Real world data **must** be used in simulations – real world examples from automotive R&D

This article is about a plastic plunger component used as a key component in an automatic gear shifter for cars and will show you a number of examples where this component could lead to very costly failures and how this can be avoided, easily, if the right measurement tool (ForceBoard™) is used in conjunction with the simulation programs commonly used as virtual prototyping tools in the automotive industry (as well as a wide range of other industries).

This article focuses on the following areas:

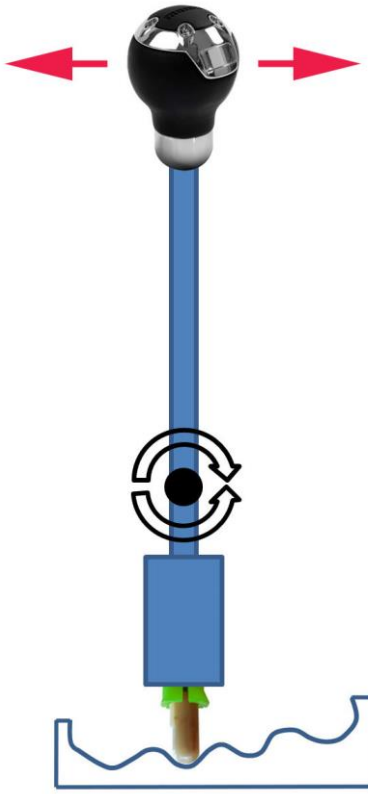
- **Friction modelling**
- **Bending modulus modelling**
- **Hysteresis / relaxation modelling**
- **Fatigue modelling**
- **Wear modelling**

Picture 1 Spring loaded plunger used in the gear shifter

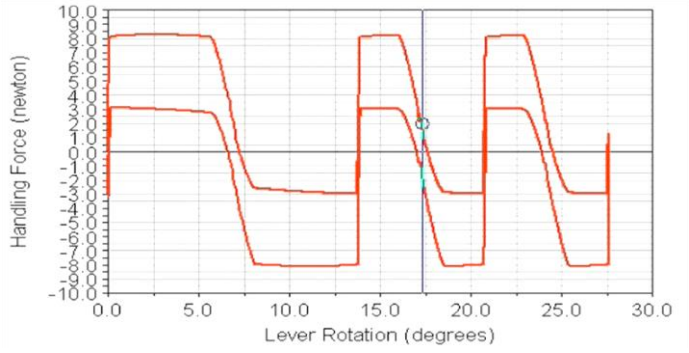
Friction modelling

One requirement car manufacturers put on a gear shifter is the maximum handling / maneuver force, it could for example be set as a requirement by the car manufacturer to 9 +/- 1 Newton in order to move from one gear / index to another. Picture 3 shows a simulated force curve for a gear shifter moving from P to R to N to D.

This means that the handling force can be optimized via CAD and FEA (finite element analysis) and MBS (muti body simulation) long before physical prototypes are made and that the entire process of using prototype molding tools can be eliminated completely which is something that can save a huge amount of money and time. Not having the correct friction parameter in this simulation model will produce an erroneous simulation results which is why it is absolutely crucial to measure the coefficient of friction (static + dynamic) between the plunger and the index track and use that real world data in the simulation model! This can easily and very accurately be done with ForceBoard™!



Picture 2 Spring loaded plunger mounted in a simplified model of a gear shifter mechanism with the plunger moving in the P-R-N-D **index track** where the coefficient of friction between the plunger and the index track plays a very important role for the maneuver force and tactile feel of the gear shifter.

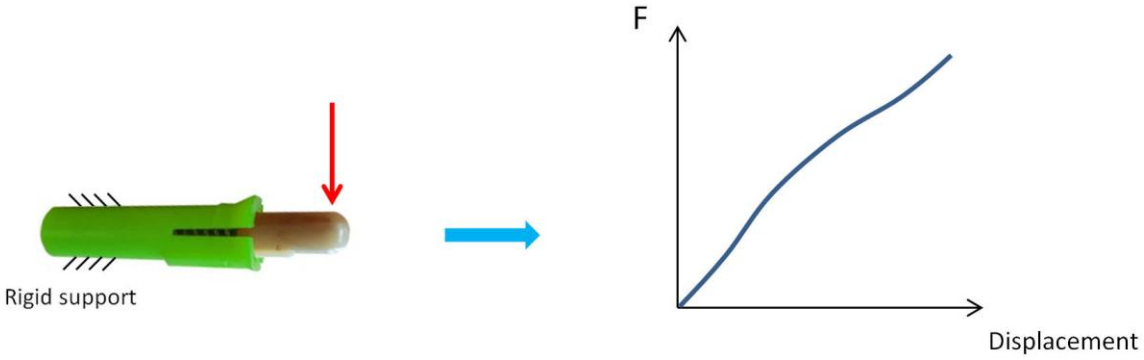


Picture 3 Simulated handling force vs gear stick rotation which correlates extremely well with the real world after using ForceBoard

Bending modulus modelling

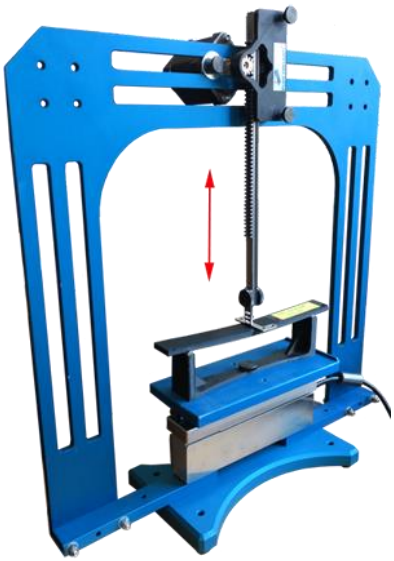
Another very important parameter in any mechanical linkage or mechanism is the force vs travel response a mechanical assembly or mechanical component has to an exerted force. For example this response can have a major impact on the play which is experience by, in this plunger example, the driver and therefore it is a direct measure of the driver experience quality.

A schematic test set-up would, for the plunger, look like this:



Picture 4 A schematic illustration of a force vs travel measurement on the plunger's assembly (plunger + spring + housing) level looks like.

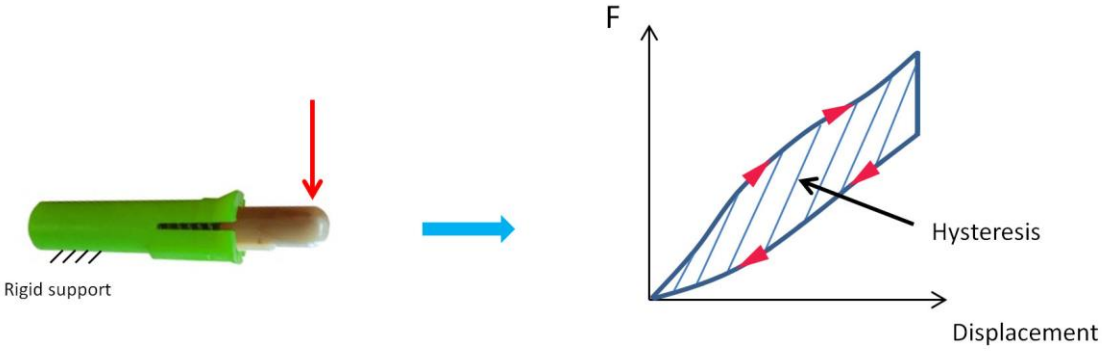
Not only does this type of measurement provide stiffness data that easily can be used directly to fine tune finite element models, it also gives you a tool to detect the amount of play/slack and any other mechanical abnormalities by analyzing the Force vs Travel curve. ForceBoard™ can do this for you in no time and it can even be programmed to output just how linear your force vs travel curve is which, also, is a measure of component and assembly process quality.



Picture 5 A ForceBoard system set up to perform an automated bending modulus test, in this case on a 3D-printed plastic beam.

Hysteresis / relaxation modelling

Similar to the reasoning in the previous bending example there is yet another factor that must be taken into account for plastic components or assemblies (like the plunger in our example) and that is the hysteresis created by an on and off loading force. Moreover, this **hysteresis is loading speed dependent** which adds another dimension to the complexity needed to be modelled in any bending calculation made via a finite element simulation on an assembly like the plunger.



Picture 6 Note that the hysteresis or energy loss presented in the above graph is loading speed dependent and this must be taken into account in you simulation for any on and off loading of a polymer component or assembly.

Luckily, ForceBoard™ is great at running this type of test to objectively measure the hysteresis and its loading speed dependency, even for very high speeds.

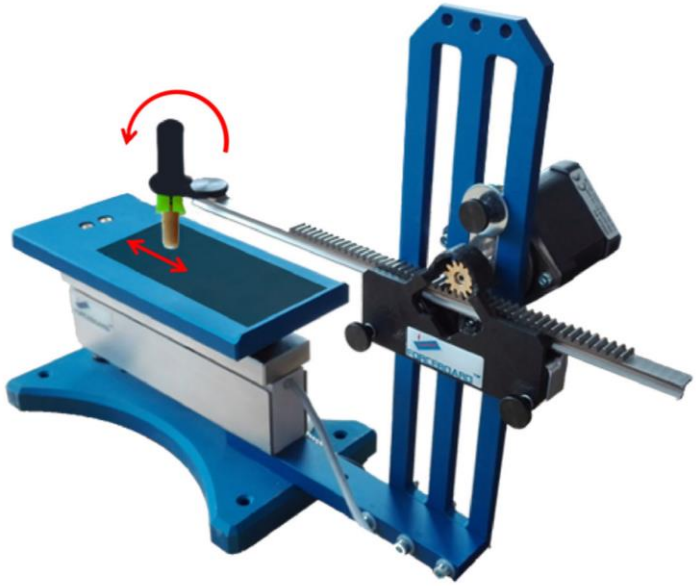
Fatigue modelling

Fatigue simulations are very reliant upon real world data and since you can program ForceBoard™ to run test loops for any number of cycles it is a very nice tool to use to retrieve real test data for use in or to correlate fatigue simulations. You simply tell the i-Motor in the ForceBoard system to move at a certain speed, a certain distance and at a certain number of cycles. Throughout such a test the ForceBoard system continuously monitors the forces in full 1D or 2D with 0.01mm displacement resolution and if any changes of these forces occurs and it can automatically report at which cycle the force fell below or raised above pre-set limits. See the ForceBoard™ i-Motor in action here!

Picture 7 Fatigue testing of the plastic plunger and metal spring assembly is very straightforward using ForceBoard.

Wear modelling

Wear simulations have become increasingly popular and to put it in simple words – if you don't run real wear tests and study the real life behavior of your test bodies then you can stop thinking about running wear simulations. For example, if you are using glass fiber reinforced plastics (very common) and you change the glass fiber volume content by just a little it can have a dramatic effect on the wear. So: Measure the wear if you think about running wear simulations! ForceBoard™ is great at linear and rotating wear tests, in the below picture our plunger is wear tested against a plastic material of the same sort that is be used in the index track from Picture 2 on the first page of this article.



Picture 8 Wear test of the plastic plunger against the same type of plastic used in the index track from picture 2 on page 1. With ForceBoard you can run this type of wear test for any number of cycles with a controlled speed and stroke length. Shortening the stroke and increasing the speed will give you wear data very fast, even for being a wear test! In this case a custom and spring loaded fixture is used to generate the normal force between the plunger and index track sheet material.

Summary

When you invest in expensive finite element and multi body simulation software for structural or mechanical purposes there is one measurement system that you don't want to be without and that is our ForceBoard™ desktop force tester! It will get your simulation models right to the point where you want them to be in order to save time and money by adopting simulations and virtual prototyping – as close to the real world as possible!