Method for measurements:

In this document, the methodology followed to achieve the project's goal of calibrating the machine will be presented. This method ensures repeatability, reproducibility and stability for the measurements used to calibrate this type of machine.

Initially, the plan was to take measurements when the machine was in a static hold, and the method was developed based on this concept. However, the measurements from the static holds showed that the engine in the machine went into an idle state. This was not a great baseline for obtaining accurate data, therefore the method had to be refined.

Instead of making static holds, the measurements were made on dynamic movements. To collect data from the measurement a recording function was implemented in the software for the machine. This function has a sampling rate of 60 Hz and the collected data represents the intended weight.

A force sensor was used to measure the actual weight output of the machine. In comparison to the function in the software, the force sensor had a lower sampling rate, of only 1 Hz. This resulted in challenges when trying to obtain smooth graphs during dynamic movements and also when trying to compare the data from the input with the data from the force sensor.To achieve smoother graphs, the movement was performed at a fairly slow pace, taking around 8 seconds per full repetition. The dynamic movements ranged in weight from 4 Kg up to 50 Kg.

The data from the sensor and the data from the software function were collected and moved to an Excel-file. The input and output data had different sampling rates, resulting in significantly more data from the computer, which needed to be addressed. During data collection, the values from the recording function were averaged every 60 samples to calculate a mean value. From this data and from the data from the force sensor, the maximum value was extracted to create two new graphs. The graph from the sensor was linear, indicating the machine operated linearly. This simplified the calibration of the machine, all that had to be done was to modify the sensor graph along the y-axis (the y-axis represents the weight). A linear function is represented by $y = kx + m$. The k-value in the software was great, but the m-value had to be adjusted. During the measurements, different m-values were calculated and changed until the final one was reached, resulting in an improved calibration of the machine.

The sensor we use:

A digital force gauge (https://docs.rs-online.com/ebc3/A700000007226729.pdf)

With the force gauge, the measurements can be recorded onto a SD-card. The contents of the SD-card can be transferred to a computer and converted into an Excel-file. The graph created in Excel can be compared to the graph generated by the software connected to the power cable. The force gauge sampling rate is 1 Hz.

Materials:

- Digital force gauge with force sensor
- Power cable
- Operating software
- Carabiner
- Handle

Procedure:

1. Plug the machine into a power outlet, start the program in Python, and calibrate the machine.
2. Reset the force gauge and its SD card.
3. Attach the force sensor between the cord and the handle.
4. Set the starting weight.
5. Start the dynamic movements
6. Start the recording function in the software
7. Start the recording function on the force gauge
8. Perform the measurements.
9. Document any potential sources of error.
10. Transfer the measurement data and convert it into graphs in Excel.
11. Synchronize the graphs.

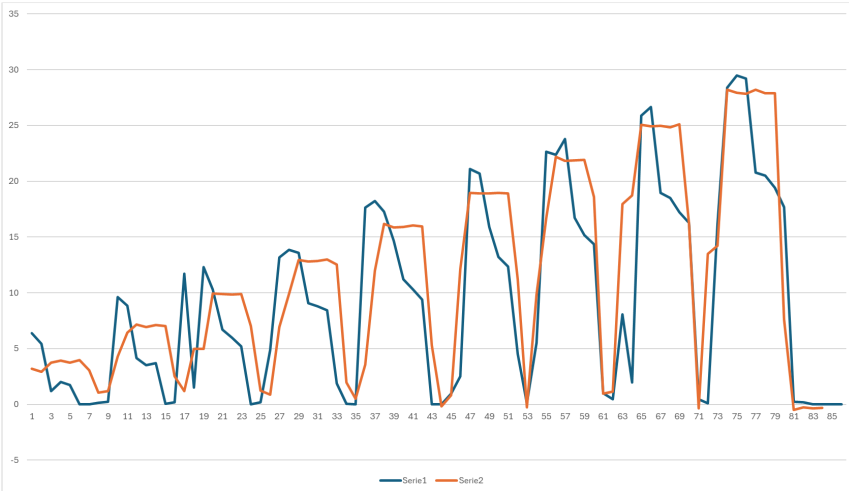

Fig.1

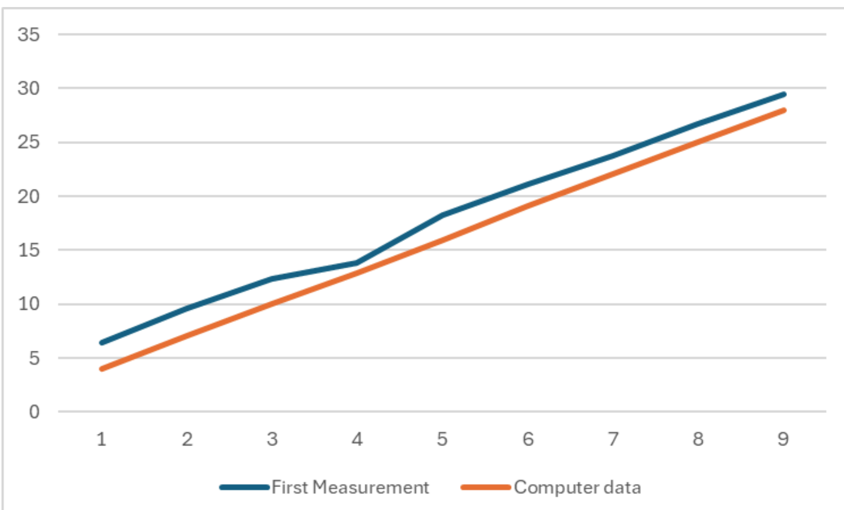

Fig.2

Fig.1 displays the graph with all the data from the function in the software (orange) and the data from the sensor (blue).
Fig.2 displays the linear graph made with the peak values from the sensor and the data in Fig.1. With this graph the calibration was possible to do.