Dynamic Simulation of the Drive Chain of a Gas Insulated Switchgear
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Product description
The main purpose of a Gas Insulated Switchgear (GIS) is to break and establish high-voltage electric current. The circuit breaker is in charge of this feature, while disconnectors and earthing switches are installed for security purposes.

Motivation & Objectives
This project was performed as a Master Thesis during a six months long stay at the PTHS-TA department at ABB Switzerland in Oerlikon and focused on the ABB ELK-14S device. The goal was to implement a model of the drive chain of the disconnector while using Matlab/Simulink. Furthermore, the model should reflect the behavior of the drive chain in function of the outdoor temperature. An important part of the mechanism is the flexible transmission shaft, whose friction parameters had to be determined precisely. Determination of these parameters was done by using experimental data. Eventually, it should be possible to perform sensitivity analyses with this tool to issue recommendations for further improvements.

Schematic representation
First, the characteristics of the drive chain had to be assessed.

Model in Simulink

Results
Single runs
The user is asked to enter the working conditions of the disconnector:
- Open or Close operation
- Length of the flexible shaft
- Ambient temperature
- Curvature of flexible shaft

Different parameters of the model are plotted for every run. Experimental and simulated current values of the electric motor can be compared as they are plotted in the same window.

Sensitivity analysis
The results from the Simulink model are exported and can therefore be easily used to compare different working conditions.

Friction model
Friction of the flexible shaft is supposed to follow the Coulomb friction model: breakaway friction torque (static friction, $T_{br}$) is typically higher than Coulomb friction (sliding friction, $T_f$). To avoid numerical problems, the friction model is continuous and piecewise differentiable. A viscous term ($T_v$) is also added.

Friction parameters
Friction parameters of the flexible transmission shaft could be determined precisely as extensive data was available from another project. Friction parameters were extracted automatically through an algorithm made for this purpose. It can be clearly seen that friction increases drastically at low temperature and if the curvature radius is low.

Recommendations
Sensitivity analyses were performed on different parameters as gearing ratio, motor voltage, ambient temperature and motor constant. The model clearly shows that torque needs are much higher at low temperature because of the higher friction of the flexible shaft. This effect can be lowered by adapting the different gearing ratios while conserving the overall gearing ratio. As there is no reliable data on the frictional properties of the SF₆ seal available, the mechanism’s sensitivity to this value had to be assessed. It seems that the mechanism is widely unsensitive to this characteristic, as the applied torque is very high in comparison to any reasonable value of friction torque of the seal.

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