Where we are with
Artificial Intelligence & Machine Learning in Rubber Development

Hans-Joachim Graf

Recipe is used 1 Time per Project / Evaluation

Reinvention Time*)
~ 1- 2 Jahre!

Mid size - / Large company:
Recipes in use ~ 500 – 2000
Laboratory recipes ~ 1000/year

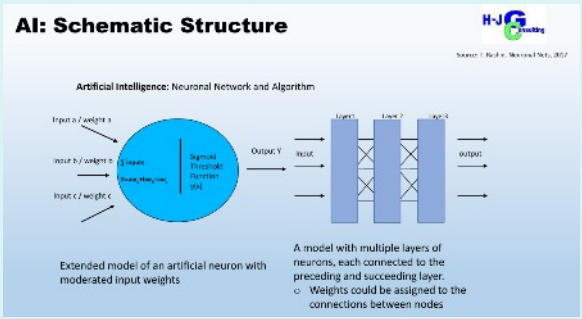
Cost of Recipe Development in a Laboratory
~ 500 US$/Recipe
=
Invest of 500.000 US$/year

**) personal Estimation*

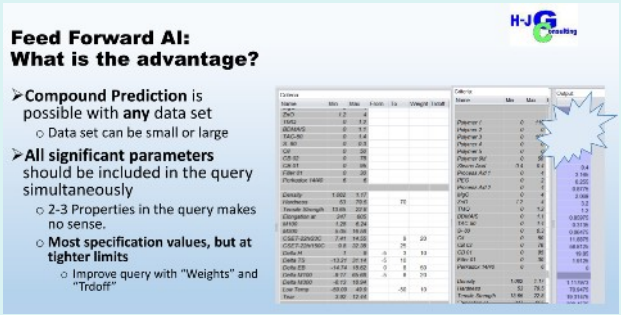
Compounds in Rubber Industry are seen as intellectual property and a sensitive topic, due to its large influence on total manufacturing cost. Surprisingly development methods are quite conservative compared to other industries. While the use of CAD (Computer Aided Design) and Simulation becoming the new standard of part development and processing, compounds created based on experience, knowledge and rules evaluated in the last centuries.
Nowadays the discussion is on, to use modern computer techniques like Artificial Intelligence [AI] and Machine Learning [ML] in compound development, but ML may find its way in processing much faster.

Artificial Intelligence

To open up the limits of DoE, Artificial Intelligence (AI) and even ML is discussed since some time. AI is created to make use of existing data (for example "Words" for spell checking or "Pixels" for Face recognition). It processes data created in the past. It works with specific neuronal network algorithm, but needs large amount of data. In rubber development there is no lack of data, but this data are not publicly shared nor available in an organized standard format. Opposite to above examples the data have measurement errors. On top, the error values are not normal distributed due to influences from time, machine, man and material. This is an obstacle for ML and specifically the training of a ML program. The other issue, the training would take a large amount of time from weeks up to months.



However, happenstance database can be improved via cross correlation analysis via taking out outliers and other errors. Rubber technology teaches us, that some physical properties depending on cross link density and / or reinforcement. There are interdependent properties which are inter correlated as well. If such relations can be generalized and considered independent from the compound composition, then such analysis is a step forward to clean up the data. It would lead to a much better compound prediction even without ML programs, which is demonstrated already.

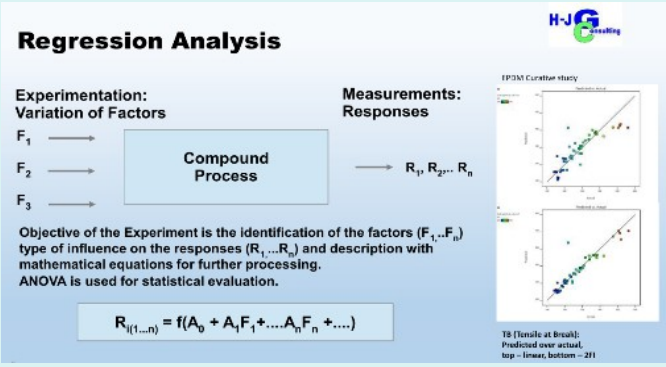


AI and DoE replacing completely trial and error or any other development strategy like One Factor A Time (OFAT) procedure. AI and DoE have its advantages and disadvantages, which will be discussed in this presentation. In modern rubber development both are needed. But the use of ML in Rubber compound development seems far away and will take a new approach.

More Information:
www.grafcompounder.com

Design of Experiments

Statistic Experimental Design [DoE] is a tool to explore new materials, it even can help, whether an ingredient in a compound is necessary or can be eliminated. This technique is based on factor – response correlations and regression analysis. However, conclusions are always limited to the limits of the experiments. Beyond extrapolation is hardly possible, if not forbidden. The smaller the DoE, the lack between confirmation experiment and prediction becomes large.



It depends highly on compound manufacturing variation and measurement precision. Compounding knowledge is, of course, helpful for the selection of factors with their upper and lower limits. In addition, the findings cannot easily be transferred to other compounds made of different ingredients like polymers, etc.