Anomaly detection in polyethylene production

The problem

- Unforeseen plant failures cause production shut-downs and may lead to damages.
- Early predictions of such failures enable corrective actions and ensure resource efficient and sustainable production.
- Decompositions in polyethylene plants are major upsets that should be avoided.

The solution

- Application of machine learning algorithms for anomaly detection and prediction.
- Prediction of plant failures in polyethylene production using those algorithms.
- Integration into divis’ ClearVu Analytics™ toolbox and Leikon’s Intexc Suite.

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The problem

Unforeseen plant failures – A waste of resources

For an integrated chemical production site, the reliability of production plants is a key factor to ensure a sustainable and resource-efficient production. In case of an unexpected failure, the production has to be continued under suboptimal conditions or even stopped. Moreover, such failures may cause damages and present risks. Therefore, it is of great interest to detect failures before they happen to counteract them or at least to limit their extent.

An example for this kind of behaviour can be found in the polyethylene plants. They can enter a faulty state that ultimately results in the shut-down of the production for multiple days and incurs significant costs. The transition from the normal to the faulty state is very fast due to the special reaction kinetics, and once the transition started, it cannot be prevented anymore. Therefore, it is crucial to detect the possible start of this event as early as possible. This behaviour has been investigated extensively in the past and neither the reasons for these failures nor an approach to predict the failure could be found. Within CoPro, data science and machine learning have been used in order to tackle the challenge to detect critical states before they lead to plant damage.

The solution

Anomaly detection in polyethylene production

Machine learning algorithms were developed for detecting and predicting anomalies in chemical process data. This technology has been integrated into divis’ ClearVu Analytics™ toolbox for data driven process modelling and analysis.

In the application at INEOS in Köln, this technology is used for detecting the upcoming of a so-called decomposition event. The predictive models are trained on process data from past decomposition events. The assumption is that in the period shortly before the decomposition, the process states are significantly different from normal process states. Thus, the states close to the decomposition are labelled as anomalies whereas all other states are labelled as normal. Based on this data, a classifier was developed and trained which can predict the type of the process state as being an anomaly (indicating decomposition) or not. An increase in the number of predicted anomalies indicates an upcoming decomposition. In order to deploy the approach, the ClearVu Analytics™ engine was integrated with Leikon’s Intexc Suite.

The process data is picked up by the Intexc Suite and the relevant parameters are passed to the model in ClearVu Analytics™. The prediction of the state is passed back to the Intexc Suite and stored in the data base. It is also possible to visualise any relevant information. A schematic representation of the workflow is shown in Figure 1.

This solution has been implemented in a dashboard using the Grafana visualisation platform. A sample screenshot of the dashboard is shown in the figure at the front side. The lower part shows selected process parameters over a certain period of time. The upper part shows the process state classified by the machine learning model. A zero corresponds to a normal state, and a one to an anomaly. In the selected time period the model detects the abnormal state in the middle of the time period.

All relevant information is compressed and presented on a comprehensible dashboard that can be easily monitored by plant operators which are also informed in the event of an anomaly. This solution has shown promising results on historical data and is now in the online validation phase at INEOS in Köln.

This approach for detecting an upcoming decomposition can be easily transferred to other predictive maintenance tasks. The increase of the number of anomalies (abnormal process states) usually indicates upcoming problems which might be equipment failures or product issues. Thus, separating the states into normal states and anomalies relative to the event and using a classifier to predict the process state can be applied to many tasks.

The summary

Machine learning detects and predicts anomalies

Predicting anomalies in process data is an important contribution to running processes optimally and avoiding undesirable process states. In this application to polyethylene production, such a fault state of the process can cause unexpected failure and a significant loss of resource efficiency. Data-driven anomaly prediction has been implemented for this process, based on an extension of divis’ ClearVu Analytics™ toolbox for automatic machine learning. Through an interface between Leikon’s Intexc Suite and ClearVu Analytics™, integration into the dashboard visualisation interface has been created, allowing for a direct visualisation of the anomaly prediction in the process dashboard.

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Further information

Fig. 1:  
Process dashboard with an indicated anomaly detection. The lower part shows selected process parameters over a certain period of time. The upper part shows the process state classified by the machine learning model. A zero corresponds to a normal state, and a one to an anomaly. In the selected time period the model detects the abnormal state in the middle of the time period.