



DESIGN PROCESS OF A PROTOTYPE MOTORCYCLE SWINGARM

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INTRODUCTION

This work presents the design process followed by the author to develop a prototype swingarm for the Yamaha R6 of the University of Wales Trinity Saint David 's motorcycle racing team, to race at the Isle of Man TT racing circuit.



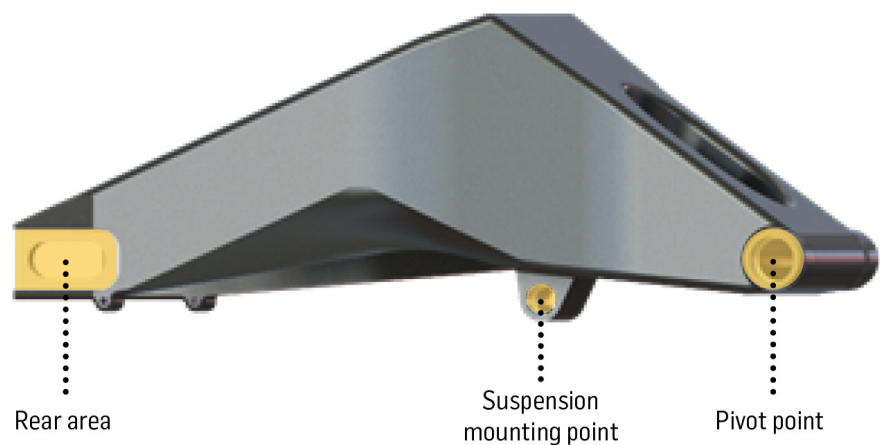
Yamaha YZF-R6 2009
Source: Yamaha

AIMS & OBJECTIVES

This work intends to provide a detailed exploration of the design process of a prototype motorcycle swingarm, developing guidelines that will enable the adoption of the same design process to the development of other major structural chassis components in a motorcycle.

CONSTRAINTS

- Location of mounting points (to guarantee original geometry and suspension performance)



Motorcycle swingarm with the three mounting points highlighted

- Volume (to guarantee clearance to the remaining components)



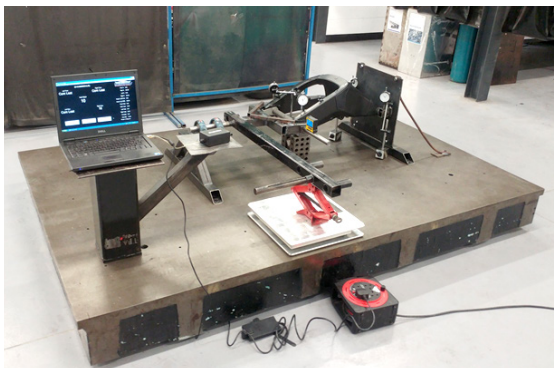
3D scan of original swingarm

- Stiffness and natural frequency values (to keep safety and dynamic performance of the original swingarm)

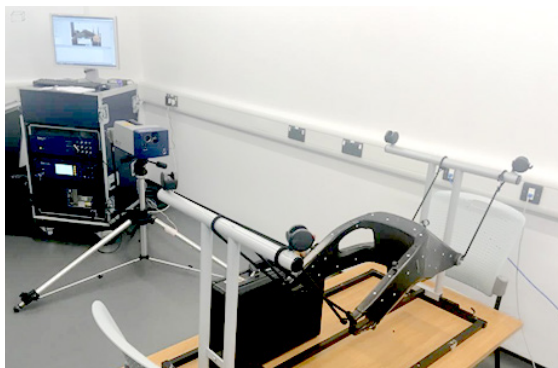
- Machining process limitations

PHYSICAL TESTING

The original swingarm was evaluated trough experimental tests for its lateral and torsional stiffness (stiffness jig) and for natural frequency values (LDV experiment).



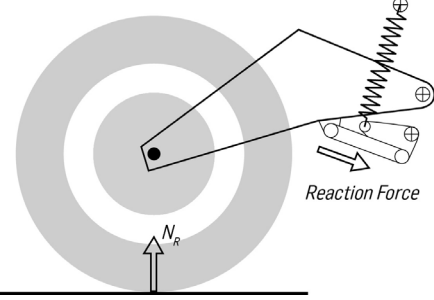
Stiffness and LDV experiments performed to the original swingarm



LOAD CASES

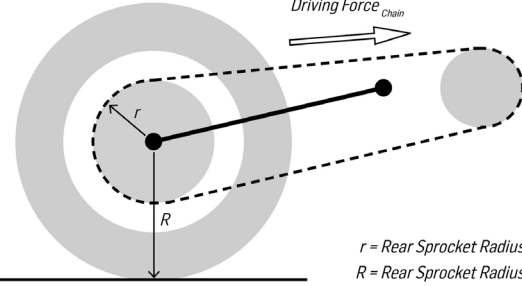
Real data acquired at the circuit of the Isle of Man TT 2019 was employed in motorcycle dynamic models (*Cossalter, 2006*) and in motion simulations developed by the author to identify the following limiting scenarios:

- Suspension forces



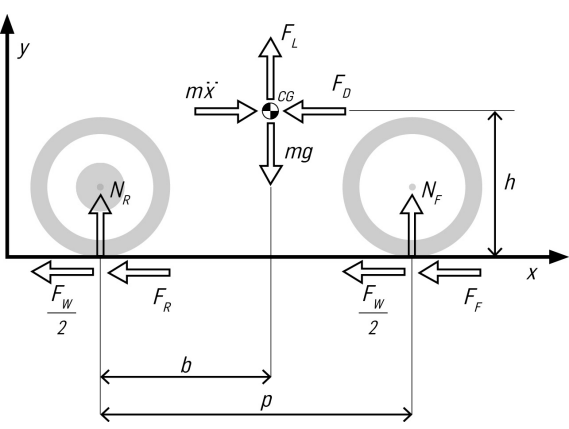
Suspension load case diagram

- Acceleration forces



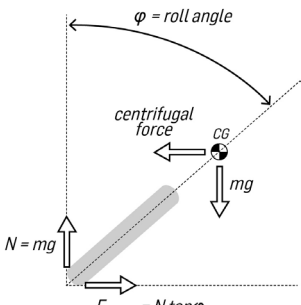
Acceleration load case diagram

- Braking forces



Free body diagram of motorcycle braking

- Cornering forces

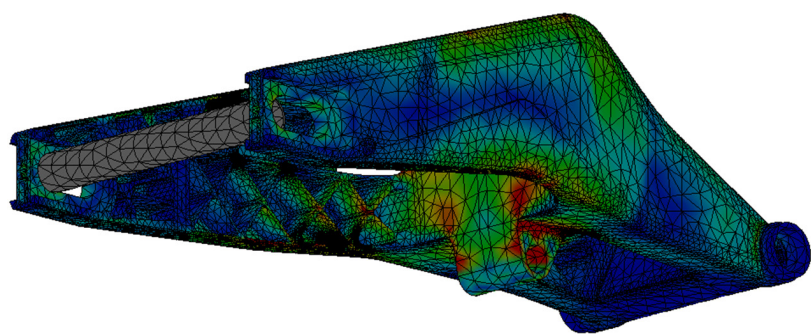


Cornering load case diagram

FINITE ELEMENT ANALYSIS

- Strength analysis

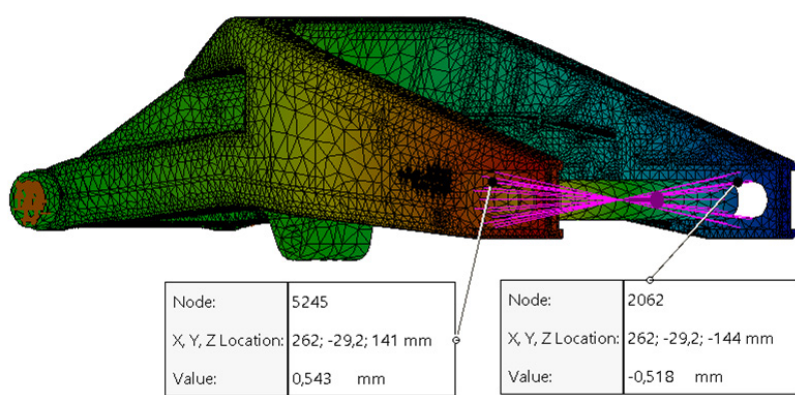
This analysis reproduced all the load cases previously calculated. Objective: stress values below the fatigue strength of the chosen material.



FEA of suspension load case - stress results

- Stiffness analysis

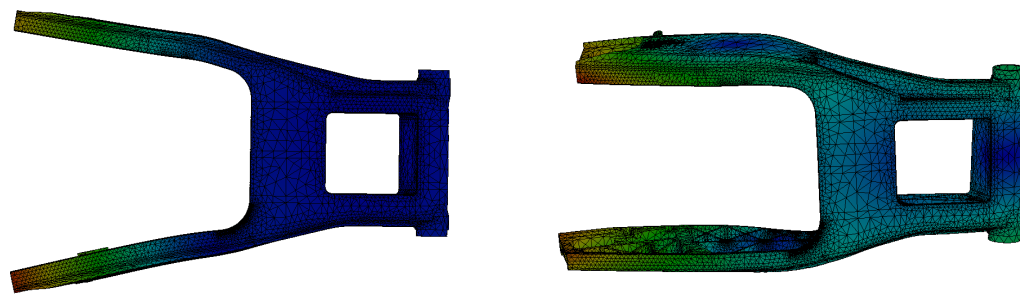
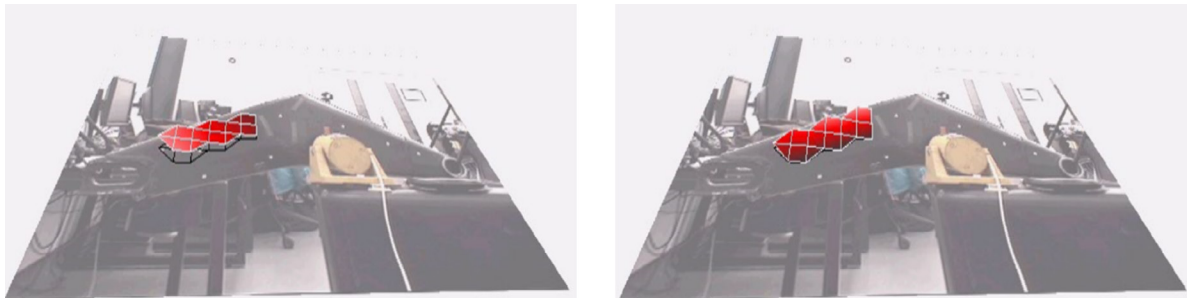
Objective: torsional and lateral stiffness values to be within reference ones.



FEA of torsional stiffness test - displacement results

- Modal analysis

Objective: validate simulated frequencies with the ones resulting from the vibration experiment (LDV).



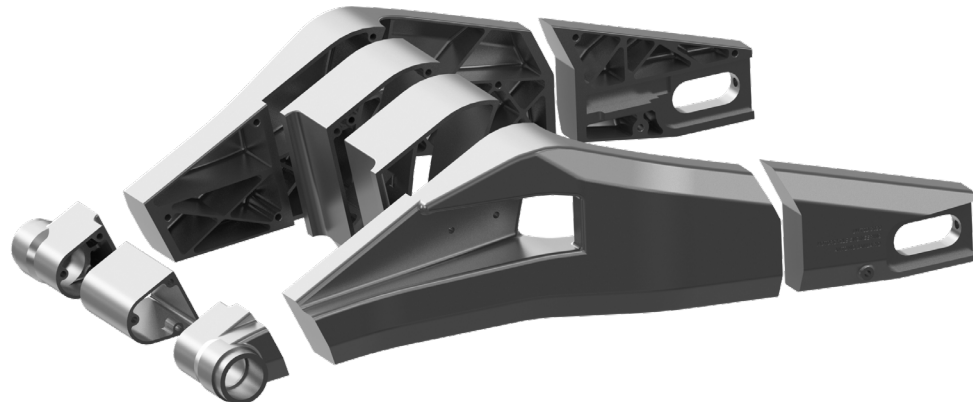
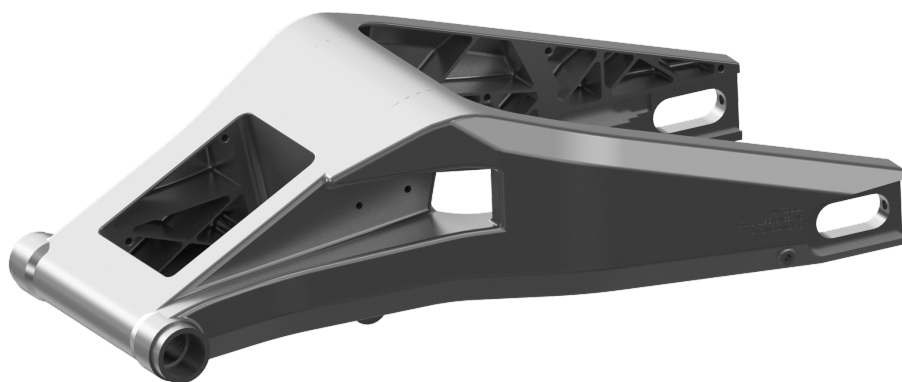
Validation of modes of vibration - LDV experiment vs. FE modal analysis

CONCLUSIONS & RESULTS

The project culminates with a new optimised swingarm design, which respects the safety and performance characteristics of the original one, also achieving a lighter result with accurate considerations to be manufactured.

Characteristics of final swingarm design

FINAL SWINGARM DESIGN		Units
Mass	6.05	Kg
Material	Aluminium 6061 – T6	
Welding Filler	4043 or 5356	
Maximum Stress	96.5	MPa
Lateral Stiffness	994 – 1449	N/mm
Torsional Stiffness	1695 – 2340	Nm/º
Natural Frequency	1 st mode 135.07	Hz
	2 nd mode 246.81	
	3 rd mode 429.06	



Final design proposal