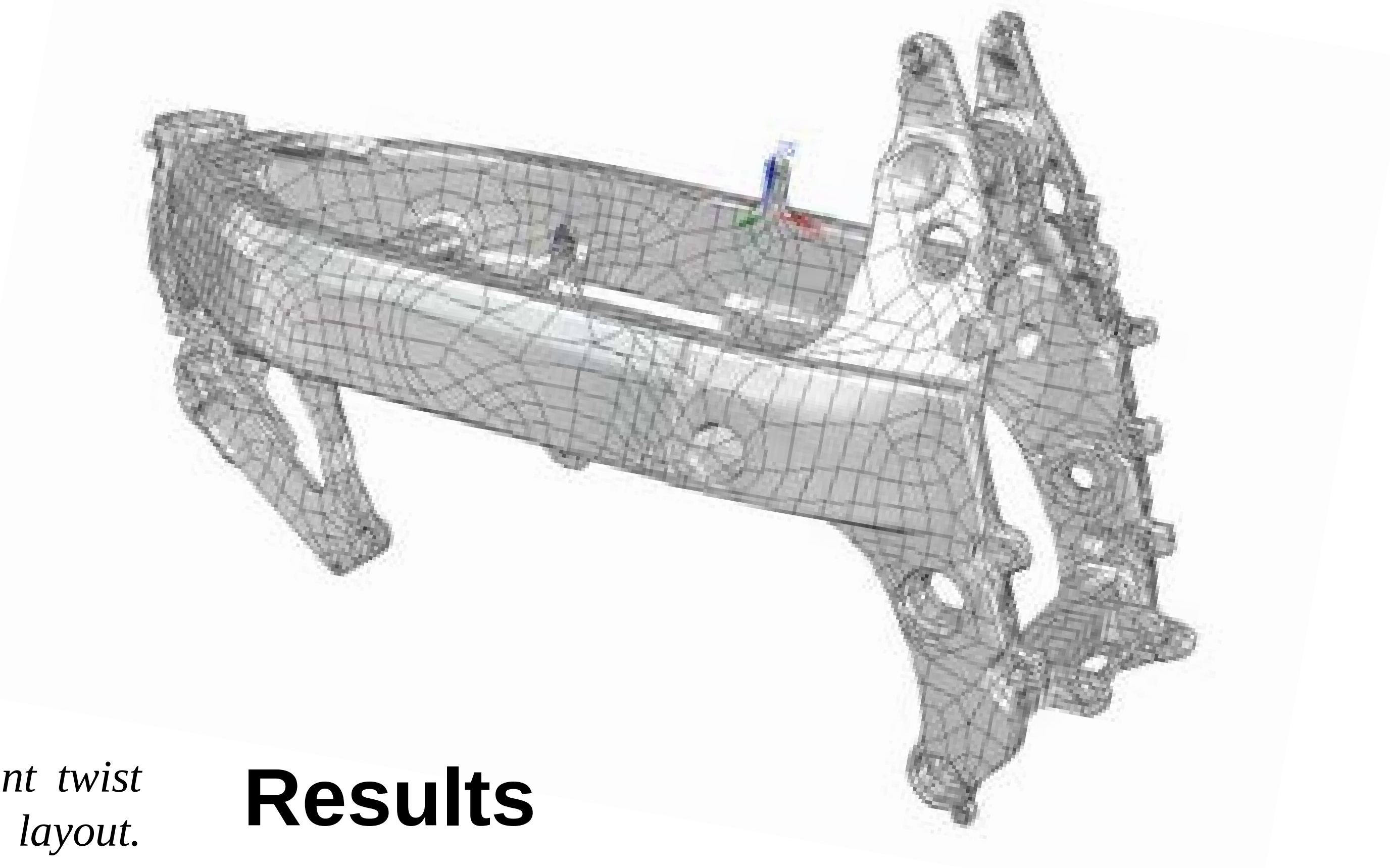


Introduction

Motorcycle’s frame are often wrongly considered as a static structure that must only hold components together and bear loads. However, the dissertation enhances the frame’s dynamic purpose, highlighting its paramount feature over handling response and rider’s feedback. Key aspect to a perfect understanding of a chassis’ analysis lies in the mechanics of materials, to then be able to evaluate the features that identifies its characteristics: torsional, lateral and longitudinal stiffness parameters. All materials deflect under an external load and it is fundamental acknowledge up to which limit the deformation will be elastic, especially when is dealt with a motorcycle’s chassis.

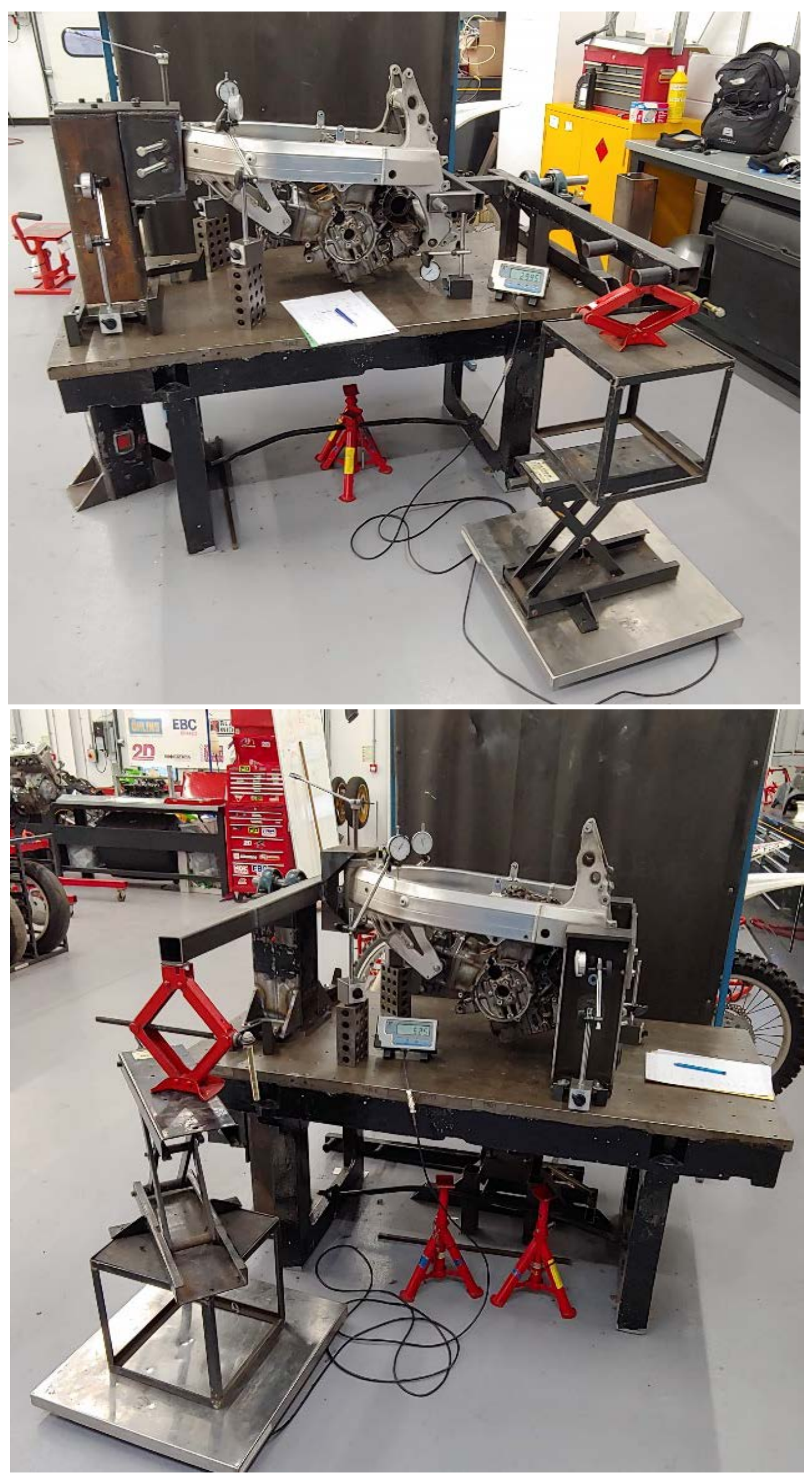
$$E = \frac{\sigma}{\varepsilon} = \frac{F}{A}\Big/\frac{\partial l}{l_0} \qquad (1)$$

(Hearn, 1977).

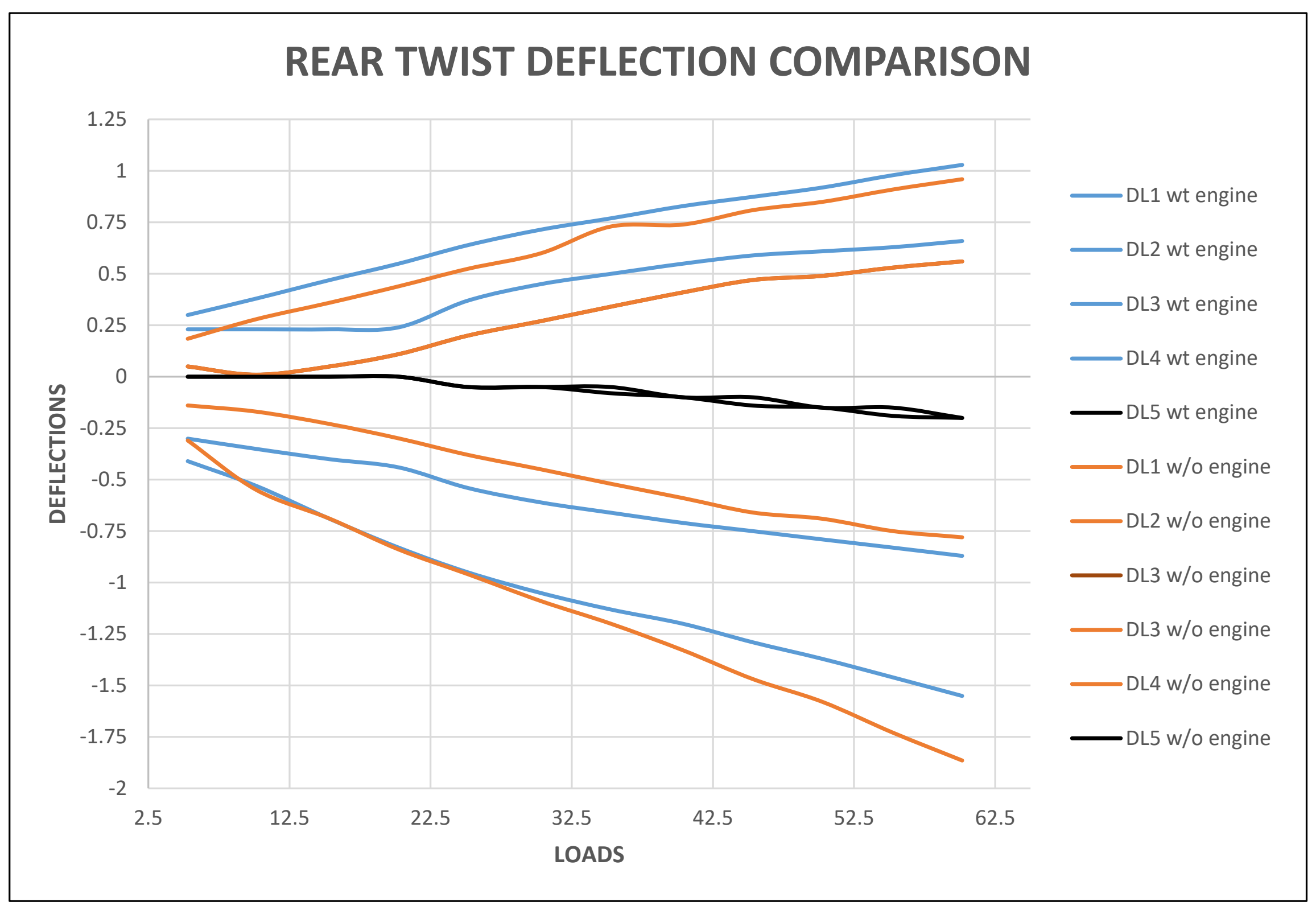
The core information are held by Young’s modulus parameter, as the equation (1) highlights. The relevance of the project is enhanced by the contemporary of the topic, highlighted in the 2019 moto2 world’s championship season of Red Bull KTM Team Ajo (MotoGp.com, 2019).

Methodology

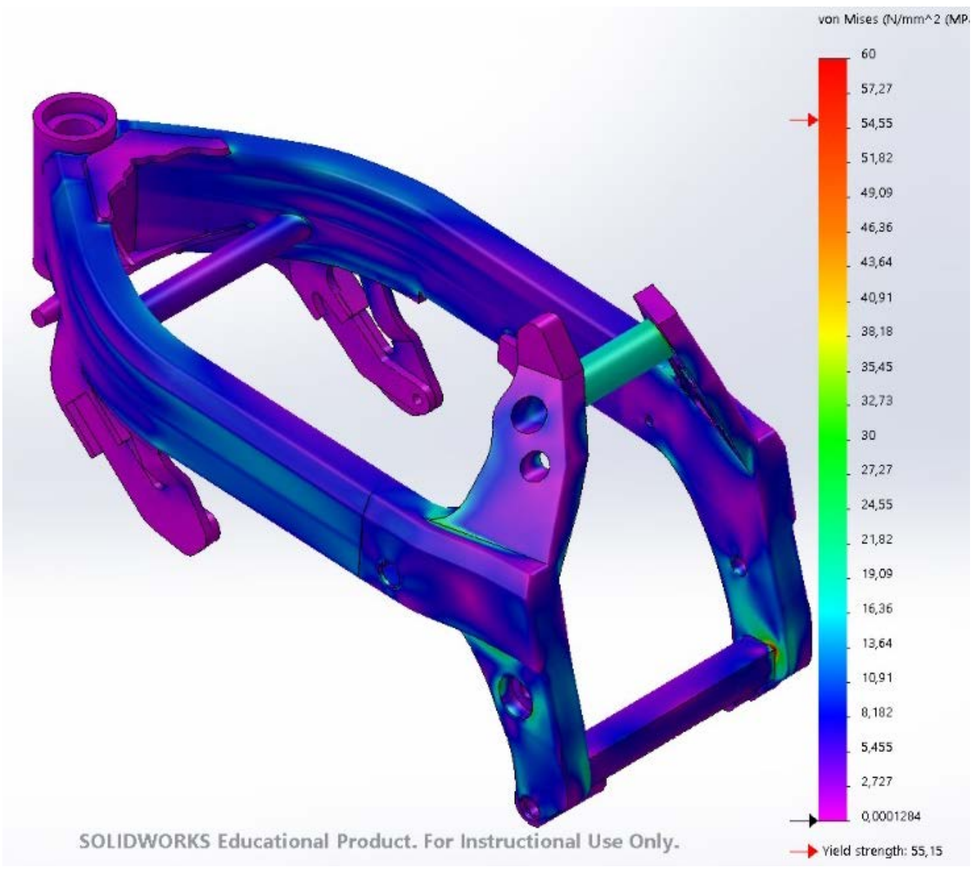
The thesis was developed as a combination of a reverse engineering processes and a pragmatical approach then validated throughout a computational analysis. Firstly, it was realized a jig capable of acquiring displacements from a twisting external load so to calculate the frame’s torsional stiffness values. It was then generated a computational model of the frame (CAD) so to finally run a finite element analysis (FEA) of it. The final step purpose was intended to validate the physical testing and identify stress concentration areas.



Rear and front twist experiments layout. Dial gauges reads the frame’s and jig’s displacements: two in the front and two in the rear frame’s section plus other three next the main jig’s holding structures. A scissor jack applies the external twisting torque and a digital scale underneath reads the magnitude input. With a 5kg increments it was applied up to a total of 60 kg. Both experiments had generated the same torque magnitude along the frame’s imaginary mid-plane



The graphs shows the comparison of the displacements’ readings of two chassis’ rear twist experiments: the blue lines are for an analysis with the engine installed within the frame and the oranges without it. The black lines are for the main jig’s element.



Rear twist FEA simulation. It is calculated the Yield strength of the structure, which is 55,15MPa and a maximum strain of 7,99E-04

The table below highlights the stiffness values between the two cases and it is used to calculate the torsional stiffness values. It is highlighted how the end values are very similar even though the gradient of their curve is different, as the graph above demonstrates.

ENGINE IN & middle bracket UNSCREW				
	DL 1	**DL 2**	**DL 3**	**DL 4**
load [kg]		60,2		
α [degrees]	0,51	0,4	0,37	0,64
K [N/degrees]	3315,0	4226,6	4569,3	2641,6
REAR TWIST ENGINE IN all tight				
load [kg]		60,2		
α [degrees]	0,49	0,41	0,27	0,63
K [N/degrees]	3447,4	4120,1	6256,4	2681,3

Results

It is acknowledged the effect of the engine mounts over the frame’s overall stiffness; it is not a matter of final magnitude value but on the contrary, the general behaviour of the structure. However, reverse engineering processes imposes the assumption of certain parameters: materials or hidden internal features. For this reason ultrasonic test would allow a more accurate model. The FEA was run assuming internal stiffening webs shapes and position as well as the material: research over motorcycle frame’s structure directed the choice of a 6061-O aluminium alloy.

The table highlights the torsional stiffness values acquired from both experiments and are then used to calculate the overall frame’s torsional stiffness value.

EXPERIMENT OVERALL RESULTS engine IN [N/°]				
	DL 1	**DL 2**	**DL 3**	**DL 4**
K rear twist	3447,40	4120,06	6256,39	2681,31
K front twist	10671,74	11704,49		
K avg	**7059,57**	**7912,27**		
K total	**7485,92**		**4468,85**	

Conclusions

The project has highlighted the importance of the mandatory accuracy of the physical tests as well as the parameters adopted for FEA simulations. In fact, the jig’s stiffness is a paramount feature as the materials and the shapes adopted for the 3D model. Both must be adopted to run and achieve accurate FEA’s results.

References

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