Modelling of cable extruders through Machine Learning

Introduction

In the production of their High Voltage Direct Current Cables (HVDC) and High Voltage Alternating Current Cables (HVAC), NKT uses triple extruders to create layers of insulation and semi-conduction in their cables to improve its electrical properties. To optimize the process, a machine learning model was created to simulate the cable-product based on the extrusion-head inputs.

Project

In simple terms, an extruder is a machine that presses out molten plastic in a mold-like fashion to acquire the desired dimensions and shape of the plastic product. These layers are extruded around the conductor (a copper or aluminium rod or wire) through three separate extruder screws that are all connected to a triple extrusion head. In the triple head the melts flow together around the conductor. Imagine putting a small rod in the middle of a toothpaste tube and pressing out the toothpaste around the rod, then we put that in the same manner in the middle of a larger toothpaste tube and press the toothpaste out again around our toothpaste coated rod. The toothpaste would in this example be the plastic and the final product will be a rod (conductor) with layers of toothpaste (plastic insulation) stacked on top of one another.

This extrusion process is controlled by manipulation of the extruder screw motor speeds; the screw is what drives the melt forward; the puller rate, which is the speed with which the extruded cable is pulled away from the triple head and the position of the separator walls in the triple head. The separator walls can be thought of as walls that keep the plastic melt from flowing together before the actual extrusion die.

To better control the process and optimize the cable dimensions so that the insulation can be thinner without running the risk of being too thin (which would destroy the cable), this project aimed to create a model that can predict how the extruder is affected by the inputs described above, with respect to layer thickness and centering of the conductor in each layer.

The model produced is a neural network of Extreme learning type. The Extreme part basically just means that the learning is a matrix operation and not weight tuning, which lets it learn extremely fast compared to models where each weight must be tuned.

The extreme learning machine was built in python, together with software that helps in the training of the model, as well as two different Graphical User Interface that can be used to simulate the model. One of the GUIs Simulate the thickness of each layer at four different points perpendicular to each other in the cable, as a line graph. The other GUI simulates the cross-section of the cable.

The model was tested and validated in the working range of the process with certain parts of the inputs unknown and was shown to capture the correct trend in the working range. If the unknown inputs matched those of the test and training sets, it would accurately simulate the real process. The model is a proof of concept of how simple it is to model complex dynamics with little computing power utilizing machine learning and serves as a foundation for building optimal controllers or other control aid for the extrusion process.