LATENT VARIABLE MODELS OF AN INDUSTRIAL ATMOSPHERIC DISTILLATION TOWER

Student: *Hamzah Al-Shawarghi* **Sponsor:** *McMaster University and British Petroleum* **Supervisor:** *Dr. V. Mahalec*

McMaster University ENGINEERING

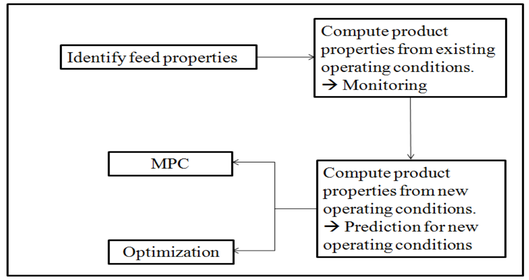
Project Goals: 1) Impacts of varying stages on separation 2) Build feed's and products' predictive models

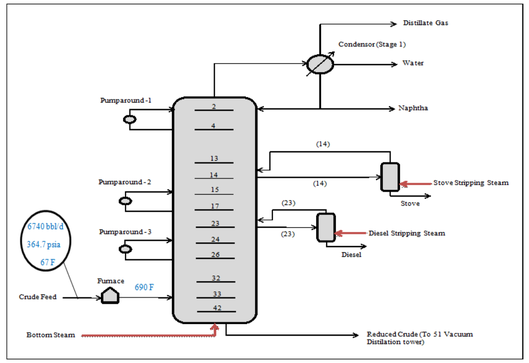
Requirements:

Goal: Develop linear models of an atmospheric distillation tower for inferential prediction of feed and products qualities, optimization of the operations, and production planning and scheduling.

Objective 1: Determine the impacts of the number of stages on the separation of the crude oil.

Objective 2: Develop predictive models that are capable of predicting the feed and products TBP Curves for the tower.





Engineering Basis:

- *Understanding of the design and operations of atmospheric distillation tower*
- *Understanding crude oil characterization and properties*
- *Ability to use simulations software such as Aspen and Hysys*
- *Understanding of latent variable methods such as principal component analysis (PCA) and partial least squares (PLS)*

Testing / Implementation:

- *The comparison of the PLS models to the rigorous models with additional test runs revealed that the PLS models predictions are in close proximity to the rigorous model.*

An example of a PLS model built to predict the products' qualities:

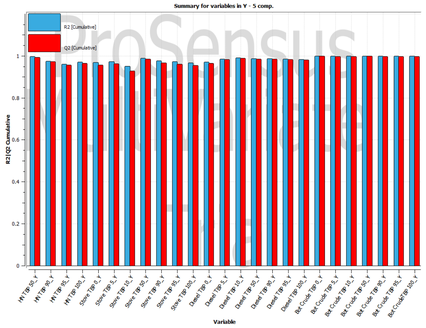
X-Variables: *Six available trays' temperatures and internal reflux ratios (IRR)*

Variables:

1) *Naphtha TBP % (50, 90, 95, 100)*
2) *Stove TBP % (0, 5, 10, 50, 90, 95, 100)*
3) *Diesel TBP % (0, 5, 10, 50, 90, 95, 100)*
4) *Bottoms TBP % (0, 5, 10, 50, 90, 95, 100)*

Results:

The PLS model has 5 components with R^2 = 98 % and Q^2 = 98 %



	Naphtha			Stove			Stove		
Test Run	Pred 95 %	Aspen 95 %	% Error	Pred 5 %	Aspen 5 %	% Error	Pred 95 %	Aspen 95 %	% Error
Run1	361.200	359.900	0.361	307.986	305.200	0.913	525.502	522.600	0.555
Run2	362.074	361.400	0.187	304.307	298.500	1.908	525.741	525.800	-0.011
Run3	361.403	361.400	0.001	310.578	320.500	-3.096	527.631	535.800	-1.525
Run4	361.339	361.400	-0.017	313.302	332.100	-5.660	526.157	525.700	0.087
Run5	361.212	361.396	-0.051	307.375	308.567	-0.386	525.527	545.771	-3.709
Run6	361.325	361.396	-0.020	307.625	313.786	-1.963	525.704	505.771	3.941
Run7	361.423	361.396	0.008	307.843	328.794	-6.372	525.858	525.776	0.016
Run8	361.130	361.396	-0.074	307.191	290.904	5.599	525.397	525.764	-0.070
Run9	361.210	361.395	-0.051	307.370	296.201	3.771	525.524	555.774	-5.443
Run10	361.292	361.399	-0.030	307.552	320.816	-4.135	525.652	505.765	3.932