Designing FSEV suspension system in Lotus Suspension Analysis SHARK

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Abstract - *In this study, the suspension geometry of a Formula style race car's suspension system was designed accordance with a Kawasaki Ninja 650® and later the engine was optimized to KTM Duke 390® for low-end torque from mid-range power delivery of Kawasaki Ninja 650® engine. In this study the suspension system is kinematically simulated with Lotus Suspension Analysis SHARK® Software. These systems are subjected to several forces in both dynamic and static conditions. Lotus Suspension Analysis SHARK® gave us an idea about the load-cases applied on the vehicle. Our primary goal is to increase suspension stiffness, which will ultimately reduce spring travel. A major change in stiffness will be made at the rear suspension system due to a significant weight change brought through the replacement of the engine, and perhaps a subsequent change in the static load on both axels of the vehicle, requiring a revised version of the front suspension geometry. Bump steer is to be improved dynamically over prior vehicles, and body roll is to be controlled substantially.*

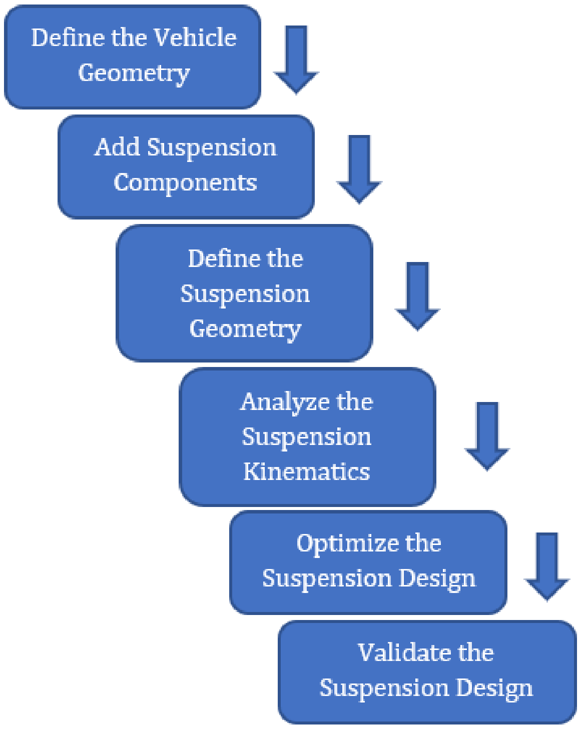
Key Words**: Suspension, suspension arms, suspension actuation mechanisms, Bump steer, Understeer, Vehicle Roll, Lotus Suspension Analysis SHARK.**

1. INTRODUCTION

The design analysis and optimization of suspension will be demonstrated in this study. Development and redesign of the suspension system for a formula type racing vehicle that provides acceptable drive comfort, good stability, and great manoeuvrability is the goal of this project. The Suspension system is a device that connects the body with the wheels. In both the static and dynamic states, there are several forces operating on the wheels. All of these forces have an impact on the design of the Suspension Assembly. The project aimed to uncover any problems with the old vehicle and then use these findings, coupled with appropriate research, to create a new suspension system that possesses improved performance. Completion of the project has seen the design of geometry for the suspension arms, suspension actuation mechanisms, uprights. So, the project will be used for a new vehicle which will be built according to the engine *KTM Duke 390®* which eventually needs a new setup of suspension & steering.

2. METHODOLOGY

To optimize bump steer and roll values, it was necessary to examine the suspension geometry using specialized software *Lotus Suspension Analysis SHARK®* was chosen for its user-friendly features and then analyzing them. Designing the suspension kinematics for an FSAE vehicle is a critical process that can significantly impact the performance of the vehicle on the track. In this study, we will discuss the steps involved in designing the suspension kinematics for an FSAE vehicle with pull-rod suspension at the front and pushrod suspension at the rear, using *Lotus Suspension Analysis SHARK®*.



Tire and Suspension Selection:

As we select Rims which have 6-inch width, we would require new tires to accommodate the width of the wheels. We have selected Hoosier Tires of size (18 x 6 R10). Up until the end of 2015, our team had been using a pushrod suspension at the front and a push rod suspension at the rear for many years. We have been inspired by the suspension geometry of Ferrari SF15-T and recently we have upgraded our suspension system into a pull rod suspension at the front for lower CG and close to roll Centre.

3. MODELING

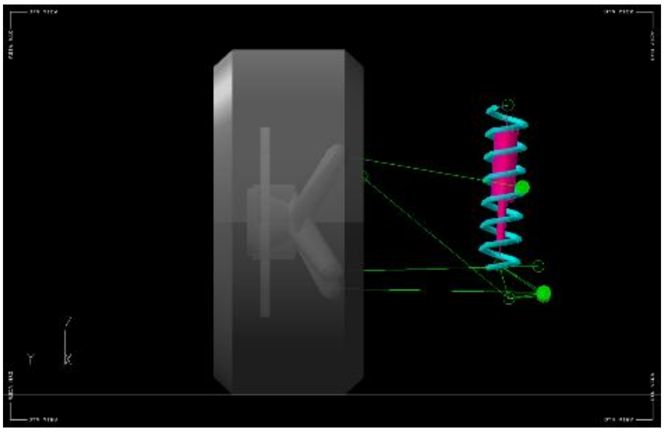


Fig -1: Front suspension geometry front view

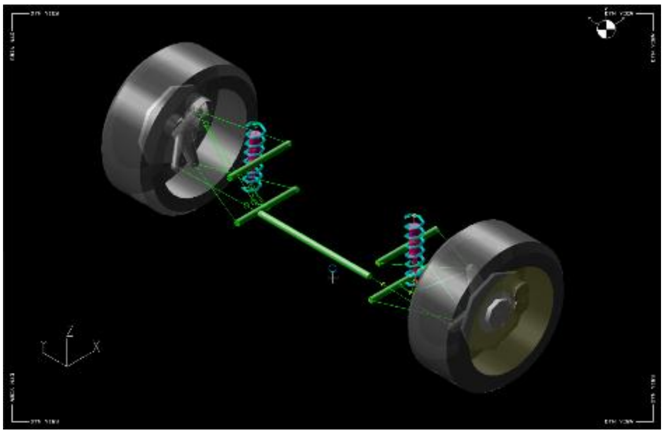


Fig -2: Front suspension geometry isometric view

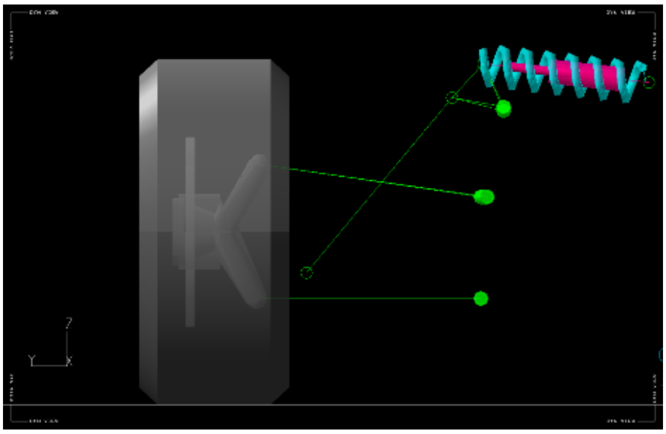


Fig -3: Rear suspension geometry front view

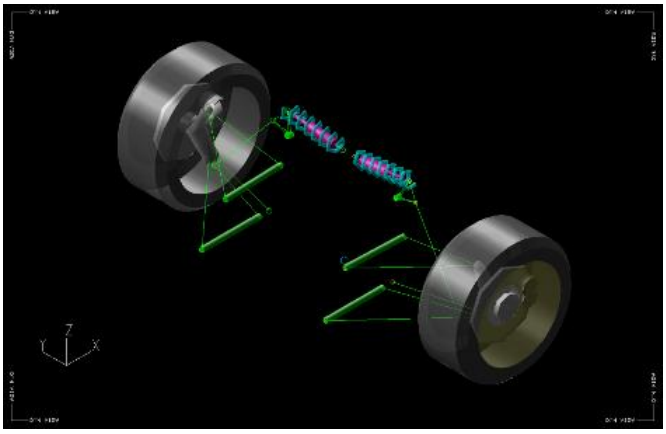


Fig -4: Rear suspension geometry isometric view

4. RESULT AND DISCUSSION

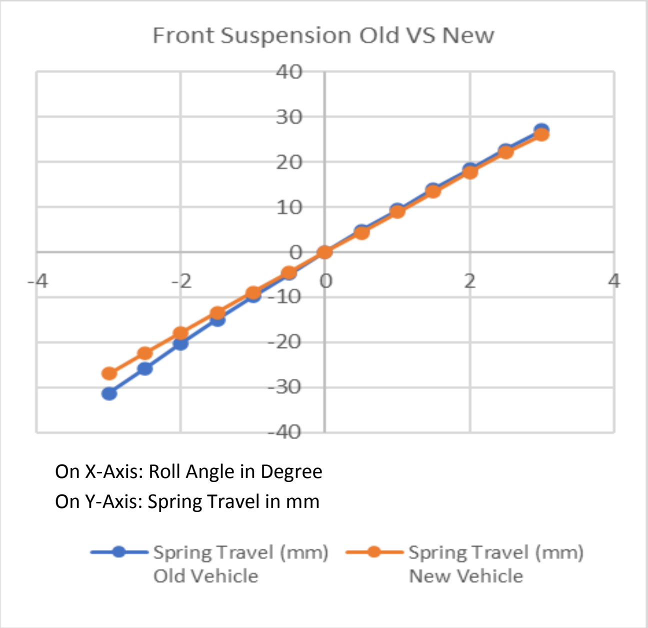


Fig -5: Roll angle (in deg) vs Spring travel (in mm)

On X-Axis: Roll Angle in Degree
On Y-Axis: Spring Travel in mm

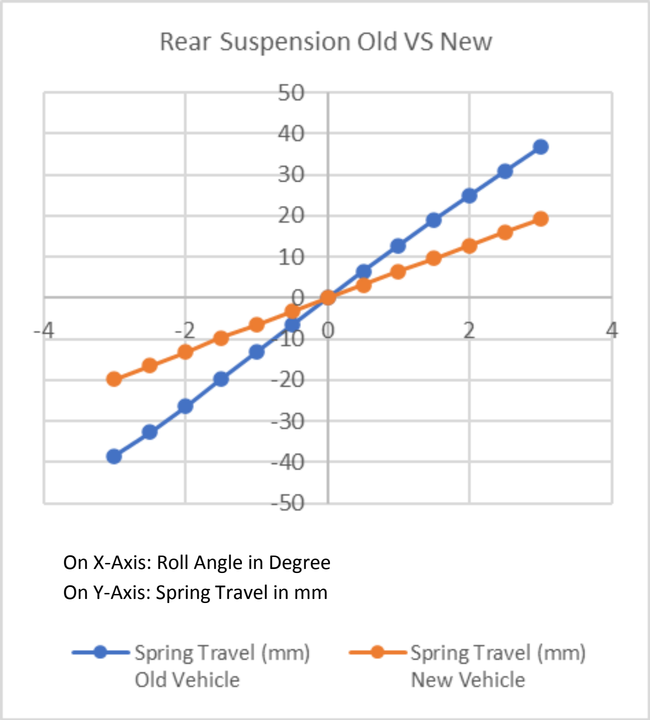


Fig -6: Roll angle (in deg) vs Spring travel (in mm)

In the new edition *Fig -6*, spring travel is less than it was, indicating that the suspension system is stiffer than it was. This was attained by redesigning the suspension geometry. Roll over stability was ultimately improved by reducing the suspension's overall position *Fig -8*, which also helped to decrease the CG height and bring it closer to the roll center. In the newer vehicle, the pushrod is connected to the lower control arm (LCA) *Fig -8*, which improves motion ratio and lowers the bellcrank pivot point, as compared with the old vehicle, where the pushrod is connected to the upper control arm (UCA) *Fig -7*.

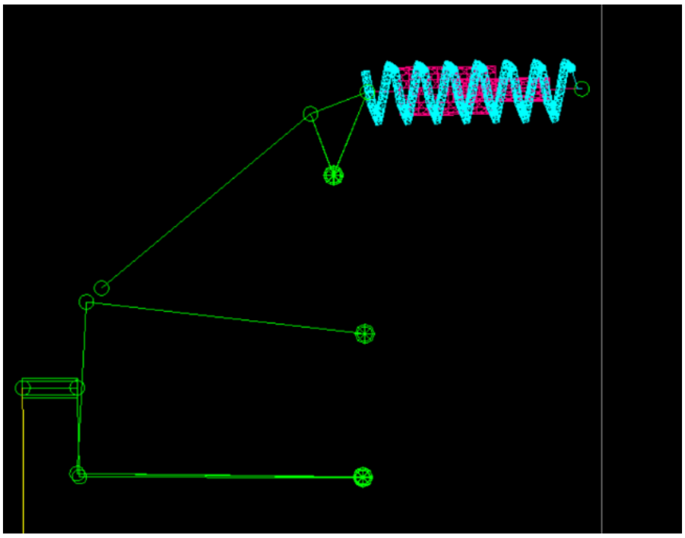


Fig -7: Old rear suspension geometry

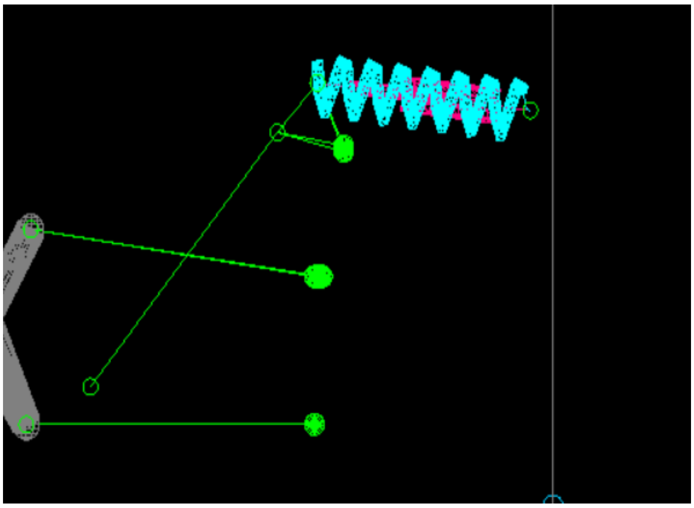


Fig -8: New rear suspension geometry

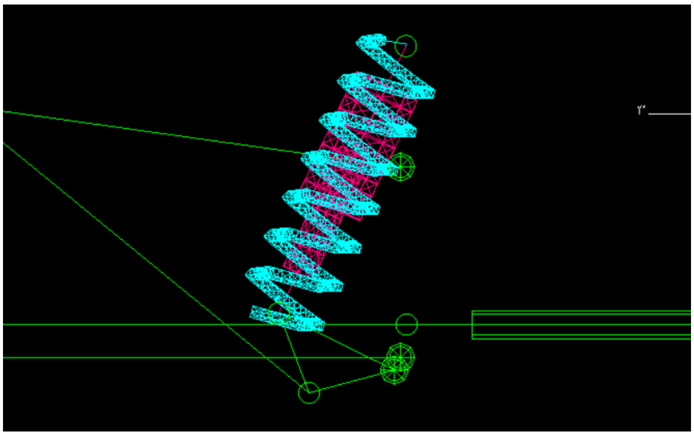


Fig -9: Old front suspension geometry

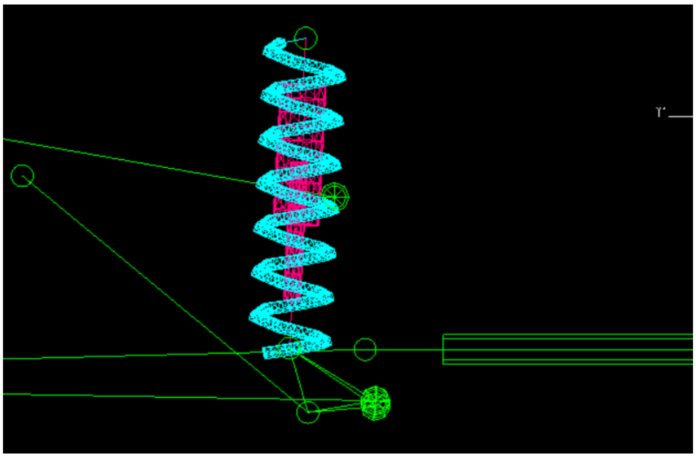


Fig -10: New front suspension geometry

In **Fig -9,** The bump steer is a condition where the toe-in angle increases as the wheel travels vertically and is caused by the inner tie rod end not being aligned with the inner mount plane. This condition was set specifically for the driver's needs. The car gradually understeers as the toe-in rises.

In **Fig -10**, According to our drivers' needs, the car should have more braking and throttle control, which will give more room for adjustments.

Hence, what we have accomplished is to have slightly more understeer in the car, which will boost the driver's confidence while cornering, and it was achieved with a slightly increased amount of bump steer.

5. CONCLUSIONS

In this study, we have replaced the engine which brought significant change in weight. Keeping that in mind, we have optimised our suspension system into a pull- rod and push-rod geometry which helped in achieving increased roll over stability, bump steer which is increased by 170%, along with the understeer behavior with vehicle performance parameters appropriate for the driving style of our driver.

REFERENCES

[1] Alejandro Diaz, Osvaldo Fernandez, Ricardo Gonzalez, Christian Ramos. "FSAE 2015 Chassis and Suspension Final Report", EML 4905 Senior Design Project. 2014.

[2] Samant Saurabh Y., Santosh Kumar, Kaushal Kamal Jain, Sudhanshu Kumar Behera, Dhiraj Gandhi, Sivapuram Raghavendra, Karuna Kalita. "Design of Suspension System for Formula Student Race Car". 12th International Conference on Vibration Problems, ICOVP 2015, Procedia Engineering 144 (2016) 1138 – 1149

[3] Jock Allen Farrington. "Redesign of an FSAE Race Car's Steering and Suspension System". University of Southern Queensland Faculty of Engineering and surveying. Courses ENG4111 and ENG4112 Research Project. 2011.

[4] Ayush Arvind Singh, Puneet Sai Naru, Kishor Laxman Adsare, Mr. Shrikant Baste. "WHEEL ASSEMBLY AND SUSPENSION CORRELATION OF FORMULA STYLE VEHICLE". International Research Journal of Modernization in Engineering Technology and Science, Volume:04/Issue:05/May-2022, e-ISSN: 2582-5208. 2022.

[5] Ojas Babannavar, Aditya M. Deshpande". Design, analysis, and optimization of an FSAE upright". IOP Conf. Series: Materials Science and Engineering, doi:10.1088/1757-899X/1166/1/012043. 2021.

[6] Muhammad Izzat Nor Ma'arof, Vong Ratanakvisal, Lim Jin Wei, Amir R. Ghani, Girma T. Chala. "Design and Analysis of the Suspension Upright Structure of a Formula SAE Car". International Conference on Innovation and Technopreneurship, Vol.2019:019, eISSN:2600-7920. 2019.

[7] Jixiong Li, Jianliang Tan, Jianbin Dong. "Lightweight Design of Front Suspension Upright of Electric Formula Car Based on Topology Optimization Method". World Electric Vehicle Journal, doi:10.3390/wevj11010015. 2020.