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Real time predictions in the process industry using hybrid-models - a case from Viking Malt A/S

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In the chemical-, biochemical-, and food production industries vast amounts of process data are being recorded using inline/online sensor measurements and offline laboratory measurements. Putting this process data to work through implementation of operator assistance tools, control systems, and digital twins has gained renewed interest in industry [Udugama 2020]. Introduction of Big-Data processing methods and Machine Learning (ML) offers opportunities for utilization of the process data. However, the data available from production processes is often not truly "Big-Data"[Venkatasubramanian 2019] due to low variation in data and time demanding laboratory measurements. As ML algorithms are inherently "data-hungry"the limitations in the available process data pose problems in the accuracy and extrapolability of developed models. A way of mitigating the limitations in process data is to introduce hybrid-models, in which well-known phenomena in the system is modelled using mechanistic modeling, while unknown phenomena is modelled using ML [von Stosch 2014].

This work applies hybrid-modeling to a germination process in the Viking Malt A/S malting plant in Vordingborg, Denmark. Viking Malt A/S is a standard company with regards to data availability such as data structures, quantity of data, measurement frequency, number of sensors etc. but modeling the biological phenomena in the germination process is complicated due to the influence from both external factors and varying process conditions. ML is applied for predicting the growth rates of the barley grain sprouting in the germination process using inputs including distribution of sprout length, water content, temperature, addition of modification promoting hormone, ambient air conditions, and raw material properties, while mechanistic insights are introduced through mass, energy, and population balances. The germination process highlights some of the complexities encountered when working with real production data such as limited number of sensors, uncertainty in sampling, low frequency lab data, and unstructured data storage architecture. The developed models will be applied in real time prediction applications for helping operators in decision making with the objective of minimizing the energy consumption of the process while satisfying the product quality constraints and yield.

Keywords: Hybrid-modeling, Machine Learning, Real time prediction, Energy optimization

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