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STRUCTURAL ANALYSIS OF AN ERGONOMIC MOTORCYCLE TEST RIG USING FINITE ELEMENT ANALYSIS (FEA)

ABSTRACT

As part of an effort to reduce global issue concerning motorcycle accidents, a motorcycle test rig named Postura Motergo was established. In validating the test rig's design, structural analyses were performed for blue print approval prior to fabrication. Computer Aided Design (CAD) model of the test rig was analyzed using Generative Structural Analysis (GSA) package in the state-of-the-art CATIA V5R20 software. The motorcyclist's weight and the material used as the test rig structure were the input into the Finite Element model. From there, the design was detailed out by the test rig's design team before coming out with a final detail design which was also analyzed using FEA simulations. Tetrahedron mesh was used to generate the meshes on the finite element model. The boundary conditions were located at every area that was assumed to have zero degree of freedom (DOF) in real condition. The loading applied was 150kg taking a maximum average weight of a motorcyclist. Results showed that the test rig's Von Mises Stress value was 1.79 x 10^8 MPa when 150kg of weight was applied. The yield strength of mild steel is 2.00 x 10^8 MPa and the factor of safety obtained was 1.12. With the positive results obtained from the FEA simulations, the Postura Motergo was approved for fabrication. In addition, the FEA proved that the design is safe to be used for motorcycle ergonomic researchers especially by the Motorcycle Engineering Test Lab (METAL). The public debut of the Postura Motergo was during the Invention, Innovation and Design Exposition 2014 (IIDEX 2014) managed to secure a Bronze medal under the Invention category. Furthermore, two academic research papers related to the Postura Motergo's test rig were also accepted to be presented at two International Ergonomics Conferences; Applied Human Factor and Ergonomics 2014 and Ergonomics and Human Factors 2014.

PROBLEM STATEMENT

- In order to replicate real scenario of motorcycle riding, commonly a high-end, thus, expensive motorcycle simulator is needed. Common simulator use real motorcycle, hence expenses to buy new motorcycle is needed. Besides that, the features available in the simulator such as vibration and control synchronization with the audio and video system caused the simulator to be expensive.
- There are various riding postures documented via the Riding Posture Classification (RIPOC) System. The issue here, for the assessment of various riding postures, there is need for various types of motorcycles and their designs.
- Prior to the fabrication of the new motorcycle test rig, the approval of the new test rig design blue print is required. Optimum design of test rig in terms of material, structure, weight, and cost are needed to ensure design validity and safety. Optimal design also ensures that overdesign would be avoided, thus, keeping the fabrication cost under low constraint.

OBJECTIVES

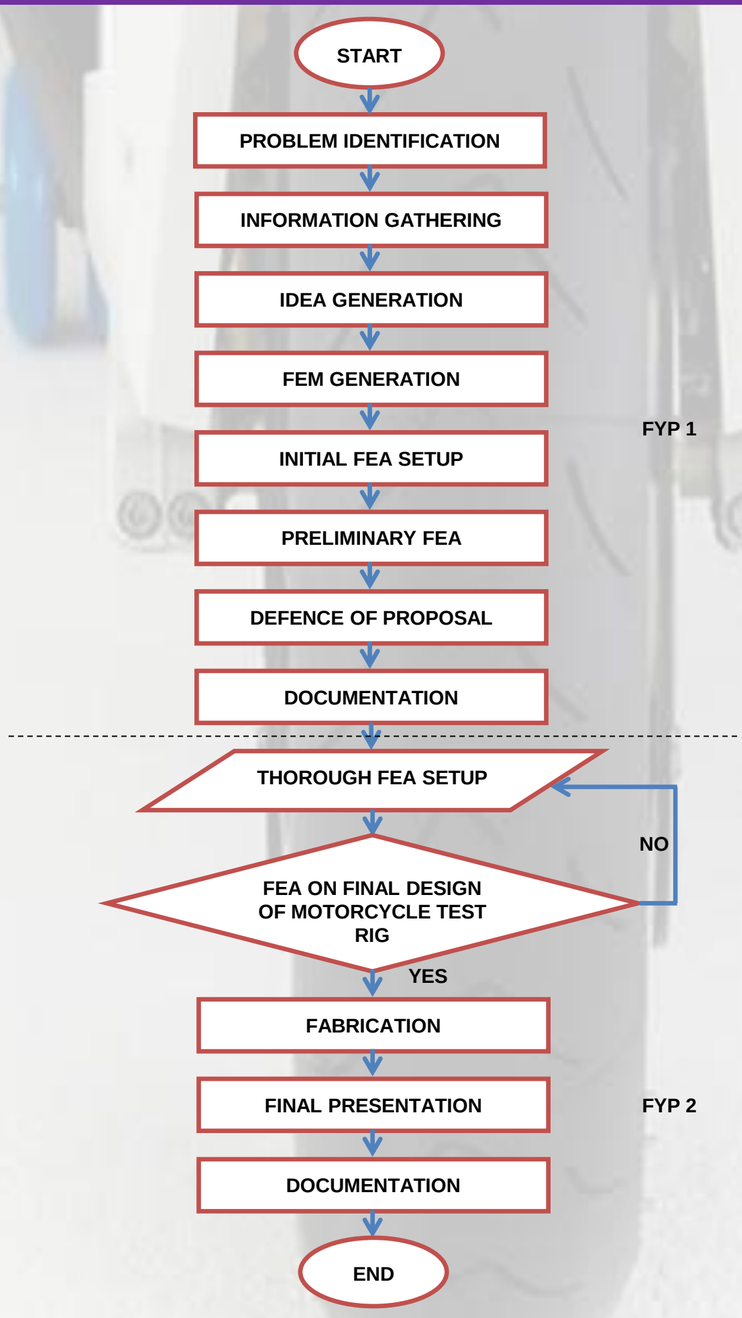
The objectives are:

- To manually evaluate loading conditions on standard motorcycle white frame chassis.
- To perform a Finite Element Analysis (FEA) simulation using established loading conditions on a newly designed ergonomic motorcycle test rig using CATIA V5 R20.
- To fabricate a motorcycle test rig as a proof-of-concept using the established design parameters.

SCOPE OF WORK

- The loading conditions evaluations on a standard motorcycle white frame chassis was performed via Free Body Diagram (FBD) analyses.
- The FEA simulation was performed using established loading conditions on a newly designed ergonomic motorcycle test rig via CATIA V5 R20.
- The motorcycle test rig was fabricated as proof-of-concept using the established design.

FLOW CHART



RESULTS AND DISCUSSION

FINITE ELEMENT ANALYSIS (FEA) SIMULATION

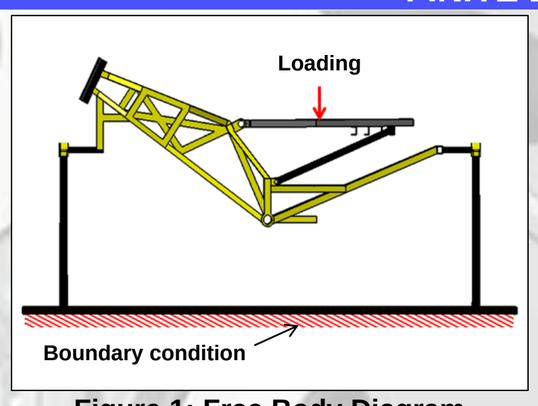


Figure 1: Free Body Diagram

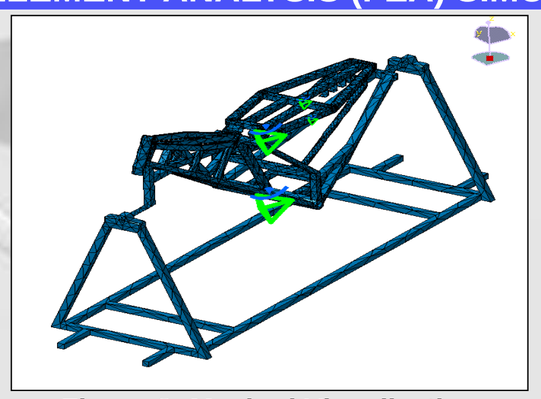


Figure 2: Meshed Visualization

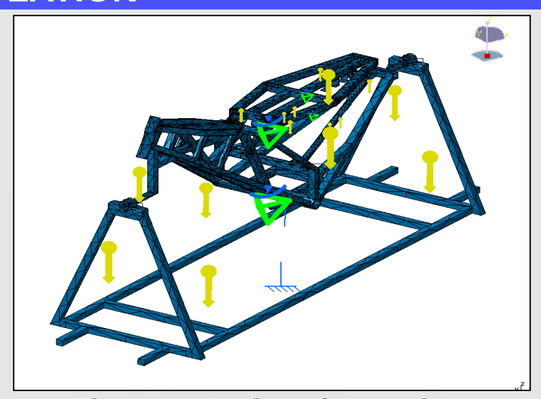


Figure 3: Assigned Boundary Condition and Loading

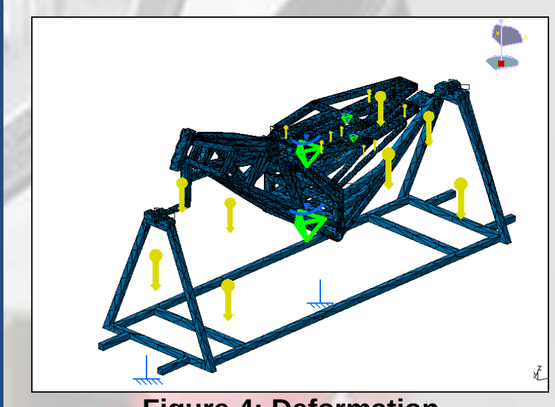


Figure 4: Deformation

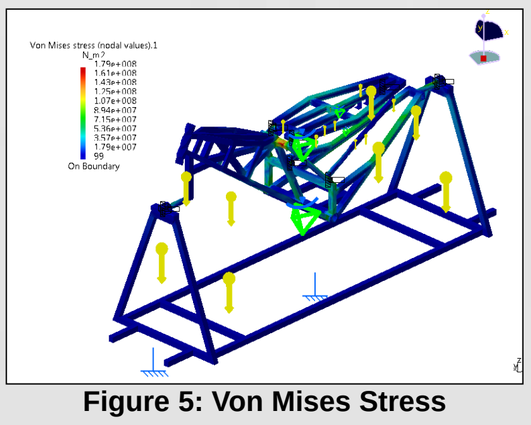


Figure 5: Von Mises Stress

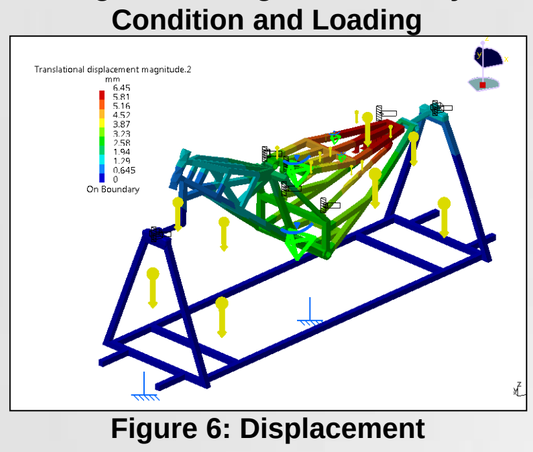


Figure 6: Displacement

RESULT	VALUE
Yield Strength of Mild Steel	200 MPa
Maximum Von Mises Stress	179 MPa
Factor of Safety	1.12

FABRICATION WORKS








TESTING OF STRUCTURE STRENGTH


ACHIEVEMENTS

1. The establishment of the Postura Motergo results in the establishment of the new Motorcycle Engineering Test Lab (METAL).
2. Filed for patent under Research, Innovation and Business Unit (RIBU) on April 3, 2014. The presentation for the filed patent was conducted with RIBU on 19th June 2014.
3. Certified with bronze award during the Invention, Innovation and Design Exposition (IIDEX) 2014 which was held in Dewan Agong Tuanku Canselor, Universiti Teknologi MARA (UiTM) from 27-30th April 2014.
4. Research papers related to the project were presented at the Ergonomics and Human Factors 2014 (EHF) International Conference, Grand Harbour Hotel, Southampton, United Kingdom on April 10, 2014 and been published as a chapter in the post-conference book for the EHF2014 conference in the 'Contemporary Ergonomics and Human Factors 2014' book with ISBN9781138026353.
5. Research papers related to the project were accepted to be presented at Applied Human Factors and Ergonomics 2014 (AHFE) 5th International Conference jointly with 2nd International Conference on Human Factors in Transportation on 19-23rd July 2014. In addition, this project will be publish as a chapter in the post-conference book for AHFE 2014.
6. Acquired a student affiliate membership in the Human Factor and Ergonomic Malaysia (HFEM) Society (095).

CONCLUSION

- Manual calculation of Free Body Diagram has been done to evaluate loading condition on standard motorcycle white frame chassis.
- CATIA V5 R20 has been used to perform FEA simulation for both preliminary and thorough FEA. From the analysis, the structure of the test rig is safe to utilized below the loading of 150kg.
- Fabrication of the test rig as proof-of-concept using established parameters has been achieved by the existence of the finished product of the fabricated test rig.

RECOMMENDATION

- Improvement can be made if a software that only focused on analyzing the structural strength such as ANSYS was used.

REFERENCES

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