Chapter 8

CONCLUSIONS AND RECOMMENDATIONS

This last chapter concludes with the final discussion of the Formula SAE (FSAE) chassis design study. The design parameters of the FSAE chassis frame are examined together with the results produced by the experimental and finite element analysis (FEA) simulations. Recommendations are also made regarding future studies as well as suggestions to resolve problems encountered in this study. The chapter will also provide the closure for the study.

8.1 FINAL CONCLUSIONS

Conclusions can be drawn regarding the verification and validation of the results produced by the study. Conclusions regarding the FSAE chassis characteristics are made, in comparison with the objectives set out in Chapter 1.

8.1.1 RESULTS VERIFICATION AND VALIDATION

The study determined and verified that the SolidWorks® FEA simulation software is sufficiently accurate for design and structural applications of a space frame chassis for the FSAE competition car. The simulation results obtained compared with adequate accuracy to the analytical solutions in the verification experiment. The obtained results were also validated by the test setup and experimental results produced by the physical, manufactured chassis. The Computer Aided Design (CAD) model’s characteristics and properties were accurately determined by the FEA simulation. The highest percentage error was 3.31%, which is exceptionally low compared to the verification experiment and general accepted engineering standards. The results validation also proved that small differences in the simulation and experimental model can influence the obtained results to a great extent.

8.1.2 DESIGNED FSAE CHASSIS

The chassis was designed using the SolidWorks® CAD and FEA software tools. The chassis was designed to meet specified design targets regarding weight and torsional stiffness while maintaining adequate strength. A FSAE chassis with a weight lower than 35 kg and a torsional stiffness higher than 300 N.m/deg is accepted as satisfactory performance properties (Michael & Gilbert, 2009). The designed chassis had a simulated weight of 33.075 kg and a torsional stiffness of 473 N.m/deg. The study validated that the designed values were reliable and accurate. The study also validated that the designed stress values and safety factor results were reliable and accurate. The designed FSAE chassis satisfied the required performance characteristics and complied with the FSAE regulations.

8.1.3 PROBLEM STATEMENT

The study accomplished its aim in applying a methodology to design and verify a torsional stiff, low weight chassis using FEA techniques. The designed chassis conformed to the FSAE regulations. It was also demonstrated that the SolidWorks® FEA simulation software can be used for chassis structural design applications.
8.2 RECOMMENDATIONS

From this study, it can be concluded that recommendations can be made to expand the research field for FSAE chassis design. The study can also lead to other research studies in the future and design projects involved in the FSAE competition.

8.2.1 CHASSIS DESIGN METHODOLOGY

Developing multiple chassis concepts with different fundamental philosophies and structural styles are advantageous. The process inspires original design ideas and obliges the design engineer to find unique and effective solutions for each concept. The process limits the engineer to combine certain structural characteristics. It is recommended that all the design principals involved are identified and combined into a single design practice. Different concepts of this single practice can then be developed using various alterations of structural application. This will give the engineer an improved fundamental design tool for developing a chassis frame.

8.2.2 CONSTRUCTION

Constructing a space frame race car chassis is a challenging exercise due to the geometry and orientation of the structural members. It should be taken into consideration that the chassis is only manufactured once and that it is a time consuming process. The pipe end profile cutting technique used was time consuming and labour intensive, but successful for the purpose of this study. The preparation of the drawings, pipe-end profiles and process remains critical. Constant scrutiny of the structure during the manufacturing process is also important to ensure the correct frame geometry and symmetry. Structural defects can significantly influence the assessment of experimental and simulation results.

8.2.3 EXPERIMENTAL SETUPS AND RESULTS

To ensure accurate and reliable experimental results, each experimental setup and execution should be understood in detail. The same applies to the measuring equipment. It was challenging to fix a chassis rigidly on a test rig with large torsional forces involved. It is crucial to ensure that all the deflections are taken into consideration. The percentage errors in the experiments can be decreased even more by improving the test setup’s accuracy. A high degree of care and thoroughness should be taken with the experimental setup, in order to reduce measurement errors, caused by human and calibration imperfection.

8.2.4 CHASSIS STRUCTURES

Space frame chassis structures are widely used in the FSAE competition. They are recommended for their practicality and for maintaining good performance characteristics in any race environment. To improve a space frame structure, its ratio of torsional stiffness to weight needs to be increased. This is no easy task as it doesn’t utilise the space between the structural members. This can be significantly improved by using advanced alloys, or by mounting structural plates in the empty spaces to transfer the loads more efficiently. The other alternative is to use a structure comprised of structural plates fixed together, known as the stressed skin chassis. If this structure is used in combination with light weight composite materials, this technique can provide superior stiffness without the weight penalty of steel space frames. The current designed space frame’s stiffness is in excess to what is required for the FSAE competition chassis. The weight can be reduced by removing specific structural members while still ensuring that competitive stiffness is retained.
8.3 CLOSURE

The purpose of this project was to design and develop a vehicle chassis for a FSAE competition car. The vehicle chassis had to conform to the FSAE rules and regulations and it had to satisfy specific performance characteristics required in a competitive environment.

Various conceptual chassis frames were designed and developed using SolidWorks® CAD and the SolidWorks® FEA simulation software. Several chassis concepts were developed and the best one was chosen and manufactured. The chosen concept had designed torsional stiffness and weight values of 473 N.m/deg and 33.075 kg respectively. The chassis conformed to the FSAE rules and can tolerate a maximum torsion of 833 N.m. The FEA software was verified and the design characteristics of the chassis were experimentally validated with a manufactured chassis.

The project is unique and one of the very first at the North-West University regarding the in depth analysis and study of a competition based vehicle chassis. The knowledge gained from the research contributed to valuable insights and skills regarding vehicle design, chassis performance parameters, manufacturing and experimental procedures. The design, development and manufacturing processes were also beneficial, in terms of education and experience, for the involved engineers, technical and manufacturing personnel. The engineering, manufacturing and testing practices can also be utilised and applied in other projects, such as the BAJA®-competition. The study was concluded as a success and envisaged to create future research opportunities for the FSAE competition and related research fields.