FSB RACING TEAM

Vehicle Dynamics

Pacejka 2002 tire model Hoosier 18x7.5

Description of making a Pacejka 2002 tire model using tire data and fitting tool from MSC Adams

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1. INTRODUCTION

1.1. General

In order to estimate the behavior of our vehicle and to calculate loads that occur in the suspension system, it is important to have a proper tire model in the software that is used to simulate driving of our car. In this report, it will be explained how to make Pacejka 2002 tire model from test results provided by TTC consortium using Adams Car software.

1.2. Goals

With the implementation of tire model in our software used to simulate vehicle dynamics we can estimate the behavior of our vehicle and make adjustments to improve general performance of the vehicle which is the goal of the vehicle dynamics department in our team. Also, we can estimate all loads that occur on elements from which suspension system consists and from those loads we can do calculations that define dimensions of all the elements in the suspension, steering and braking systems.

2. Steps for making a model

2.1. Analysing the data from tire testing

TTC consortium provides FSAE teams with results from tire testings on tires that are used by FSAE teams. Every test consists of sweeps that show how changes in longitudinal or lateral slip angles affect achievable longitudinal and lateral forces, they show how does camber angle affect possible traction, how does pressure, temperature, etc. affect tire performances. More about the structure of testing can be found on their website.

First thing I had to do was to analyse the data. Every sweep should be checked to see if there was some mistake. Usually, mistakes happen after changing the camber or in the transition from pure longitudinal slip range to combined range. Those sweeps need to be eliminated from the results because they can give bad approximations inside the tire data fitting tool. The goal is to take as „clean“ splines as possible from testing data without „jumps“ in the results. An example of a „clean“ spline is shown in the next figure.

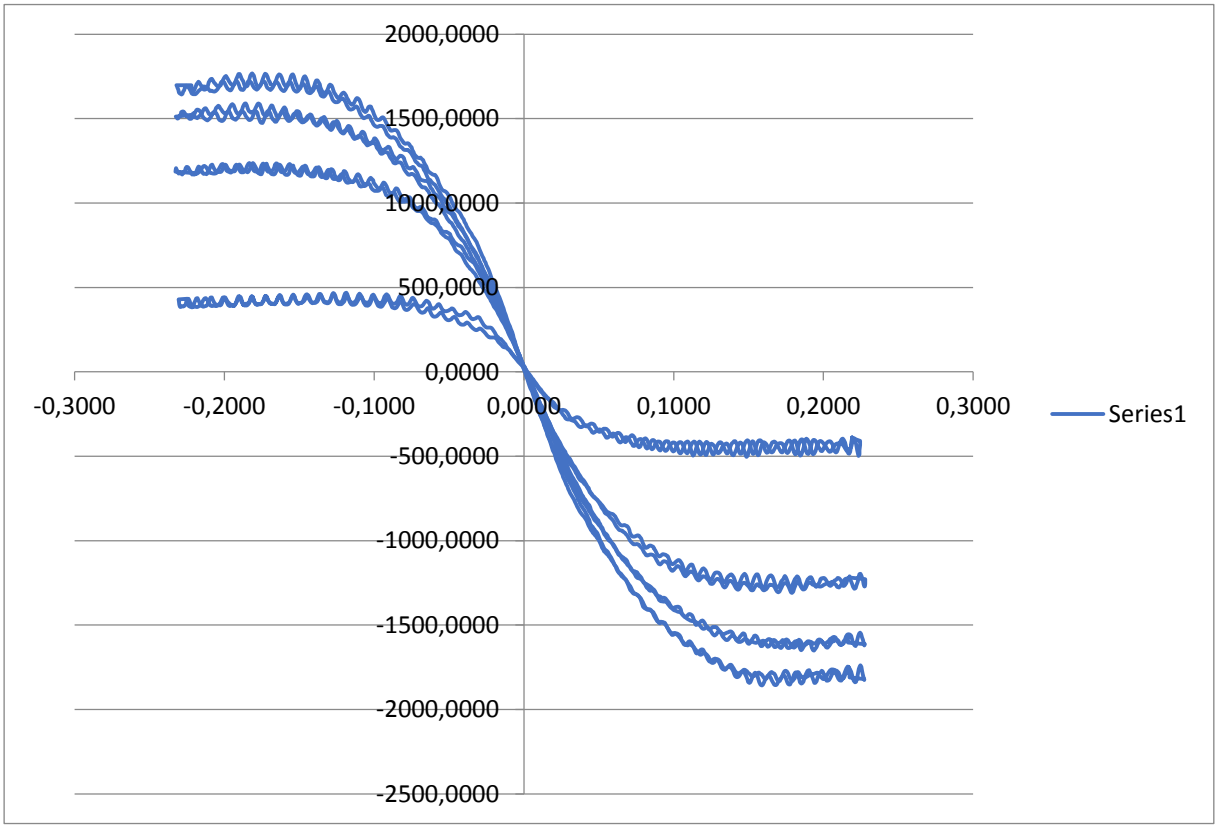

Figure 1. An example of desirable testing data

As shown in Figure 1. these results show negligible deviations and they will provide good results later on in defining tire model.

2.2. Data files used for tire data and fitting tool

MSC Adams software reads data from text files. When copying tire data from testing it is important to use the syntax that the software is able to read. An example of a file used for uploading data in software can be found in the installation directory of MSC Adams software.

An example of the syntax used to upload data in software is shown in the next figure.

```
**MEASURCHANNELS
SLIPANGL   slip angle                    rad        1.0        0.0        0.0
LONGSLIP   longitudinal slip             -          1.0        0.0        0.0
INCLANGL   inclination angle             rad        1.0        0.0        0.0
FZW        vertical load                 N          1.0        0.0        0.0
FX         longitudinal                  N          1.0        0.0        0.0
FYW        lateral force                 N          1.0        0.0        0.0
MXW        overturning moment            Nm         1.0        0.0        0.0
MZW        aligning torque               Nm         1.0        0.0        0.0
INFLPRES   inflation pressure            Pa         1.0        0.0        0.0

**MEASURDATA
0.000    0.000    -0.001   883.720 -71.690 31.553   -2.967   -5.027   55410.000
0.001    0.000    -0.001   886.930 -81.220 16.247   -3.960   -3.867   55510.000
0.001    0.000    -0.001   892.890 -90.140 1.433    -3.553   -3.067   55460.000
0.002    0.000    -0.001   892.650 -98.220 -13.447  -4.413   -3.293   55360.000
```

Figure 2. Example of the syntax

In these files there should be at least 3 different files. One for determining the relation between vertical load, lateral slip angle and lateral force, one for determining the relation between vertical load, longitudinal slip angle and longitudinal force and one for determining the relation between vertical load and tire stiffness.

Tire testing data concludes cornering and braking tests from which the first two relations can be acquired. The last relation should be taken from results where longitudinal and lateral slip angles are zero.

2.3. Tire data fitting tool

To open Adams tire data fitting tool Adams Car needs to be started. From the ribbon simulate in Component analysis tire data and fitting tool can be found. The interface of the tool is shown in the next figure.

Figure 3. Interface of the tool

From ribbon file, it is needed to select *Create new tire property* and chose PAC_2002. After that, it is required to select *Create property* and then select *tire fit* tool from the tools ribbon. Inside that tool, it is required to upload data files previously created. An example is shown in the next figure.

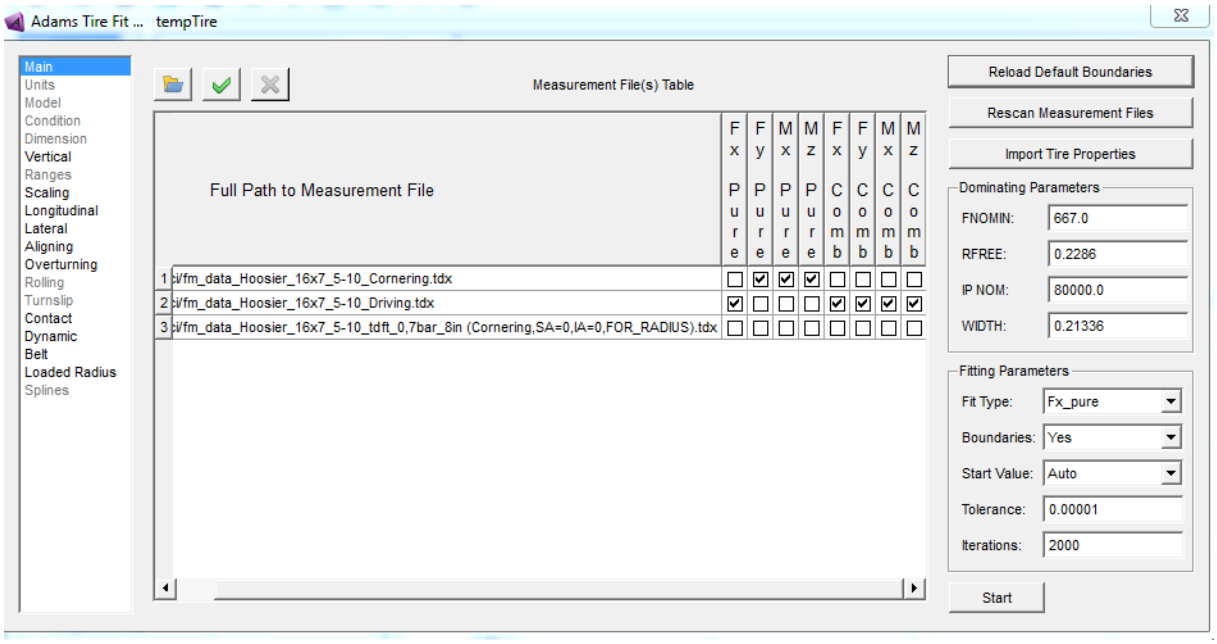

Figure 4. An example of uploaded data

After the upload is completed first it is required to import tire properties. After that, it is needed to start with the fitting process. Order of fitting is next: *Fx_pure, Fy_pure, Mx_pure, Mz_pure, Fx_combined, Fz_combined, Mx_combined, Mz_combined.* After those characteristics, it is possible to fit all the other needed parameters. More directions can be found in document *Learning_Adams_Tire* [1.].

2.4. Validations of tire property

After the fittings are completed the tire model is created. It is mandatory to validate if the tire model gives the same results as the testing. This can be done in *Plot Parameters*, shown in the next figure.

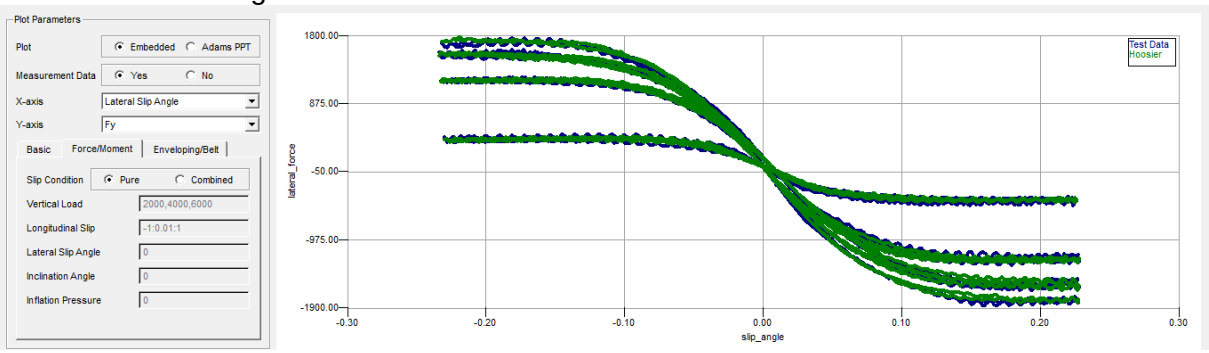

Figure 5. Validation of tire property

In figure 5. the blue lines represent testing data and green lines represent data from tire property for the same conditions as in testing. This validation needs to be done for all other parameters that are in tire property.

3. Conclusion

Tire model is an essential part of any vehicle model which is used to simulate the behavior of the vehicle. More complex tire model results with simulations that show physical behavior closer to physical behavior in the real world. Our team uses the Pacejka 2002 tire model which is satisfactory for our needs to estimate the performance of our vehicle and to estimate the loads that occur during specific driving maneuvers.

SUMMARY

- Explanations of how to use tire data and fitting tool
- Explanation of how to validate the results
- Using tire properties to simulate the behavior of our vehicle

ATTACHMENTS AND TECHNICAL DOCUMENTATION

[1.] Learning_Adams_Tire
[2.] Adams_Tire_Help
[3.] Hans B. Pacejka, Tyre and Vehicle Dynamics