Southern Water Corporation

Solving an Organization's problem with Data Analytics

"This project analyzed time series data from production performance over a period of time to predict pump failure in order to aid preventive maintenance schedule and optimize plant availability"

Problem Statement Worksheet (Hypothesis Formation)

How will Southern Water Corporation optimize long term profitability and avoid asset failure whilst reducing maintenance cost by 20% year on year.

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1 Context

Southern Water Corporation is one of the largest desalination plants in Israel. It retails fresh desalination water for residential, public and private consumption.
Having witnessed a surge in demand from customers, she is taking a strategic overview of the business financial heath to determine the impact that scaling up to meet this demand is having on maintenance and life of assets.

2 Criteria for success

- **Identify a list of variables that may provide an indication of when the pumps may be failing**
- **Come up with a prototype linear equation that can be used to 'describe' what variables are closely related to pump failure**

3 Scope of solution space

Focus on controlling operational costs and preventing untimely asset failure which will lead to eventual loss of revenues

4 Constraints within solution space

- **Production Manager's goal of meeting production target may be at variance with Reliability Engineer's goal of shutting down the plant for maintenance.**
- **Data on past machine failures may not necessarily and accurately predict future failure dynamics.**

5 Stakeholders to provide key insight

- **Head of Finance –Joanne O'Neil**
- **Production Manager– Melanie Griggs**
- **Head of Analytics – Andrew Xu**
- **Chief scientist - Joanna Luez**
- **Reliability/Maintenance Engineer – John Lukes**

6 Key data sources

- **Income Statement – year to Date**
- **Production Data – year to Date**
- **Maintenance Data- year to Date**
- **Cash Flow Statement – year to Date**

Solutions Approach

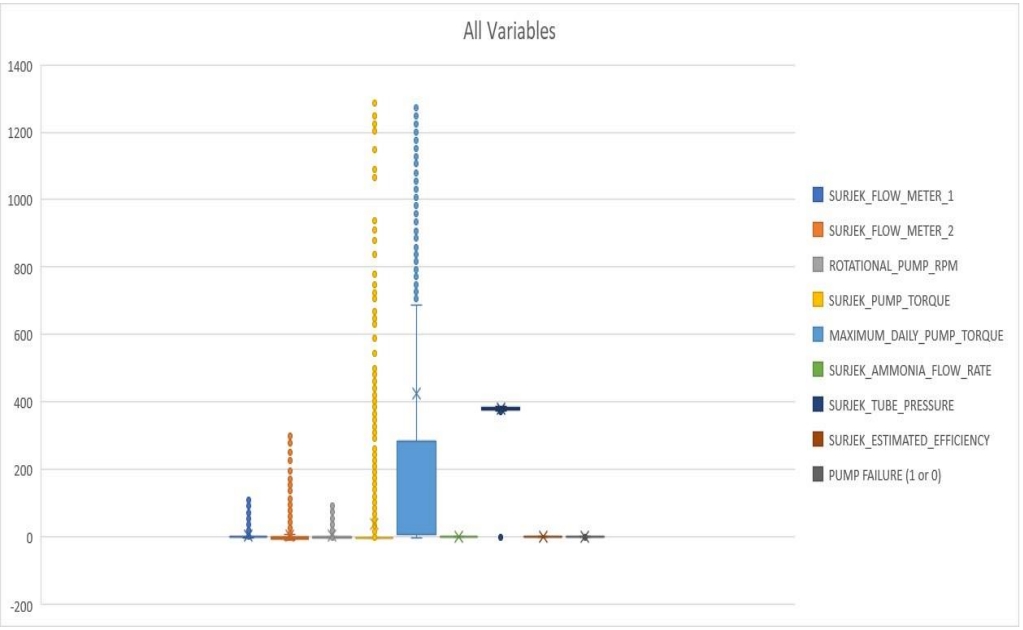
In solving this problem, times series data generated from Southern Water Corp Desalination Plant was retrieved in order to determine what variables are most related to pump failure. The following key parameters from maintenance data was observed.

* *SURJEK_FLOW_METER_1*
* *SURJEK_FLOW_METER_2*
* *ROTATIONAL_PUMP_RPM*
* *SURJEK_PUMP_TORQUE*
* *MAXIMUM_DAILY_PUMP_TORQUE*
* *SURJEK_AMMONIA_FLOW_RATE*
* *SURJEK_TUBE_PRESSURE AND*
* *SURJEK_ESTIMATED_EFFICIENCY*

7000 rows of data were statistically analyzed to see how they behave relative to pump uptime/downtime.

The analysis started by charting boxplots with all the variables plotted to see what variables stand out? Then boxplots with all variables were plotted when the Failure Mode is “Yes” versus when the Failure Mode is “No”. Comparing these boxplots side by side, we were able to see what variables move in response to the Failure Mode being Yes?
Furthermore, we plotted the rolling standard deviation of these variables against the failure time periods to further highlight parameters that stand out in failure modes. All of the above is to help us answer the first criteria for success which is to Identify a list of variables that may provide an indication of when the pump may be failing.

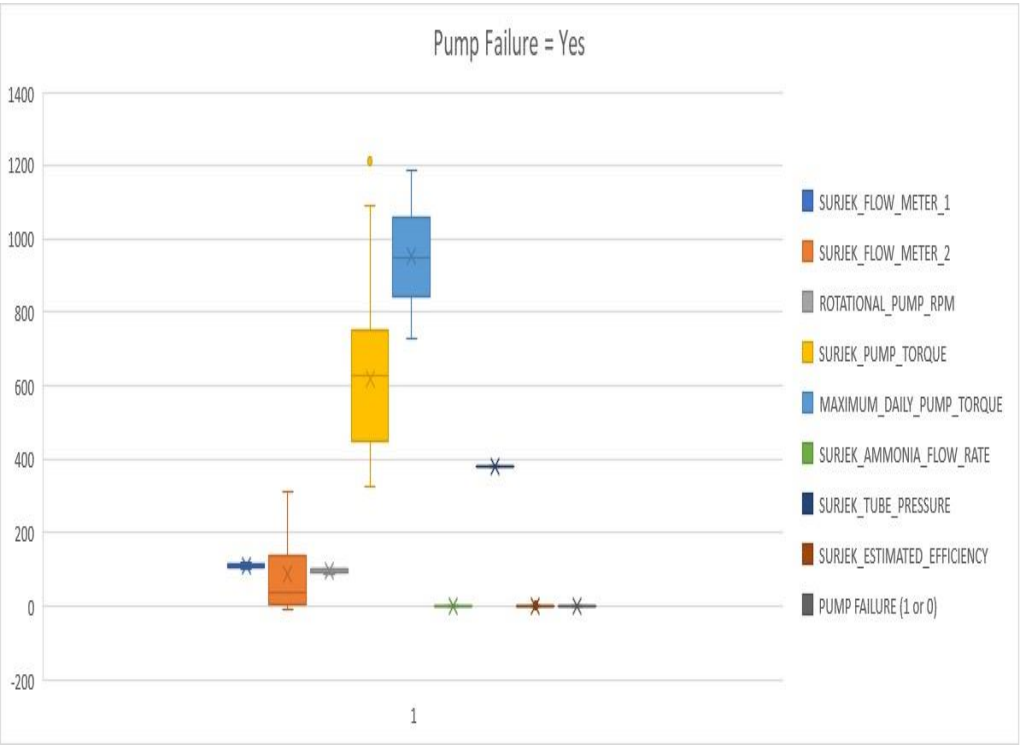
Going forward, using inferential statistics (correlation and regression analysis) we were able to come up with a prototype multivariate linear equation that can be used to describe what variables are closely related to pump failure and predict failure mode scenarios.

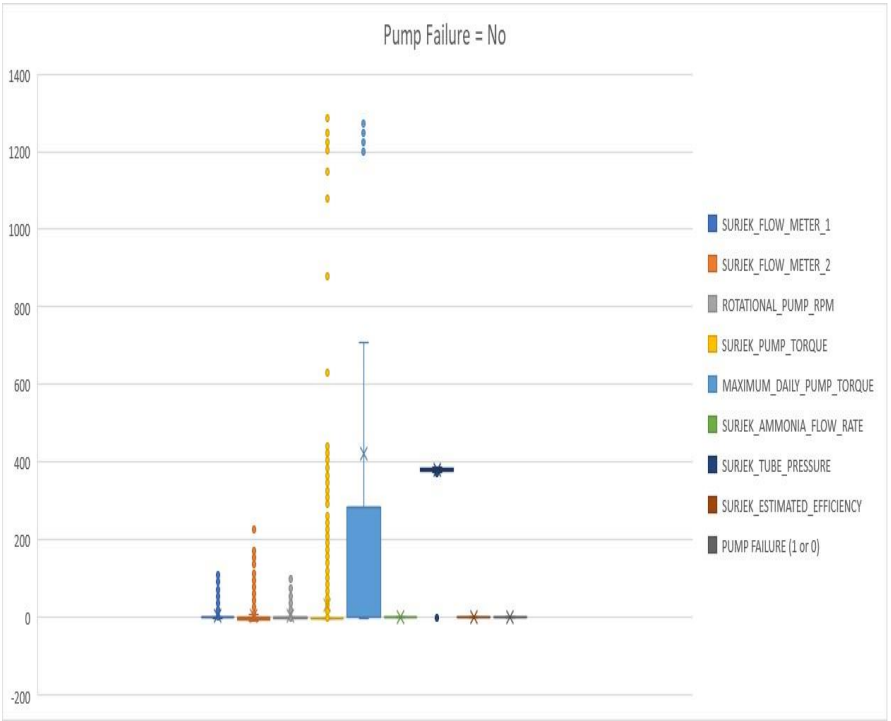


Comments:

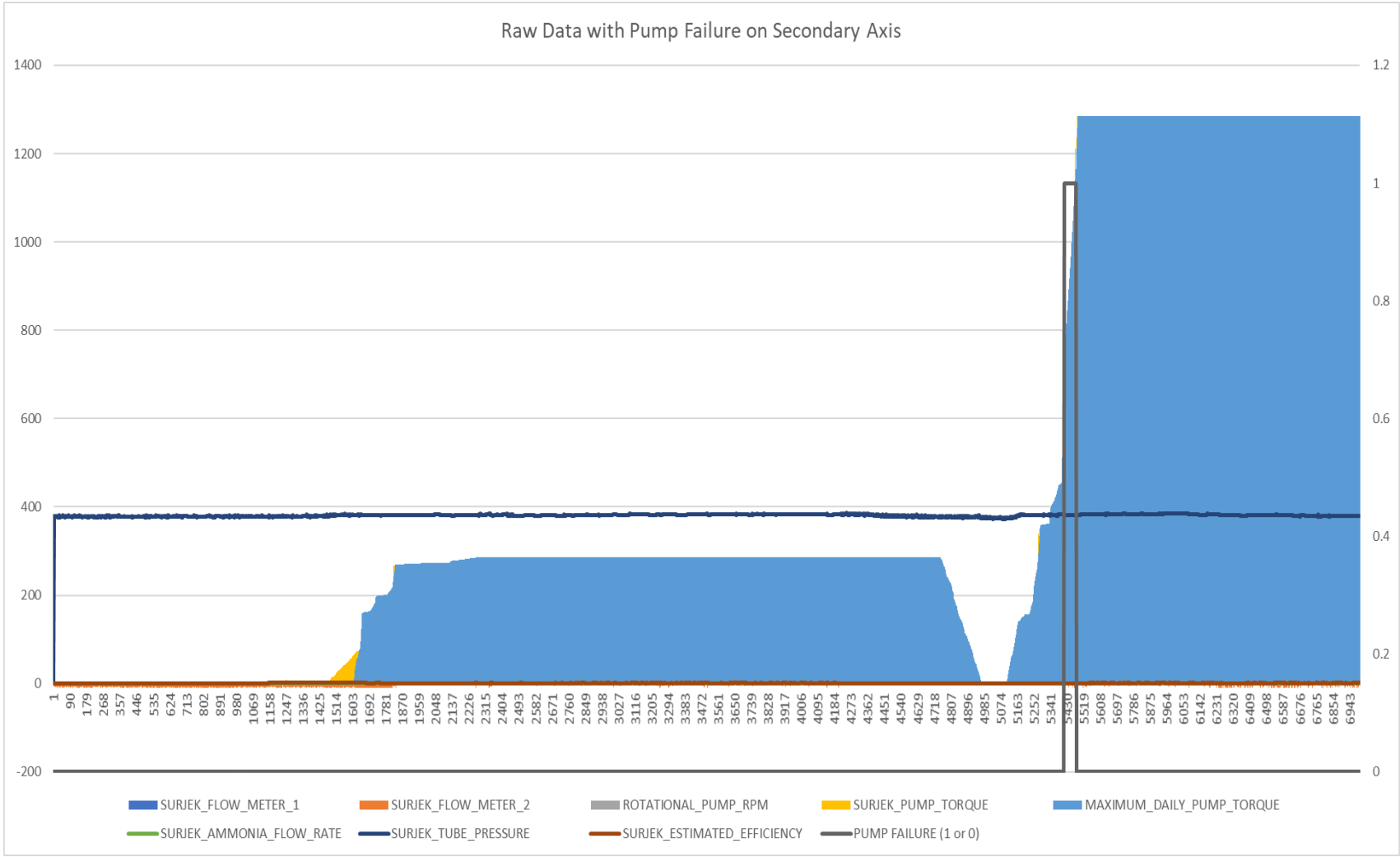
All Variables – Max daily pump torque and Surjek pump torque seems to stand out with highest data spreads

Pump Failure mode =Yes/No - Max daily pump torque and Surjek pump torque are still the ones moving significantly with the pump failure mode.



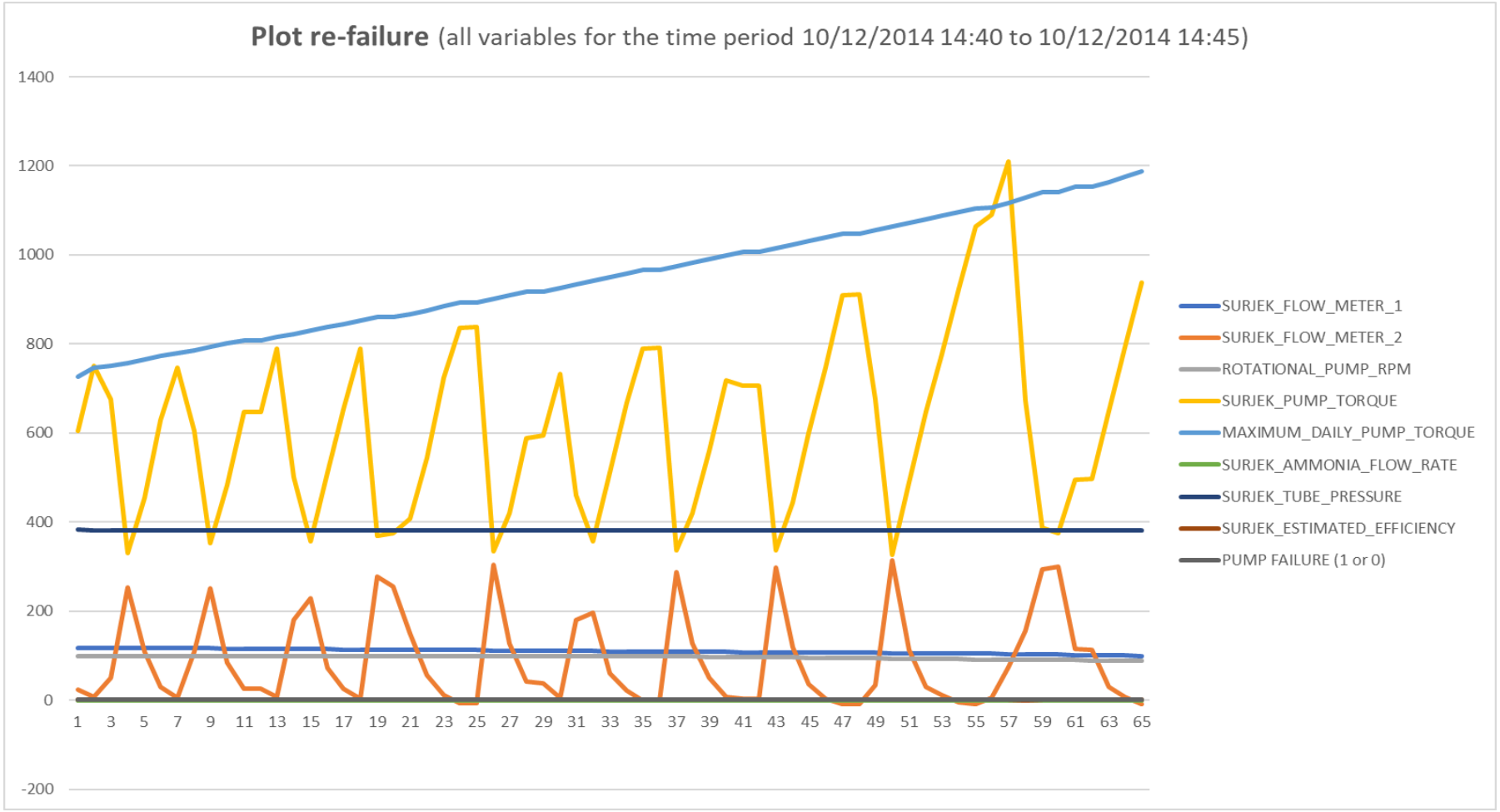


Correlation/Causation- It's safe to conclude that there's a correlation between max_daily_pump_torque and Surjek_Pump_Torque with respect to pump failures but this does not necessarily depict causation.



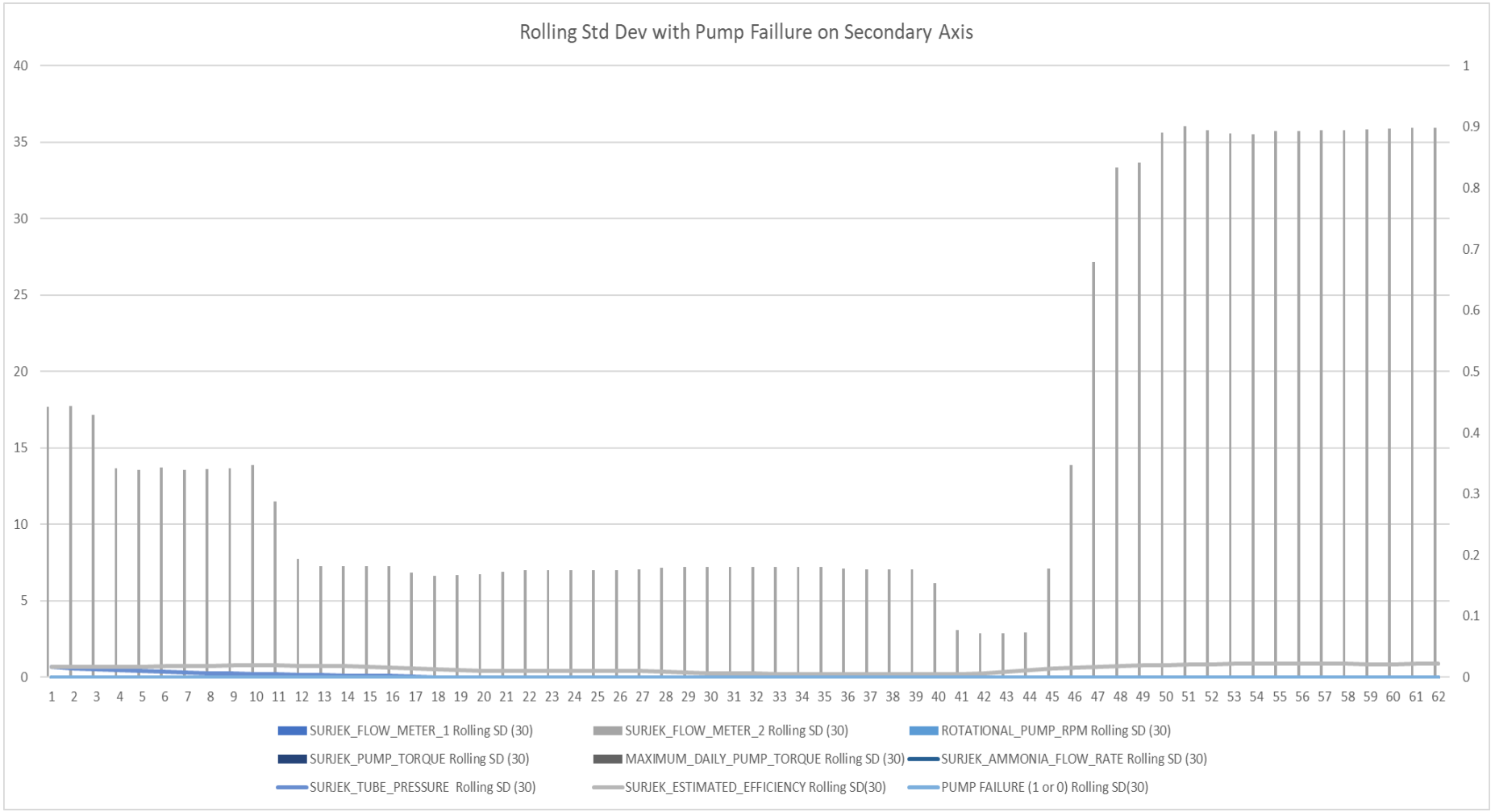
Comments:

'Max daily pump torque' stands out as a major determinant of pump failure (blue region) and a little bit of surjek pump torque (yellow region)



Comments:

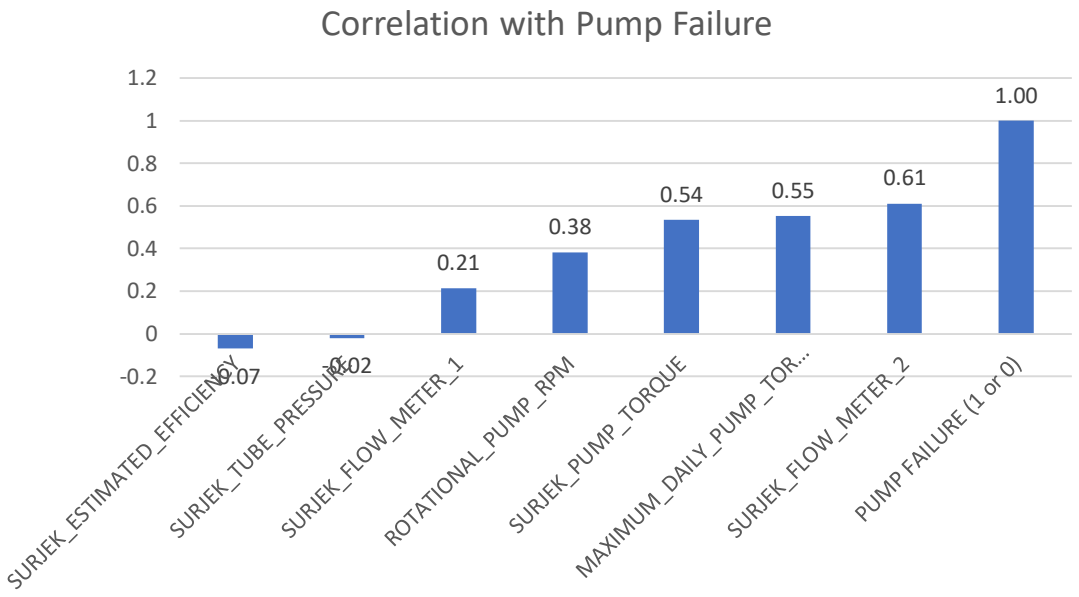
Only 'Max daily pump torque' seem to move slightly with the pump failure when we zoom in on pump failure mode while Surjek Pump torque has the maximum variation.



Comments:

Only 'Surjek Flow Meter 2' stands out this time when zoomed in for time period 12/10/2014 14:40 to 12/10/2014 14:45. Bu there is no pump failure here.

Correlation and Regression Analysis



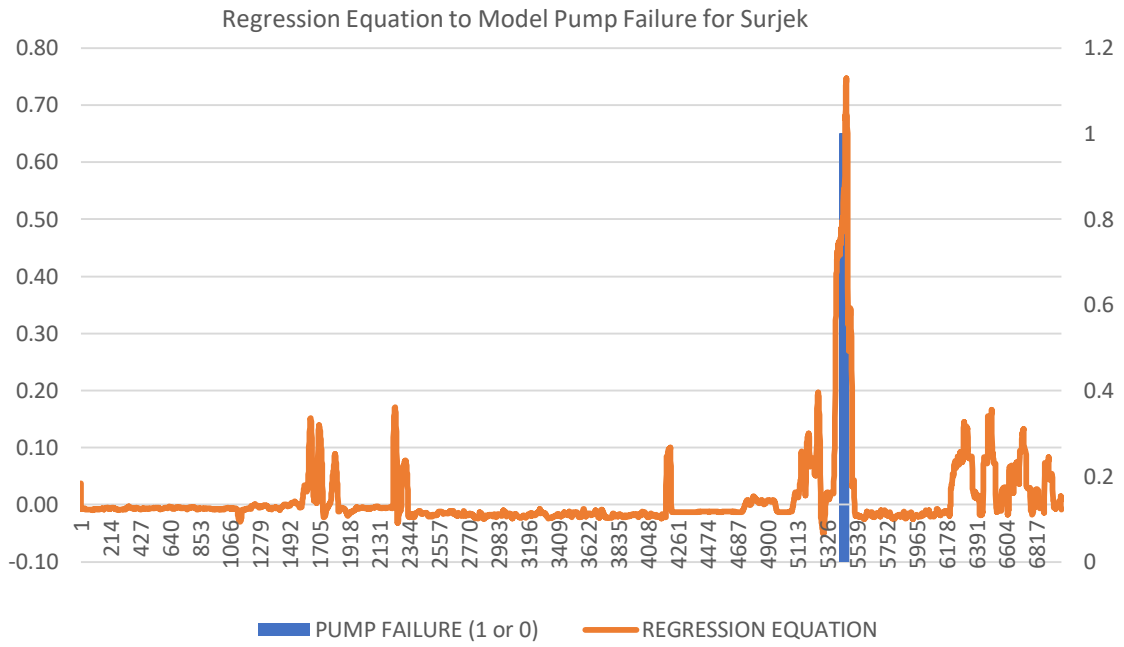
Correlation > 0.5 is very significant

SURJEK_ESTIMATED_EFFICIENCY	-0.06984408
SURJEK_TUBE_PRESSURE	-0.02052327
SURJEK_FLOW_METER_1	0.21342086
ROTATIONAL_PUMP_RPM	0.382259028
SURJEK_PUMP_TORQUE	0.53529471
MAXIMUM_DAILY_PUMP_TORQUE	0.553287393
SURJEK_FLOW_METER_2	0.611275356
PUMP FAILURE (1 or 0)	1
SURJEK_AMMONIA_FLOW_RATE	#DIV/0!

Correlation Matrix

	SURJEK_FLOW_METER_1	*SURJEK_FLOW_METER_2*	*ROTATIONAL_PUMP_RPM*	*SURJEK_PUMP_TORQUE*	*MAXIMUM_DAILY_PUMP_TORQUE*	*SURJEK_AMMONIA_FLOW_RATE*	*SURJEK_TUBE_PRESSURE*	*SURJEK_ESTIMATED_EFFICIENCY*	*PUMP FAILURE (1 or 0)*
SURJEK_FLOW_METER_1	1								
SURJEK_FLOW_METER_2	0.092376911	1							
ROTATIONAL_PUMP_RPM	0.247884943	0.15905218	1						
SURJEK_PUMP_TORQUE	0.586672049	0.405336665	0.411534798	1					
MAXIMUM_DAILY_PUMP_TORQUE	0.154925109	0.516477227	0.295968285	0.458389364	1				
SURJEK_AMMONIA_FLOW_RATE	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	#DIV/0!	1			
SURJEK_TUBE_PRESSURE	-0.008312236	-0.069016452	-0.014058326	-0.02662968	-0.006651472	#DIV/0!	1		
SURJEK_ESTIMATED_EFFICIENCY	-0.101375313	0.101283675	-0.01110262	-0.061754828	-0.185131261	#DIV/0!	-0.15220936	1	
PUMP FAILURE (1 or 0)	0.21342086	0.611275356	0.382259028	0.53529471	0.553287393	#DIV/0!	-0.020523274	-0.069844078	1

Regression Equation to Model Pump Failure



Summary Statistics of Correlation and Regression Analysis

	Coefficients
Intercept	-0.013022
SURJEK_FLOW_METER_1	-0.001472
SURJEK_FLOW_METER_2	0.0028563
ROTATIONAL_PUMP_RPM	0.0046253
SURJEK_PUMP_TORQUE	0.0005505
MAXIMUM_DAILY_PUMP_TORQUE	0.001635
SURJEK_AMMONIA_FLOW_RATE	0
SURJEK_TUBE_PRESSURE	0.0004774
SURJEK_ESTIMATED_EFFICIENCY	-0.019583

Multivariate Regression Equation to Model Pump Failure

Y (Pump Failure) = -0.002(SURJEK_FLOW_METER_1)+ 0.003 (SURJEK_FLOW_METER_2) +0.005(ROTATIONAL_PUMP_RPM) +0.001(SURJEK_PUMP_TORQUE) + 0.002(MAXIMUM_DAILY_PUMP_TORQUE) +0.001(SURJEK_TUBE_PRESSURE) - 0.020(SURJEK_ESTIMATED_EFFICIENCY) - 0.013

In summary our overall analysis reveals that SW Corp need to pay particular attention to the following variables which are strongly correlated with pump failure:

SURJEK_PUMP_TORQUE

MAXIMUM_DAILY_PUMP_TORQUE and

SURJEK_FLOW_METER_2