Multibody dynamics in the development of Formula Student

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1 Introduction

Project Formula Student is the worldwide competition between universities. The goal of this project is the building of the car which will be able to participate at specific forms of races (acceleration, skidpad, autocross and endurance race) and satisfy the design rules.

The paper deals with the design and dynamic behaviour of a formula and its separate parts and subsystems. The dynamic simulations and basic calculations were provided in MATLAB and MSC.Adams multibody software.

2 Multibody model

The formula can be generally represented by complete multibody model which is composed of these subsystems: front and rear suspension and anti-roll bar, steering, chassis, tires, breaks and powertrain. The particular elements of these subsystems in MSC.Adams were modelled as rigid bodies.

The first step in suspensions design is a solution of kinematic variables (camber, toe and wheel track) changing during the jounce. The long distance of the instant centre from the wheel center via Trzesniowski (2012) causes the minimum changes of kinematic variables what is desired for better stability during the manoeuvres. Both suspensions were designed as double-wishbone. The layout of arms in space had to reflect to the possible places on the tube frame and upright for the gripping the arms and another important kinematic parameters like height of the roll centre, anti-dive, anti-squat had to be taken in account too. The suspension contains springs and dampers too. The stiffness of used springs was calculated from the wheel hub reaction to the expected mass and its percentage distribution on each suspension. The stiffness of the springs directly affects desired equilibrium vertical position of the chassis.

The position of the steering subsystem and steering rack displacement is based on the Ackerman variable and the minimum turn radius which is given by the rules. The Ackerman variable describes the steer angles and their difference between both wheels. Ackerman affects the vehicle behaviour during the turning. The final position of the steering rack was defined by desired values of steer angles and turn radius for the prescribed steering rack displacement.

Above mentioned process of suspensions and steering subsystem design was performed on the separate systems (Fig. 1). Supposed designs of these subsystems were verified by predefined analyses in MSC.Adams (Parallel wheel travel, Roll test and Steering test) which simulate selected real situations on the road. The final design and acceptable changes of values of tracked parameters during the analyses were reached by manual geometry improvements and repetition of the analyses. The automatic optimization process is not easy to realize because of many tracked parameters and other external conditions.

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Designed subsystems were added to the complete multibody model (Fig. 2). The chassis subsystem were represented by overall mass and moments of inertia of the rest of formula parts which were not modelled in MSC.Adams subsystems. Tires, powertrain and brakes subsystems were described by characteristic parameters and dependence from the data list of producer. The complete multibody model was verified and observed during the analyses which simulate real behaviour in specific races. During these analyses the acceptable settings of the dampers and torsion stiffness of anti-roll bars were established. Results of dynamic simulations in MSC.Adams automatically contain the forces and torques in joints. The forces and torques will be used in FEM analyses of designed parts. The FEM analyses will be provided by other team members of UWB Racing Team Pilsen.

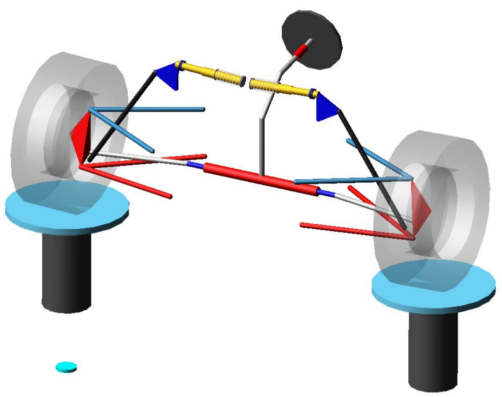

Figure 1: Front suspension with steering

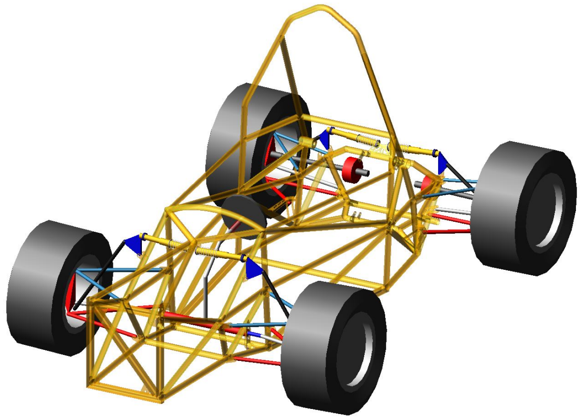

Figure 2: Formula – multibody system

3 Conclusions

Designed formula for the Formula Student competition was represented by the multibody system in MSC.Adams. All parts were modelled as rigid bodies. The correctness of kinematic motions with desired changes of characteristic parameters was verified on the separate subsystems of rear and front suspension with steering. The kinematically verified subsystems were added to the complete multibody model and dynamic analyses were provided for the simulation of the real behaviour on the road. The results from analyses are bases for future FEM analyses and establishment other important parameters and settings for ideal behaviour during the races.

Acknowledgement

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References

Trzesniowski, M., 2012. *Rennwagentechnik*. Graz.