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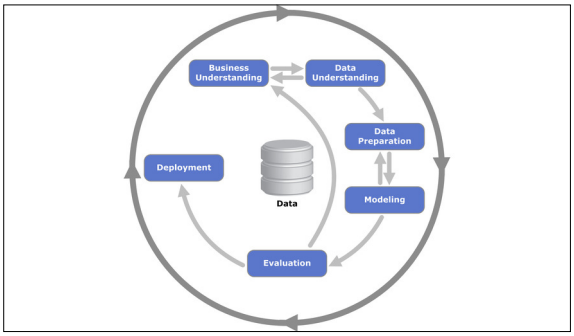
| Subject Area | Innovation in Products, Processes and Materials - Business Engineering and Productions |

# Statistical Data Analysis in the Production of BLDC Motors

Drive of the company BELIMO Automation AG.
BELIMO Automation AG, Technisches Datenblatt LM24A, 2019.




Cross Industry Standard Process for Data Mining.
https://novustat.com/

1) Fit ordinary linear regression model

$$y_t = \beta_0 + \beta_1 x_{1,t} + \cdots + \beta_k x_{k,t} + \eta_t$$

2) Compute optimal ARIMA order of $\eta$
3) Fit ARIMA regression model
4) Adjust variables according to ARIMA fit

$$x_t^* = x_t - \varphi_1 x_{t-1} - \cdots - \varphi_p x_{t-p} - \theta_1 \epsilon_t - \cdots - \theta_2 \epsilon_{t-1} - \cdots - \theta_q \epsilon_{t-q}$$

$$y_t^* = y_t - \varphi_1 y_{t-1} - \cdots - \varphi_p y_{t-p} - \theta_1 \epsilon_t - \cdots - \theta_2 \epsilon_{t-1} - \cdots - \theta_q \epsilon_{t-q}$$

5) Fit adjusted linear regression model

$$y_t^* = \beta_0 + \beta_1 x_{1,t}^* + \cdots + \beta_k x_{k,t}^* + \epsilon_t$$

6) Check assumption of independence of the error terms

Concept of adjusted linear regression modeling.
Own presentment

Initial Situation: The company BELIMO Automation AG, based in Hinwil, develops, produces and sells electric actuator solutions in the heating, ventilation and air conditioning technology. BLDC motors, which are manufactured by an external partner, are used in their damper drives. The agreed tolerance limits for speed and current consumption are relatively generous. The aim of this work is to find conspicuous features and influencing factors in the production data in order to optimise the production of BLDC motors.

Approach: The CRISP-DM model was chosen as the methodology. This allows the individual work steps to be flexible and dynamic. First, the various data sets from the period 2016 to the end of 2019 were combined in a data package in order to check its integrity. The second step was the explorative data analysis. The goal was to understand the data and to identify first patterns. It quickly became clear that most variables have a high temporal impact. Therefore a time series analysis was necessary to better understand these temporal effects. During this step a specially developed algorithm was used to calculate optimal ARIMA parameters. To finally model a linear regression analysis, the temporal effects had to be filtered out of the variables. The underlying algorithm corrects the variables according to the residuals from the time series analysis in an iterative process until the residuals of the regression model are independent.

Result: Finally, it could be shown that the speed, the current of the load motor and the process time have an influence on the current consumption. However, these influences are relatively small. It has also been shown that a regression model is particularly useful if the BLDC motors produced are measured at the nominal point. Unfortunately, a clear recommendation for process optimization cannot be given.