Indirect measure of change in raw material

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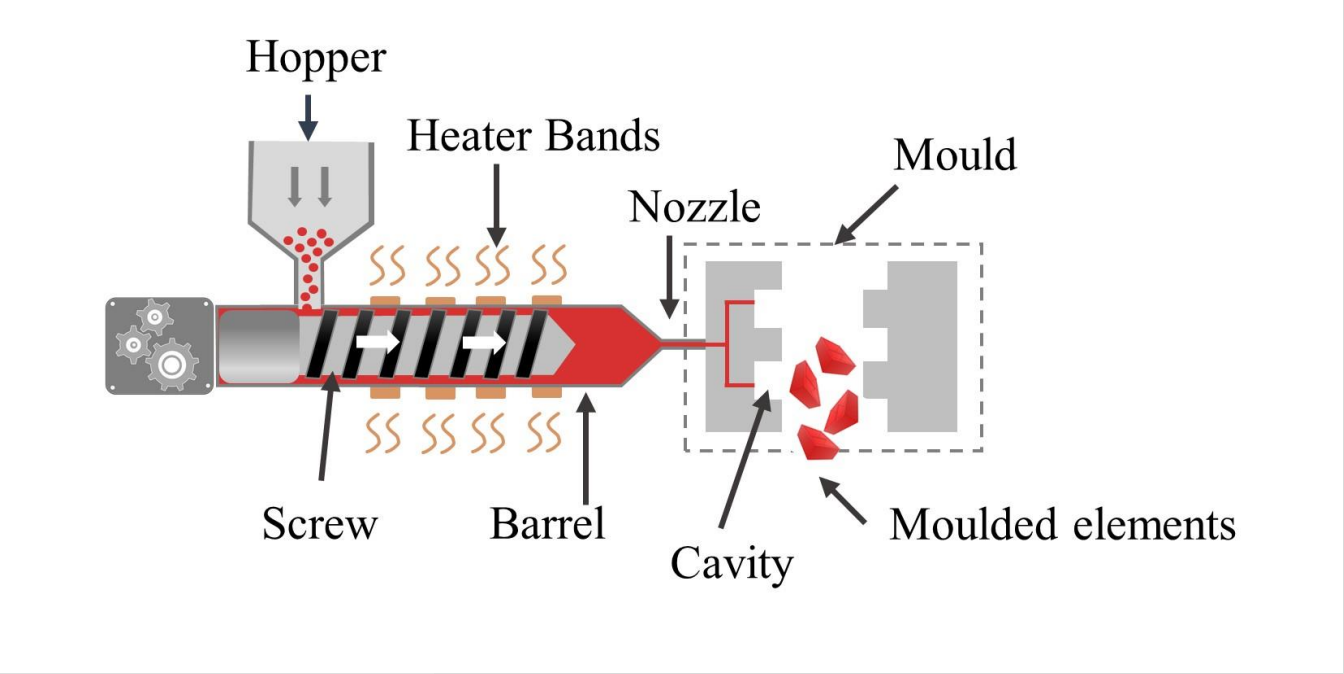
Innovation in Operations

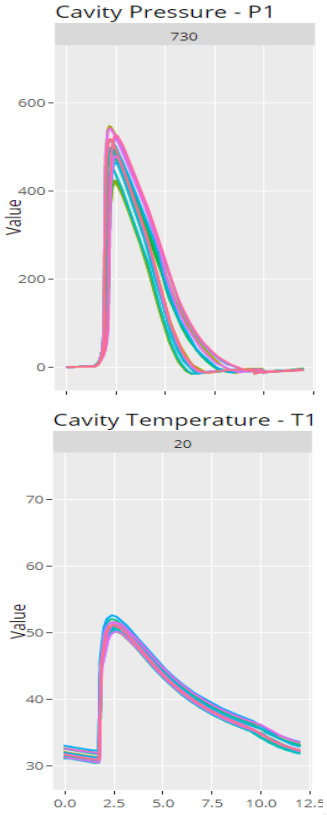
DTU

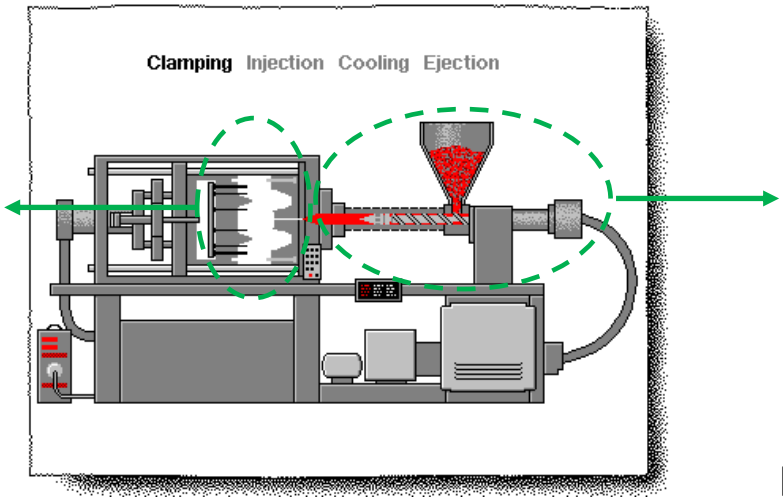


Injection Moulding
- and data collection

Injection moulding data

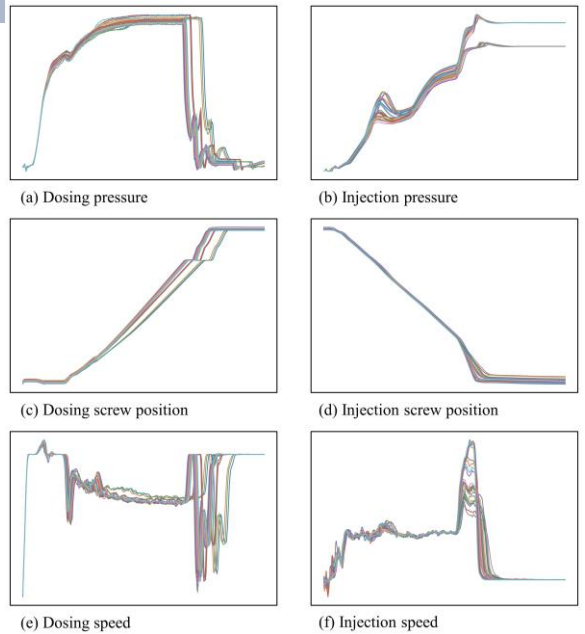
Cavity Profiles





https://www.docsity.com/en/news/education-2/plastic-processing-techniques-explained-interesting-gifs/%3Cbr+/%3E/

Machine Profiles



Process data

Measure:

- Peak
- Difference
- Average

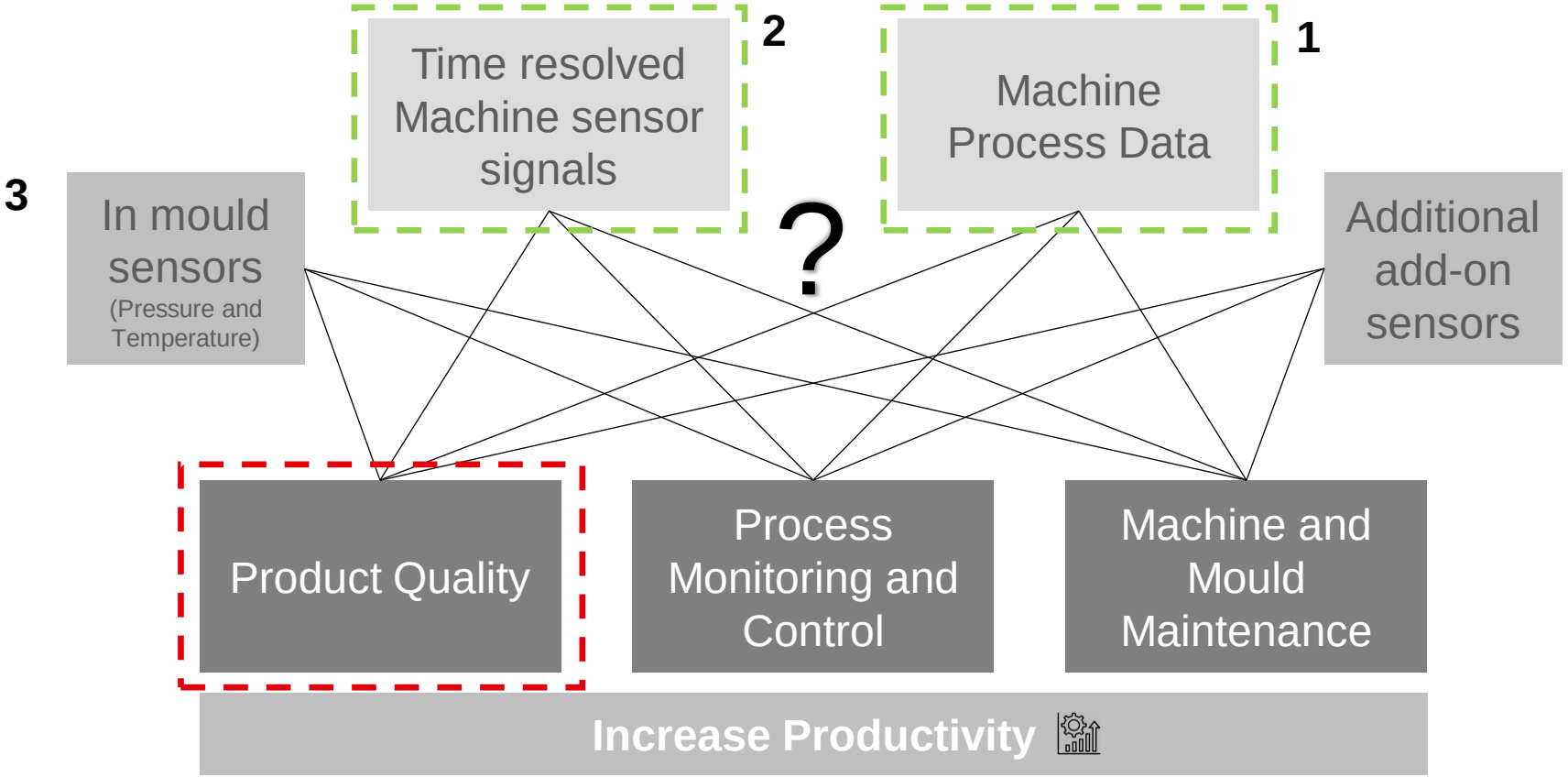
Parameter:

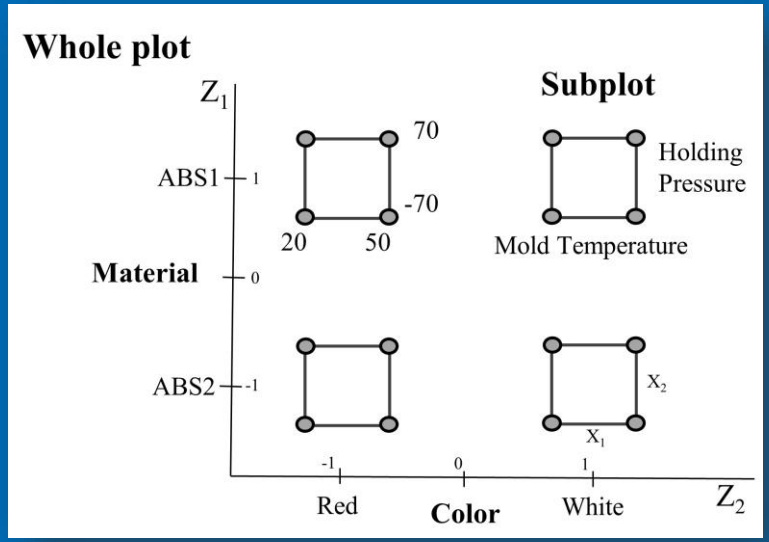
- Pressure
- Temperature
- Time
- Distance

Example:

- Holding press
- Barrel temp
- Injection time
- Cushion

Best use of data from Injection Moulding

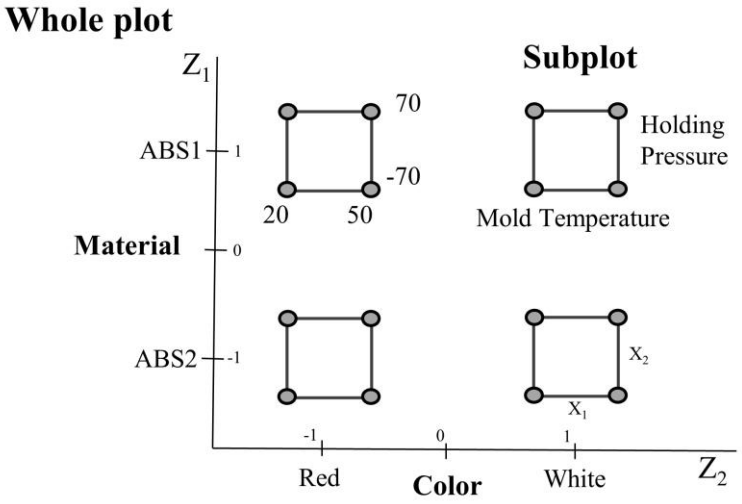




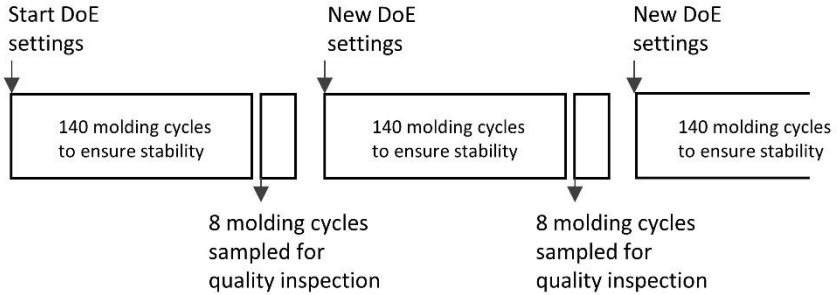
Experimental setup

How to obtain data and overcome challenges with small data sets

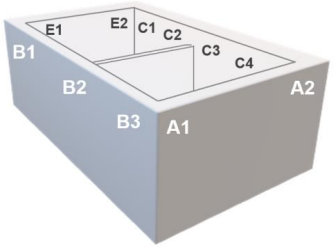
Experimental setup



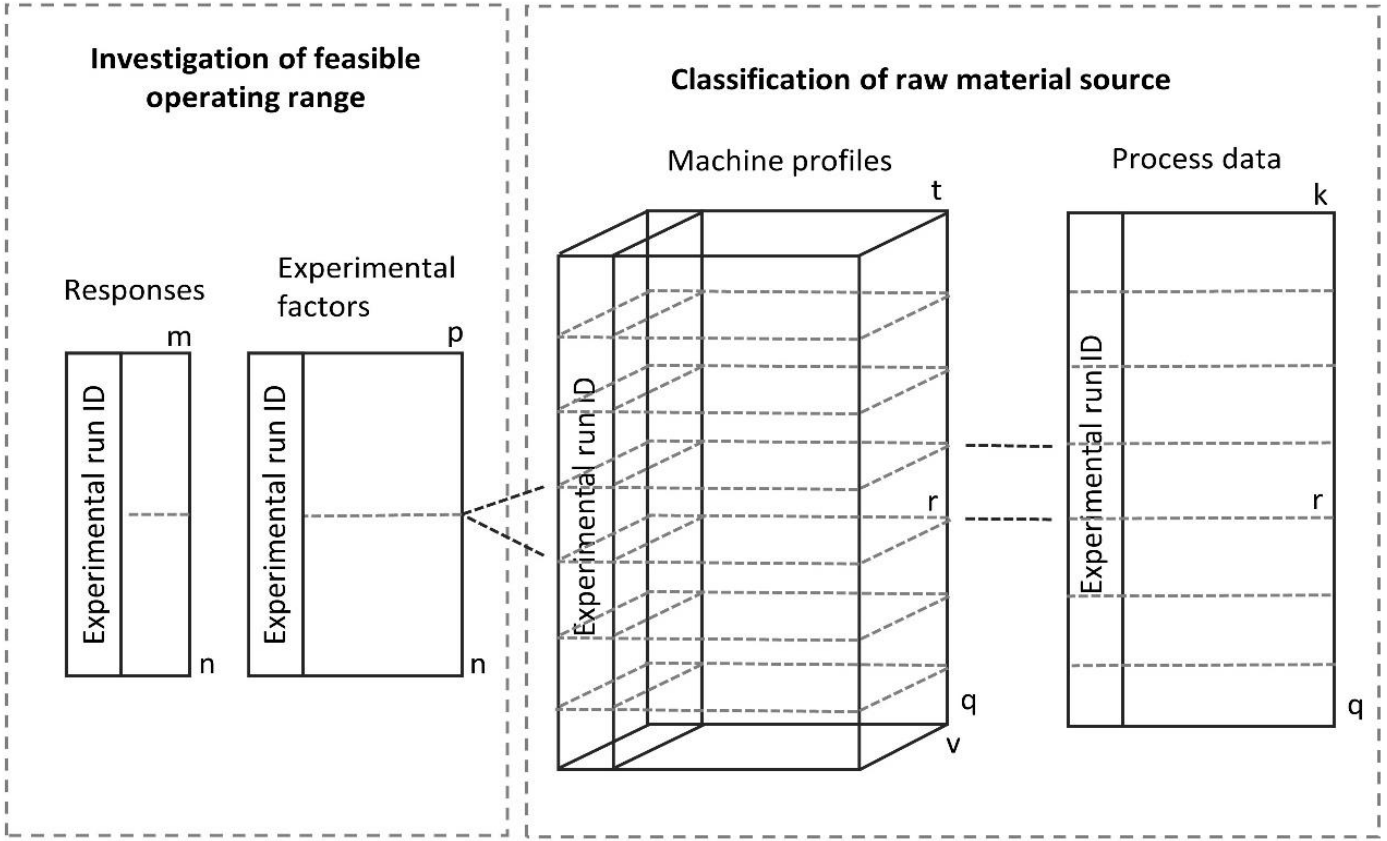
The design used is a replicated split plot design in the form of $2 \times 2^2 \times 2^2$ resulting in 32 test runs



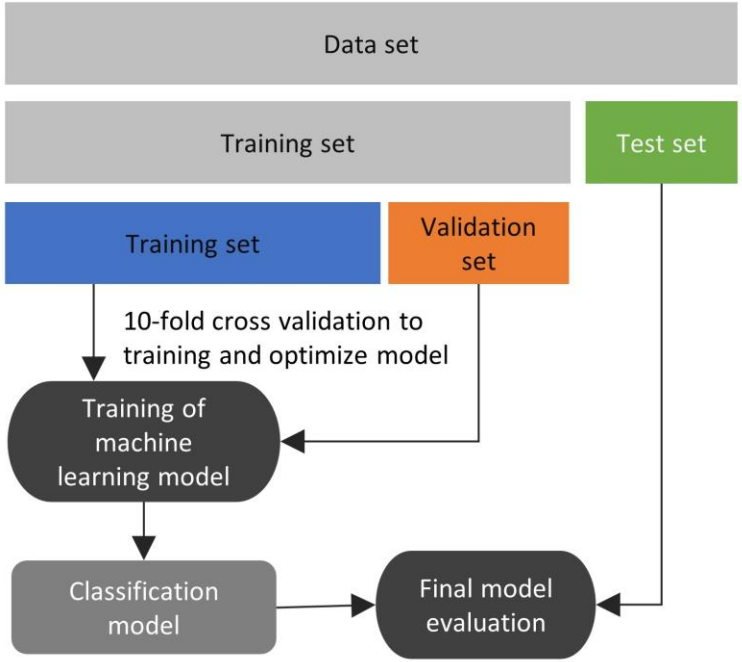
Shape of the molded element and measuring points



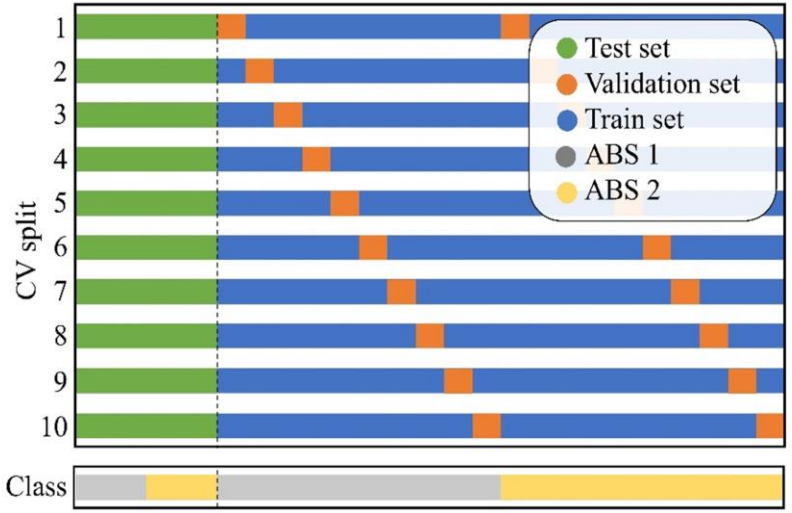
Structure of data used



Structure of data used

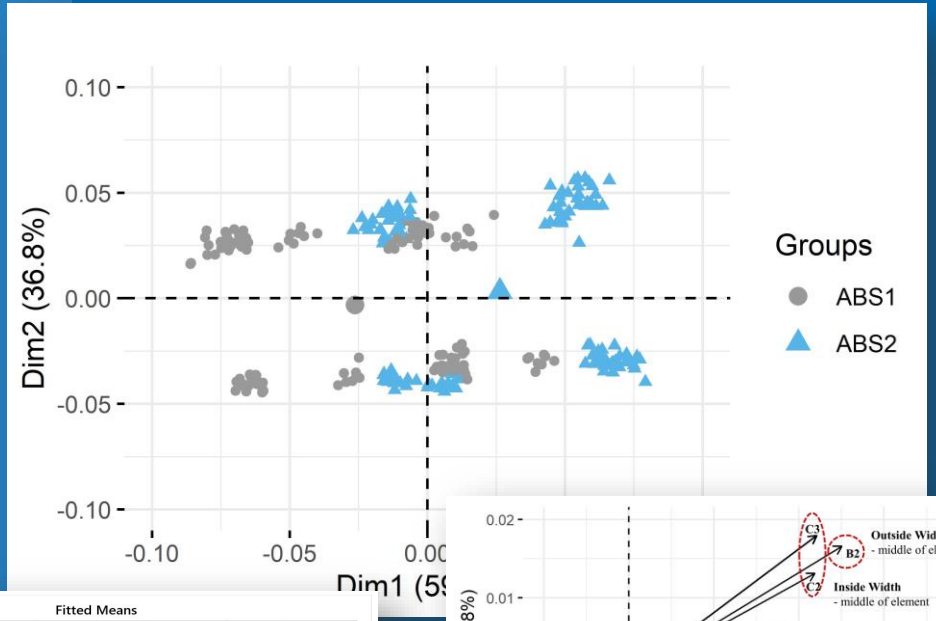


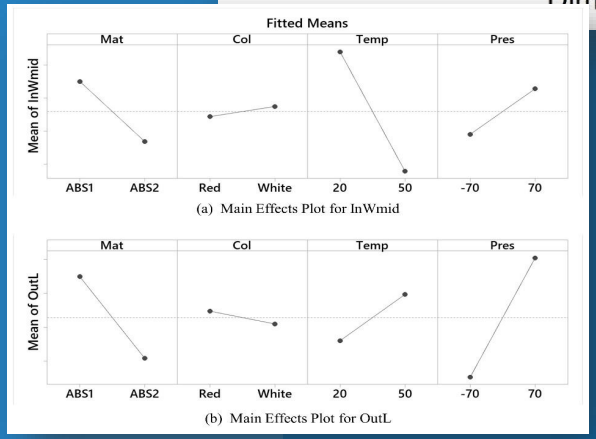
(a) Overall data flow in model training, validation and evaluation

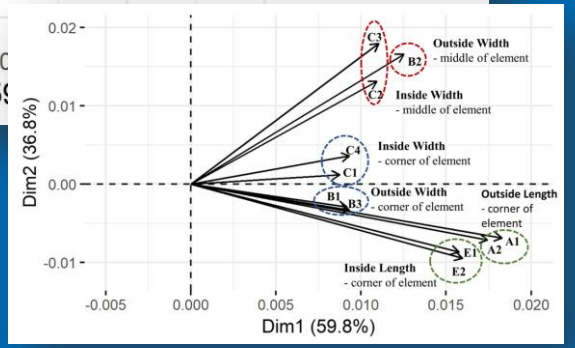


(b) Illustration of stratified splitting in test and validation

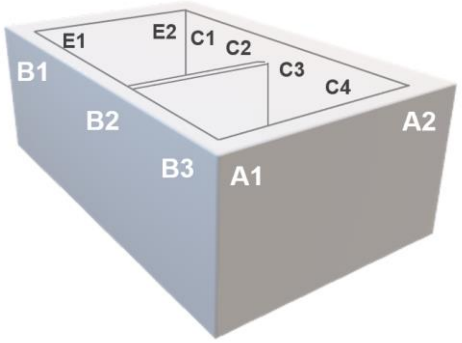
Results and reflections

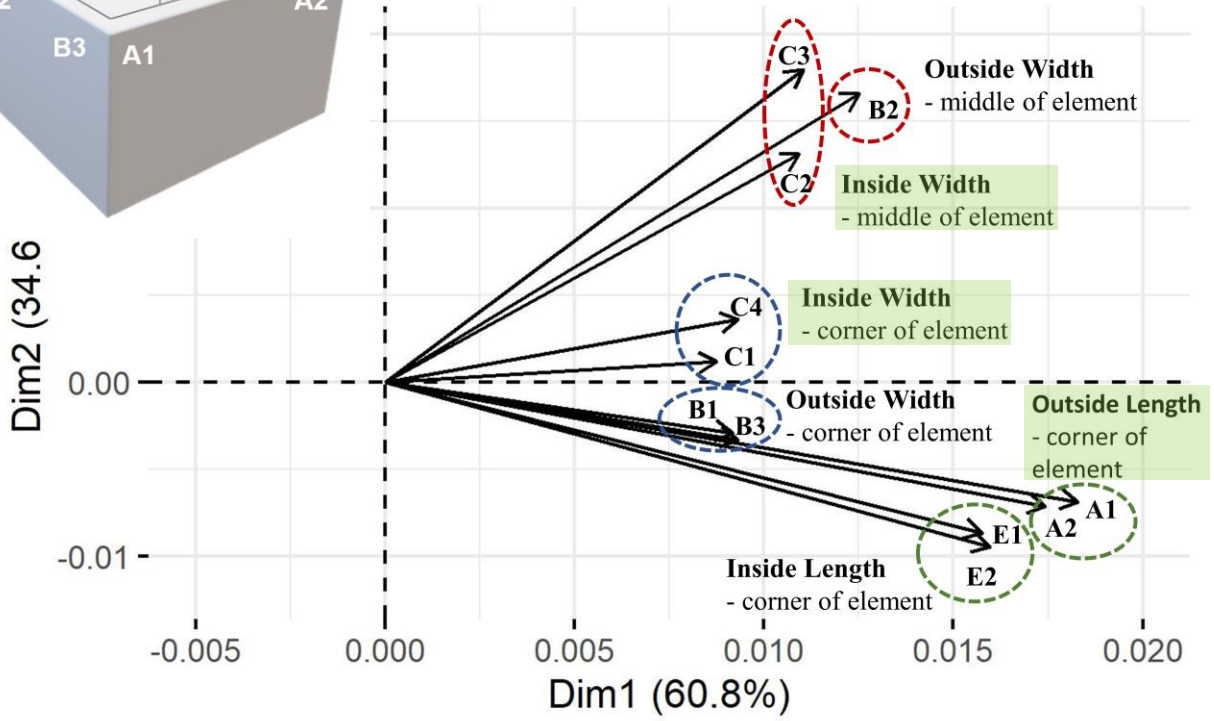


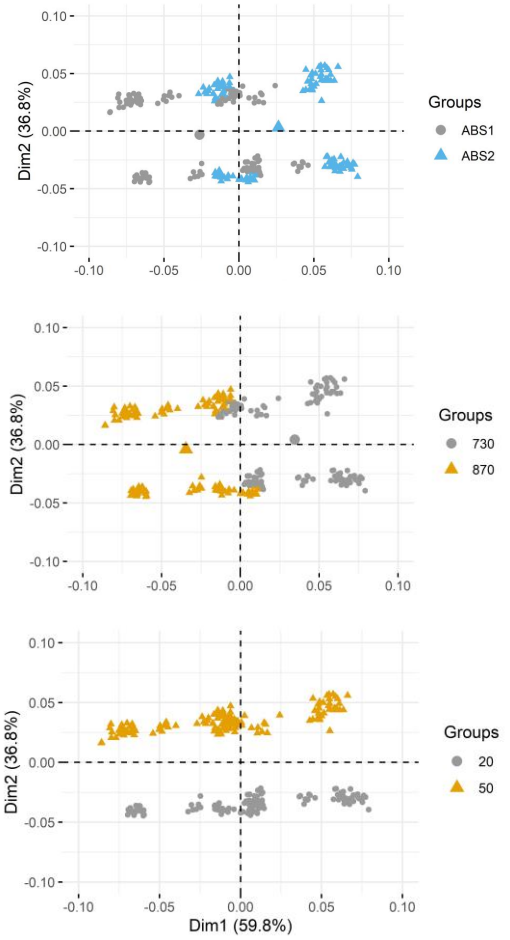




PCA exploration of responses



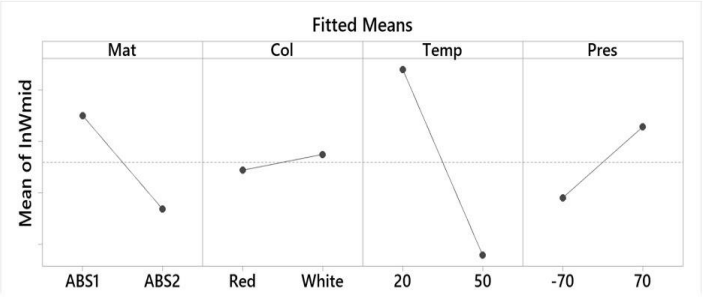




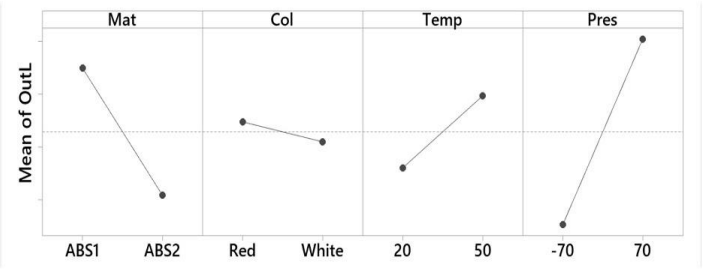
PCA created in R using the prcomp function and factoextra package for visualizations.

Evaluation of responses

		InWmid				OutL			
Source	**DF**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**	**Adj SS**	**Adj MS**	**F-Value**	**P-Value**
Mat	1	0,00264	0,00264	95,71	**0,001**	0,00462	0,00462	70,94	**0,001**
Col	1	0,00008	0,00008	2,73	0,174	0,00011	0,00011	1,73	0,258
Mat*Col	1	0,00001	0,00001	0,48	0,526	0,00001	0,00001	0,1	0,768
WP Error	4	0,00011	0,00003	3,81	0,022	0,00026	0,00007	13,35	0
Temp	1	0,01041	0,01041	1435,97	**0**	0,00148	0,00148	303,64	**0**
Pres	1	0,00151	0,00151	208,88	**0**	0,00985	0,00985	2018,48	**0**
Mat*Temp	1	0,00003	0,00003	4,1	0,059	0,00000	0,00000	0	0,962
Mat*Pres	1	0,00000	0,00000	0,25	0,623	0,00001	0,00001	1,64	0,217
Col*Temp	1	0,00002	0,00002	2,21	0,155	0,00001	0,00001	1,57	0,228
Col*Pres	1	0,00000	0,00000	0,07	0,795	0,00000	0,00000	0,04	0,844
Temp*Pres	1	0,00007	0,00007	10,02	**0,006**	0,00001	0,00001	1,03	0,325
SP Error	17	0,00012	0,00001			0,00008	0,00001		
Total	31								



(a) Main Effects Plot for InWmid

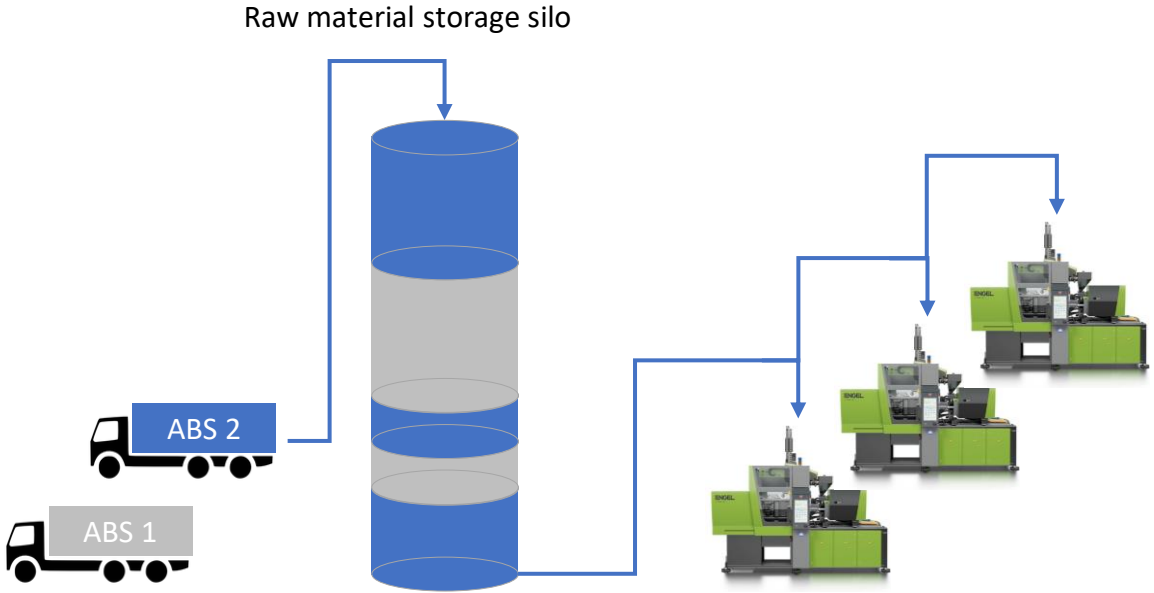


(b) Main Effects Plot for OutL

DoE created and analyze in Minitab 19

Raw material flow

- source of raw material is unknow at the injection moulding machine

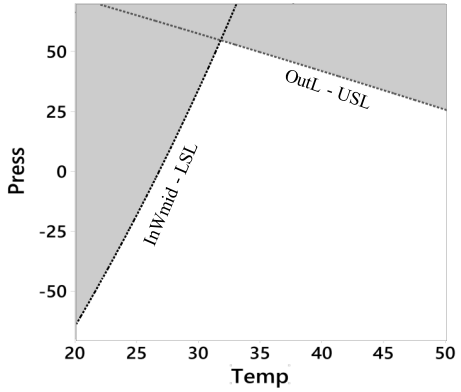


Potential solutions:

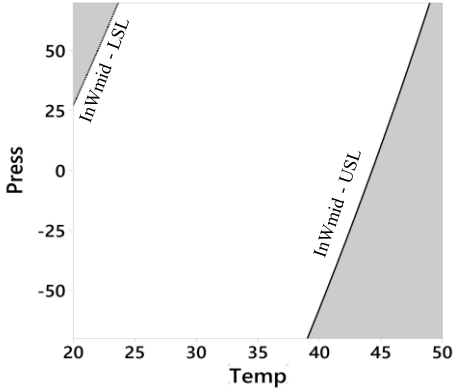
- Change material storage and handling system to achieve traceability.
- Use NIR/IR at the machine or central placed in the feeding system to detect change in material (might also be possible to monitor variations over time).
- Extract information of material variation from machine in-built sensors.

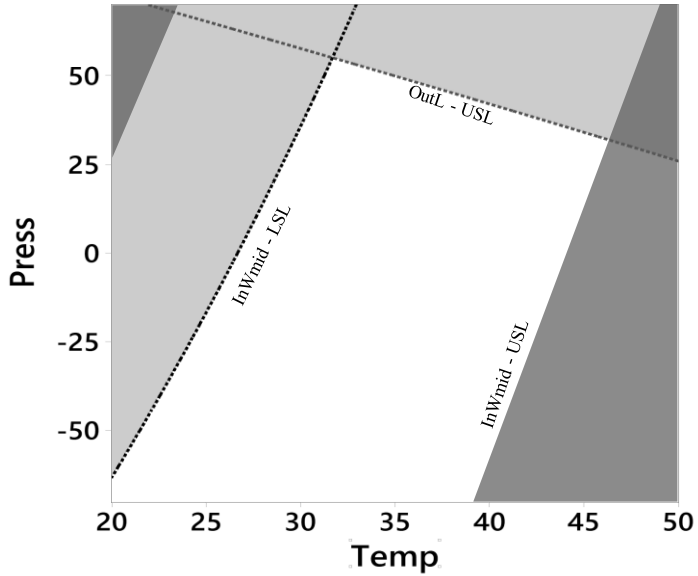
Operating window

(a) ABS1



(b) ABS2

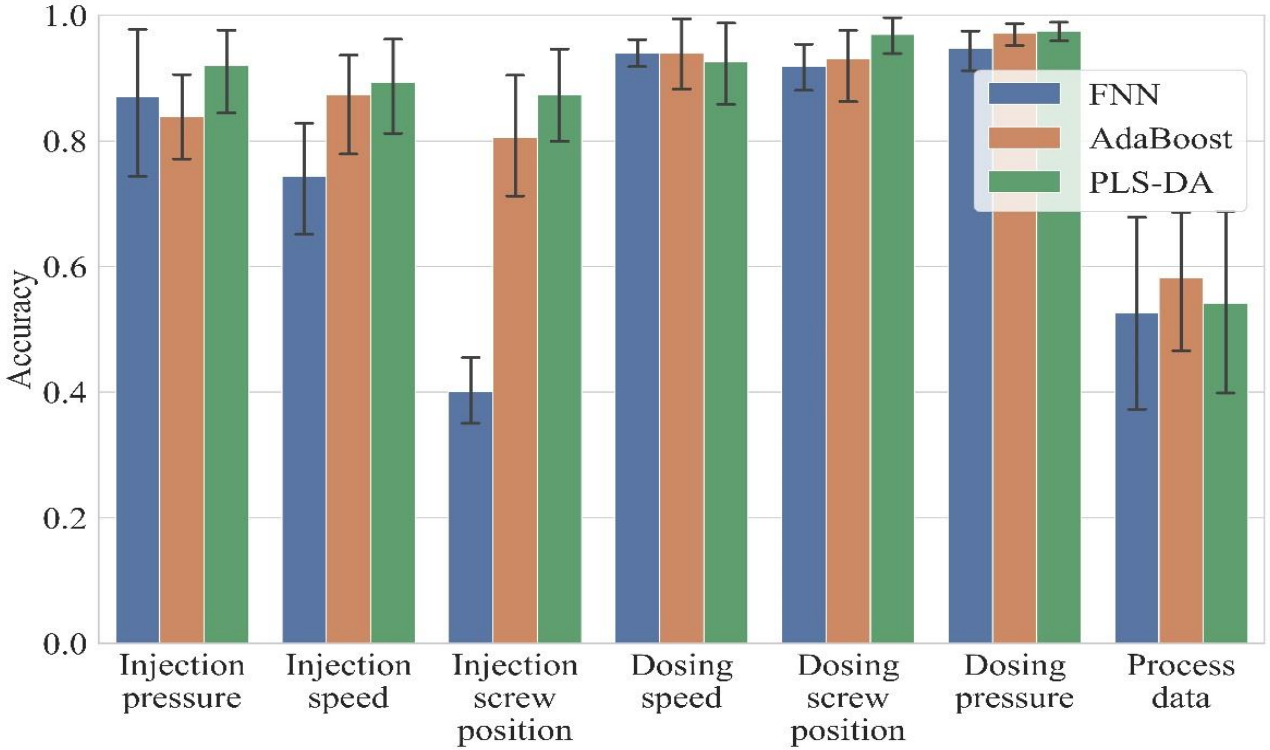




(c) ABS1 and ABS2 contour lines overlaid in same contour plot

Material classification

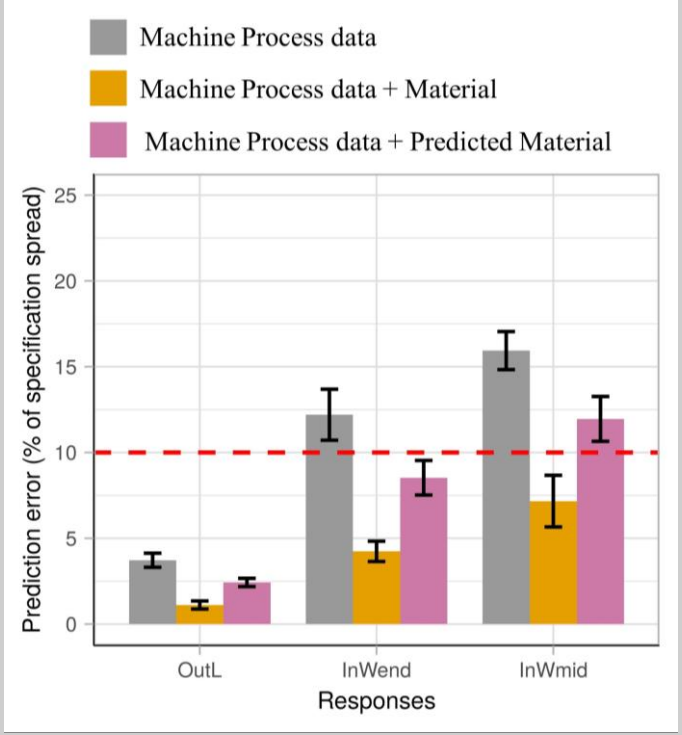
ABS from vendor 1 or 2?

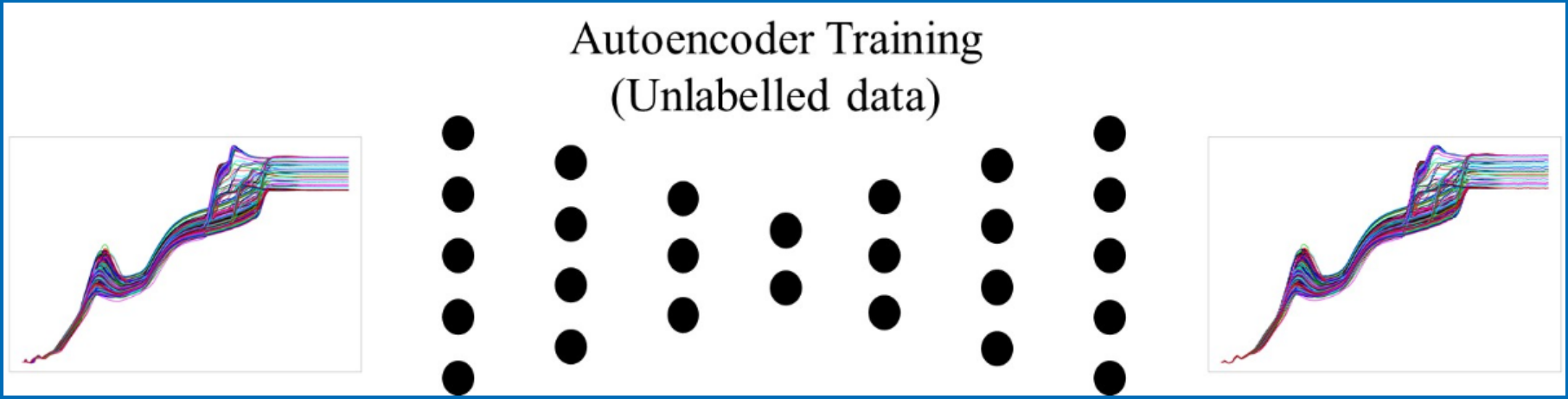


PLS-DA created in R using the “mdatools” package (thanks, Sergey, great package), AdaBoost using “adabag” and “keras” used for FNN

Prediction of element quality

-using the classification of material as input

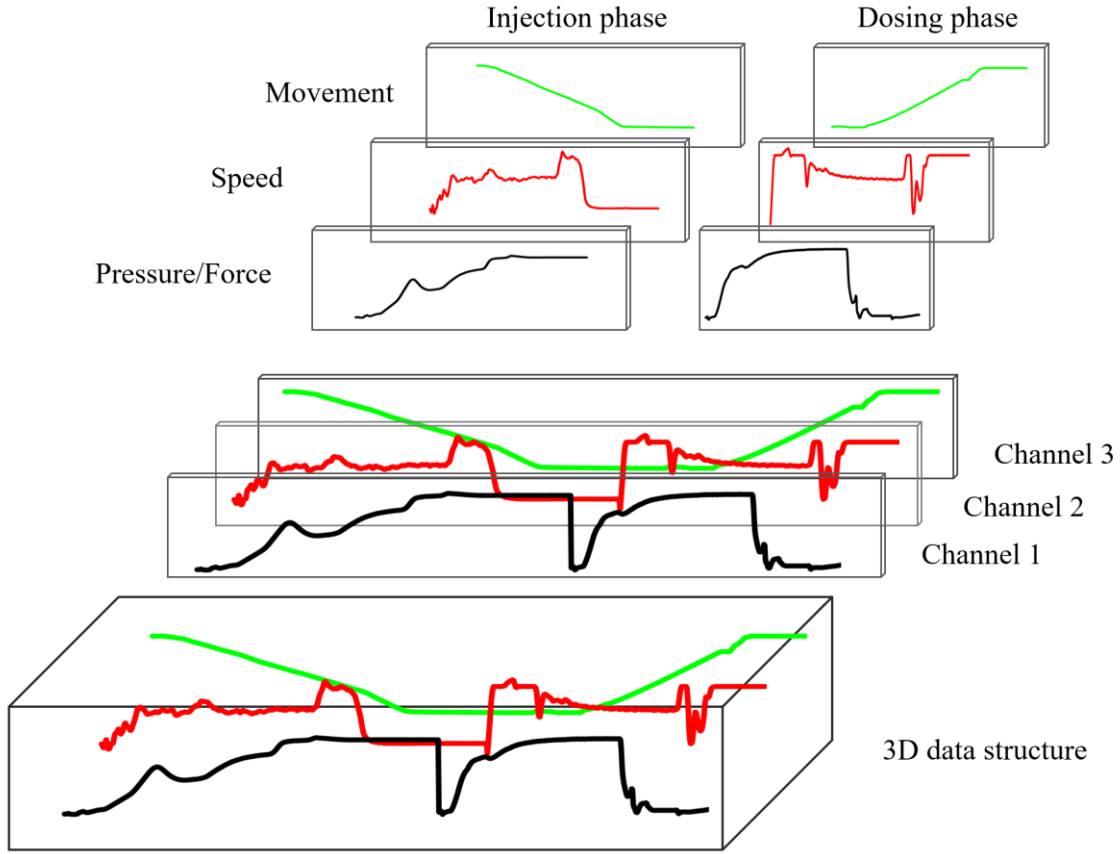




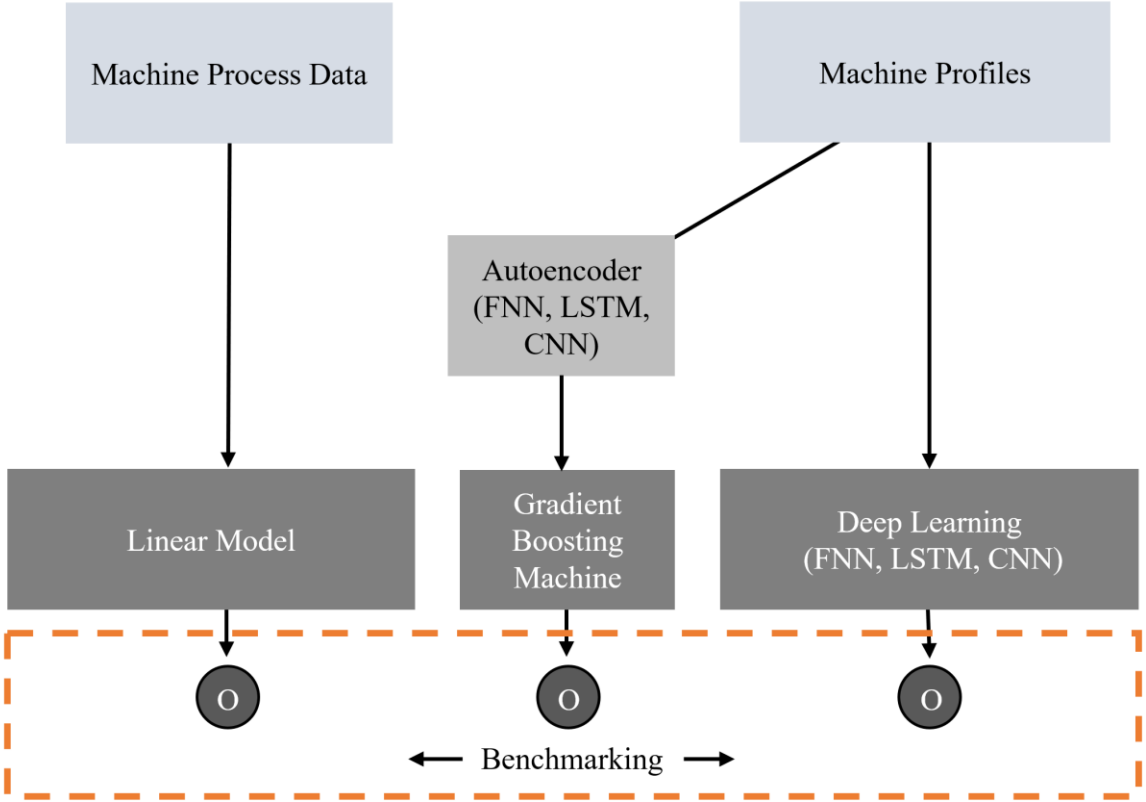
Prediction of element dimensions

How to obtain data and overcome challenges with small data sets

Utilizing profile data



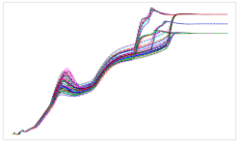
Modeling overview

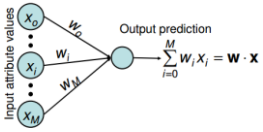


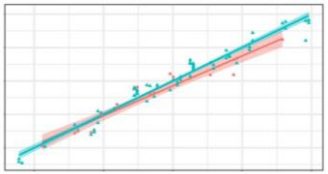
All Deep Learning done in R and Python using keras

Utilizing profile data

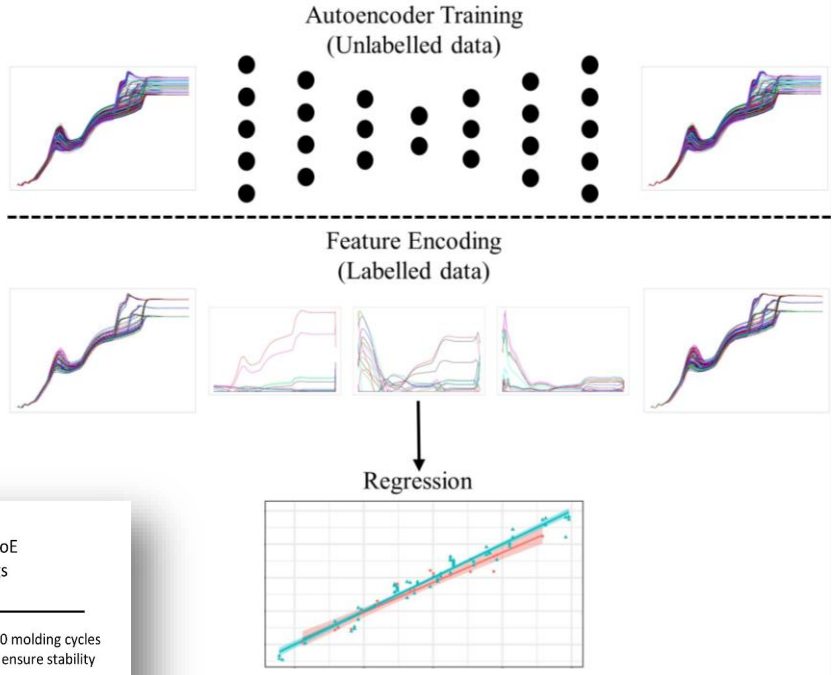
Supervised learning







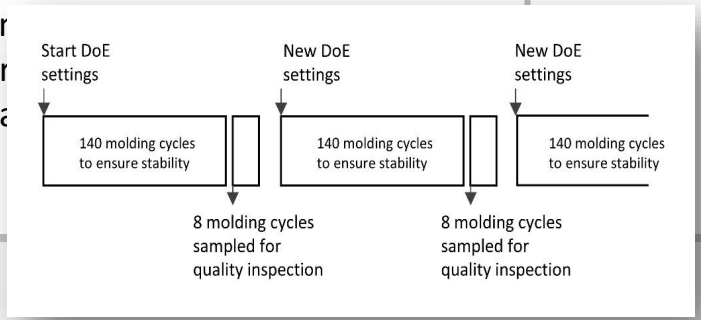
Unsupervised learning



Limitation:

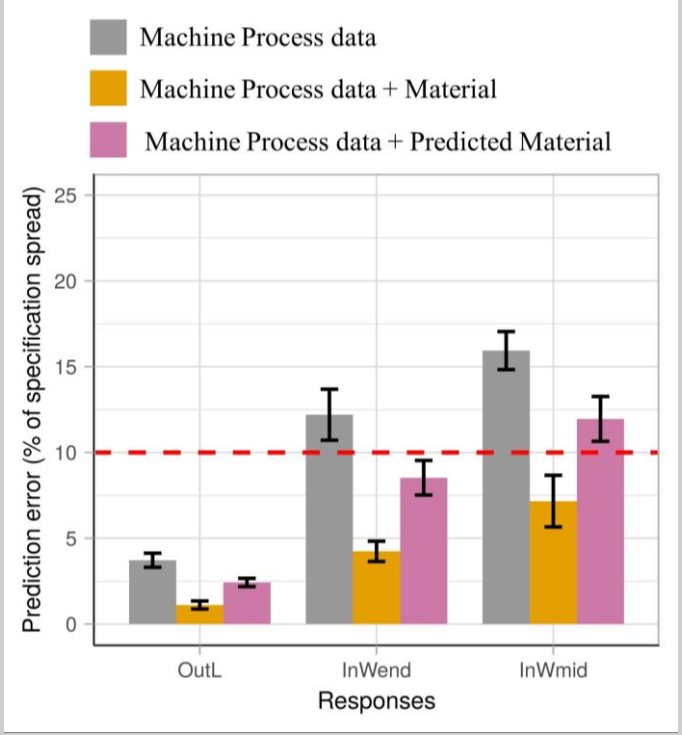
Only 32 samples to be used for training and validation.

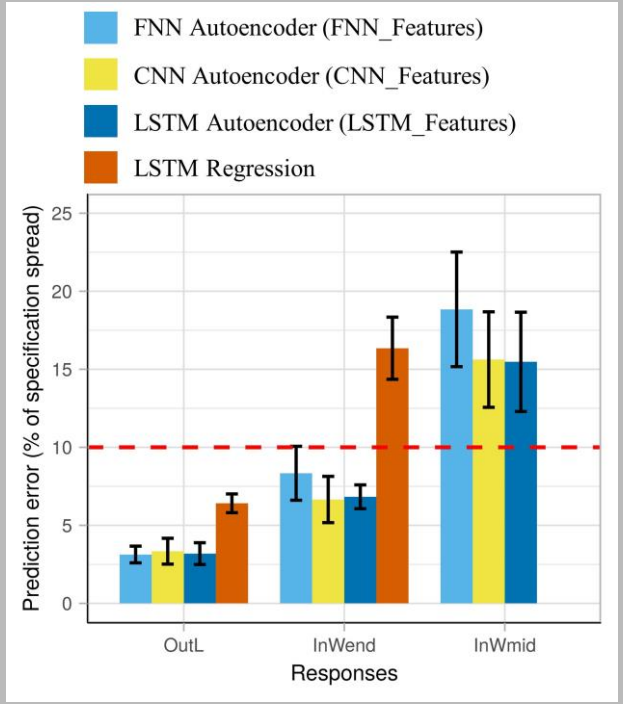
When using Deep Learnir
to estimate the many par
unusual to have more tha
estimate)



Deep Learning models

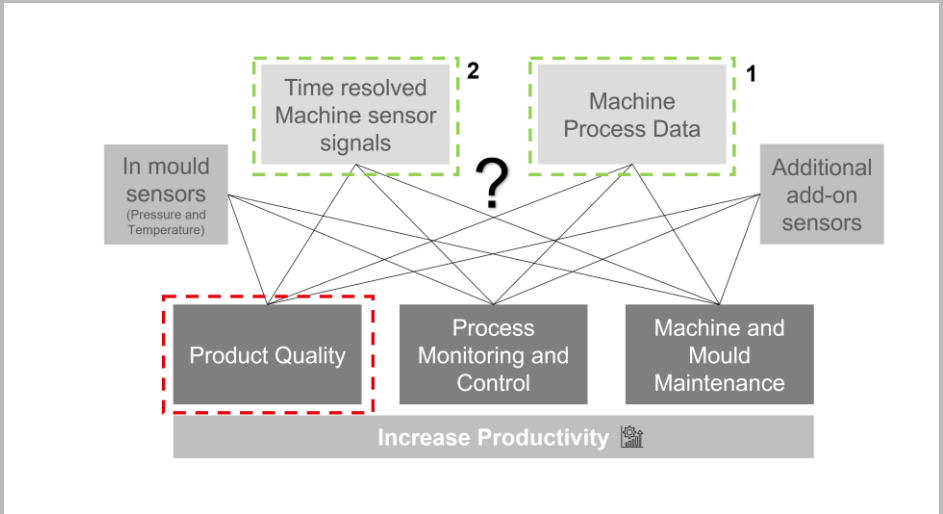
-using Machine profiles in different combinations





Reflections

- Process variables can be used as indirect measures of e.g. raw material variations.
- The readily available engineered process variables can bring you a long way.
- Consider the whole “cost of data utilization chain”, that include: connection, data collection, data storage, analytics and action/reaction.
- Using autoencoders (using unlabelled data) and pre-trained networks can help overcome obstacle with low number of labelled data.



Thanks to Martin Dybdahl and Murat Kulahci for great collaboration