OPTIMIZATION OF PROCESS VARIABLES FOR MAXIMIZING PRODUCTION EFFICIENCY FOR A GLOBAL INDUSTRIAL GAS MANUFACTURER

AILABS Academy

PROBLEM STATEMENT

- Automatic production volume estimation using level meter
- Determination of optimum value of process variables for maximum production utilizing minimum power

SOLUTION SUMMARY

Pain Points	Current Action	Our Solution
• High cost associated with power. (INR 2 crore monthly bill)	Manual adjustment of process variable using Engineer's expertise.	• By applying Data Analytics, we have shown that a maximum 6.51% power saving can be achieved. (About INR 12 lakhs / month saving)
• Manual volume measurement of LOX, LIN production. (prone to errors)	Manual calculation of LOX, LIN production during decantation.	• We have developed a system for automatic production measurement from level meter readings.

SOLUTION APPROACH

Our solution involves three different phases:

Phase I: Arriving at Production Estimation

Production volume is estimated from level meter readings

Phase II : Clustering of Production Mixture

Clustering of production mixture

Phase III : Optimum Configuration of Process Variables for Minimum Spezi

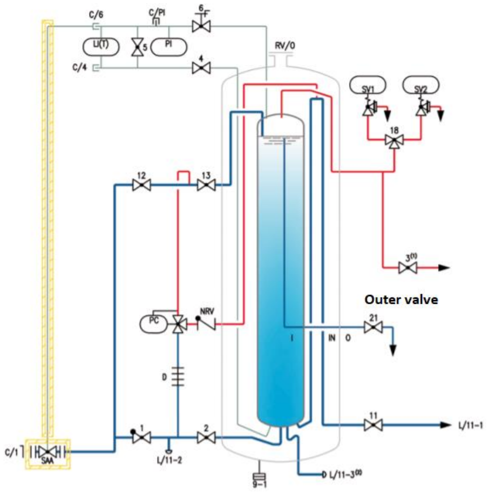
Cluster-wise determination of optimum value of process variables for maximum production utilizing minimum power

DATA CHALLENGES

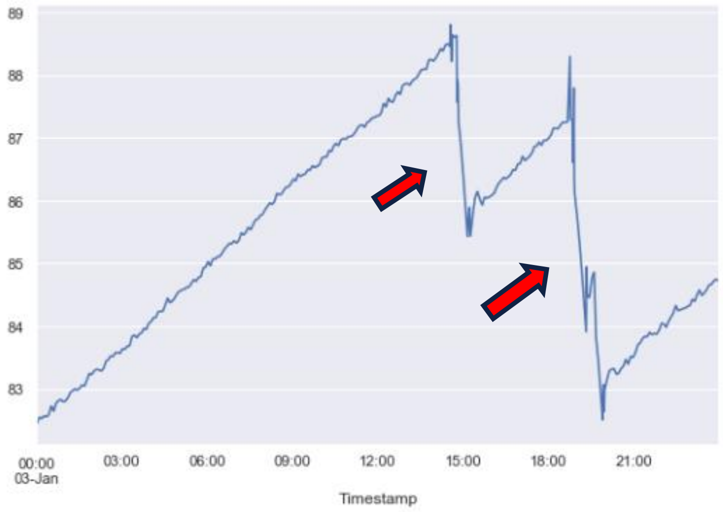
Challenges	Our approach
• Different frequency of datasets	Made calculations at 15 minute frequency as a production efficiency metric has to be computed using power and production
• Lots of 'BAD' values of several process variables	As 'BAD' values occur when data is not captured by sensors, we treat them as missing values and fill/discard them as needed
• Negative values and very high positive values for level difference readings	Replaced with mean of last 60 minutes

CURRENT CHALLENGES IN PRODUCTION ESTIMATION

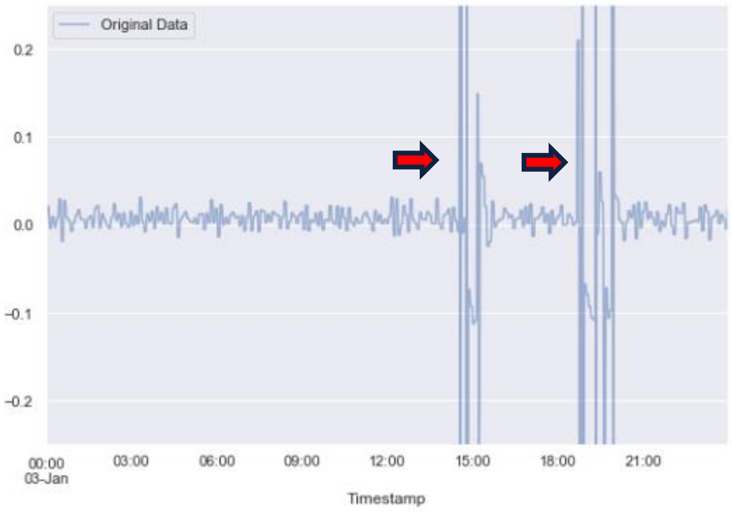
- Level meter is attached with a tank which has two valves, one for in flux and other for out flux.
- This makes production estimation challenging as plant engineer has to manually record decantation times to get an accurate measure of production.



Level meter reading



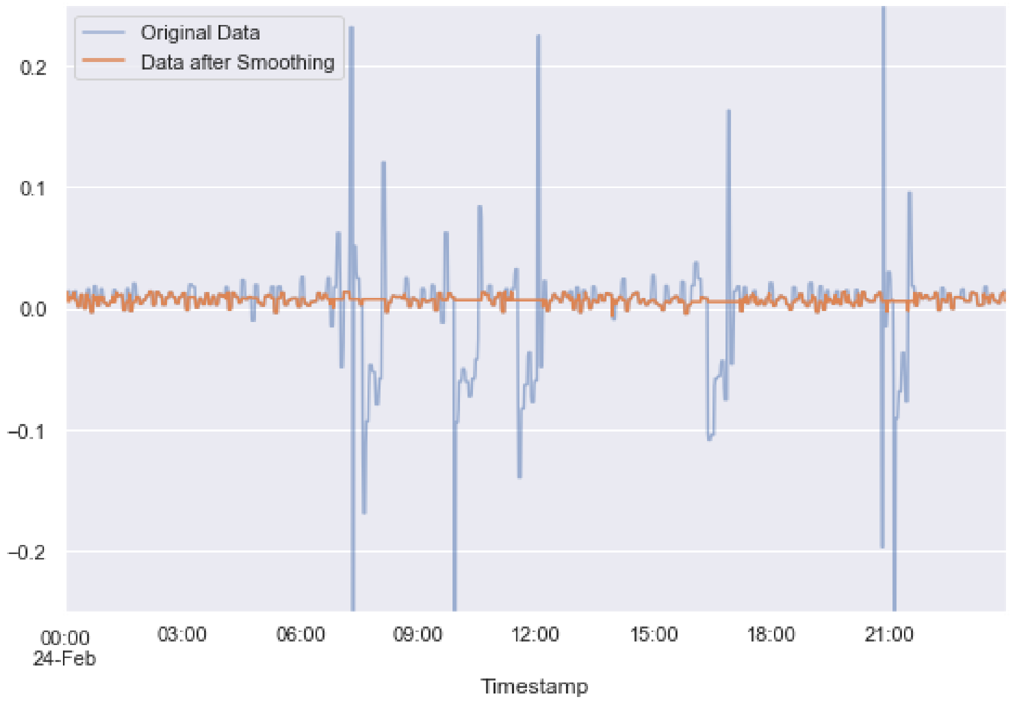
Level difference reading



➡ Sudden change due to Decantation

OVERCOMING CHALLENGE USING SMOOTHING ALGORITHM

- Need to smooth out the spikes in level difference to take into account the production during decantation
- Smoothing algorithm sharply reduces the spikes
- Helps us to determine production from level differences directly
- Removes the need for manual recording of decantation times for estimating production



DETERMINATION OF PRODUCTION VOLUME

- Production is estimated for LOX, LIN from level meter readings as follows:

$$production = \sum level\ difference\ \times const$$

where the sum is over required frequency

- Production is estimated for GAN from flow meter readings as follows:

$$production = \sum flow\ rate \times time \times const$$

where the sum is over required frequency

* LOX-Liquid Oxygen, LIN-Liquid Nitrogen, GAN-Gaseous Nitrogen

PRODUCTION EFFICIENCY METRIC

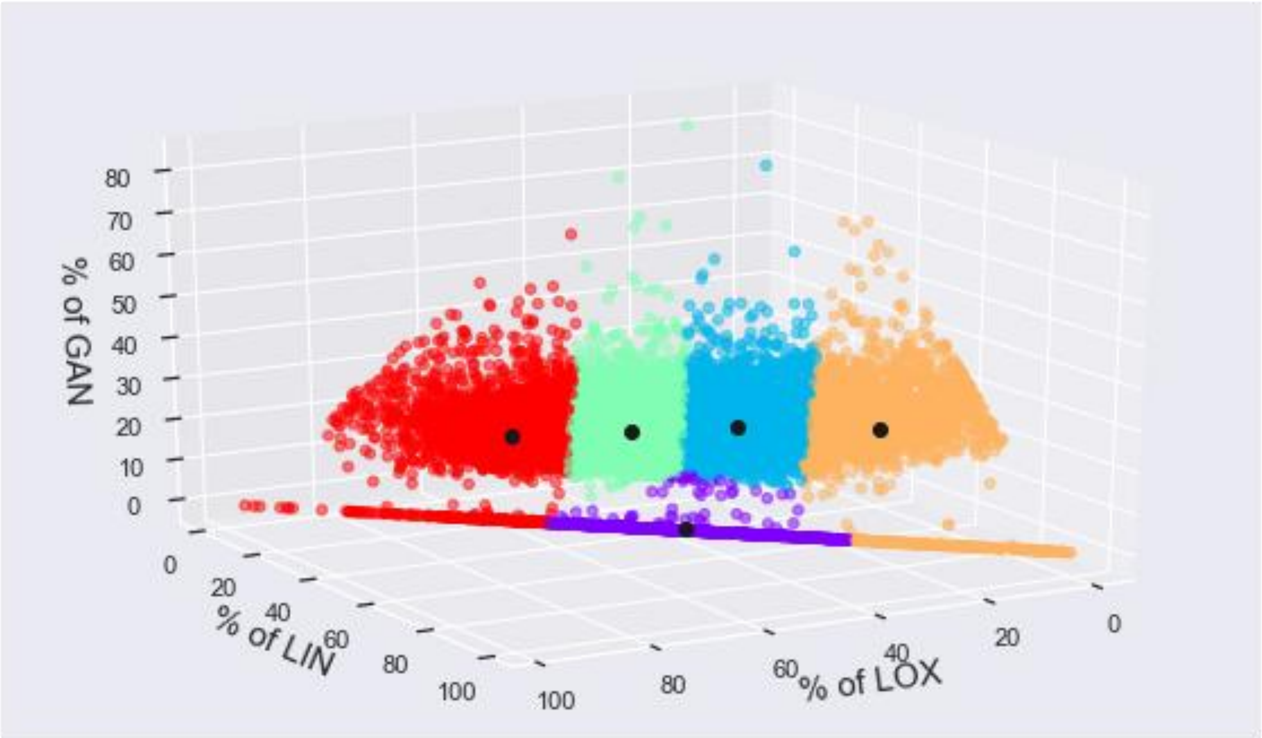
- Production estimation is then used to compute power density, the client metric for production efficiency

$$Power\ Density = \frac{power_{input}}{\sum production}$$

- Minimizing power density leads to maximum production volume utilizing minimum power

CLUSTERING OF PRODUCTION MIXTURE

- Clustering of production mix is needed to identify different modes of production
- **K-Means Clustering** was used to cluster production mixture
- **Elbow method** was used to determine optimum number of clusters
- Cluster centroids represent the different modes of clustering



OPTIMUM CONFIGURATION OF PROCESS VARIABLES

- Once clusters are obtained, optimum configuration of process variables has to be determined

- For each cluster

  - Identify the timestamp with minimum power density
  - Extract the process variables data for the timestamp

RESULTS: COMPARISON WITH PLANT PRODUCTION CALCULATION

Daily Production	RMS Error
LOX	0.1776
LIN	0.2948
GAN	0.0063

RESULTS: OPTIMUM PROCESS VARIABLE VALUES

Optimum values of 7/227 process variables

Cluster	0	1	2	3	4
Spezi	0.534914806	0.782935888	0.716549952	0.879436758	0.500385771
Power	1122.51	1074.98	1149.03	1099.27	1152.03
AI141-4.PV	0.21573177	0.21735625	0.062159315	0.209731072	0.073316589
AI30-4.PV	0.0818711	0.099571295	0.089999914	0.11961773	0.666256845
AI30-8.PV	0.051268339	0.014723748	0.073375531	0.026855469	0.065918922
FI45-22.PV	-0.008789063	0.002194576	-0.0078125	-0.004882813	-0.013366692
LC49-4.PV	0.09765476	0	0.072485782	0.146484375	0.183105469
PC401-1.PV	-0.005615234	-0.049560547	-0.019287109	-0.005077446	0.030517578
PI16B-14.PV	5.494772911	0.01953125	5.456542969	0.012207031	0.007324219

RESULTS: TESTING WITH 2020 DATA

- Client provided us with data up to mid-June 2020
- AILABS provided client with daily production estimations
- Production modes determined by clustering successfully captured production modes during lockdown period also
- AILABS provided client with optimum configuration for production for each production mode


THANK YOU