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Distributional Considerations in Inference based Condition Monitoring Stages: Detection, Diagnosis, Prognosis.

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Abstract

The major focus of **condition monitoring (CM)** is in its' prognostic and fault prediction abilities, the power of which is determined by selecting appropriate analytical techniques. Making the correct distributional and theoretical assumptions is the key to model robustness and strength of inference. Likewise a condition based rather than time interval based maintenance regime ensures near optimal performance for the duration of process operation,

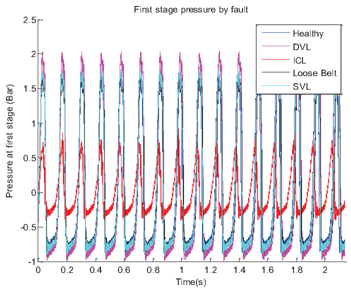


Figure 1 Variable profiling, first stage pressure measurements by fault (load 100).

1. Detection

Identifying faults or deviant behaviour through variable profiling.
Figures 1 and 2 show ICL to exhibit very different characteristics to the other fault cases..

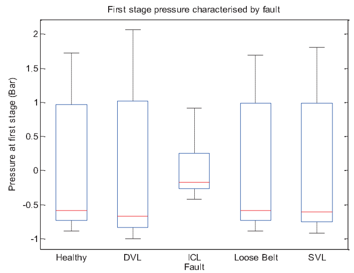


Figure 2 Distributional characteristics of first stage pressure measurements by fault (load 100).

Distributions exhibiting severe negative skew may be represented by the **Beta** distribution with suitable shape parameters p and q and upper and lower data bounds a and b or by **Extreme Value Distributions**.

Positively skewed: Lognormal, Gamma or Weibull distributions; Exponential in extreme cases exhibiting positive outliers only.

2. Diagnosis.

Having detected a deviation from the norm during operation accurate diagnosis of the source is critical. The more timely and precise the diagnosis of a fault, the greater the opportunity for planned maintenance potentially reducing the impact of disruption due to need for emergency intervention.

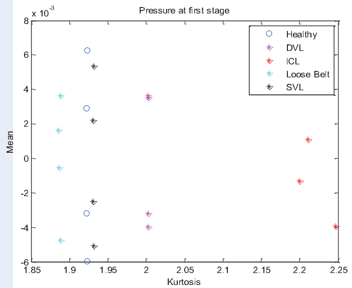
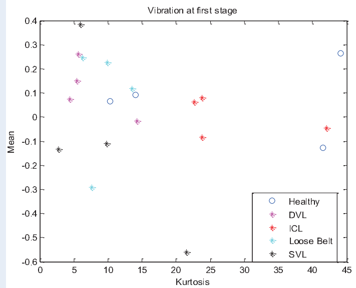


Figure 3 Scatter plot to show the Mean and Kurtosis of first stage pressure per number segment., load 100

Kurtosis	Fault
< 1.9	Loose belt
2.0±0.1	DVL
> 2.2	ICL
1.9-1.9270 *	Healthy
1.9270-1.95	SVL

* mid-point of healthy and SVL means.



No obvious clustering by either summary statistic or combination .

Figure 4 Scatter plot of mean and kurtosis for the first stage vibration measurements per number segment with load 100

3. Prognosis

The ultimate skill of the condition monitoring process is the ability to make evidence based predictions of future behaviour based on current and past performance. Multivariate statistical analyses of historical data through monitoring deviations from expected or normal operating conditions or target values is utilised in the construction and assessment of prognostic modelling.

Data distributions.

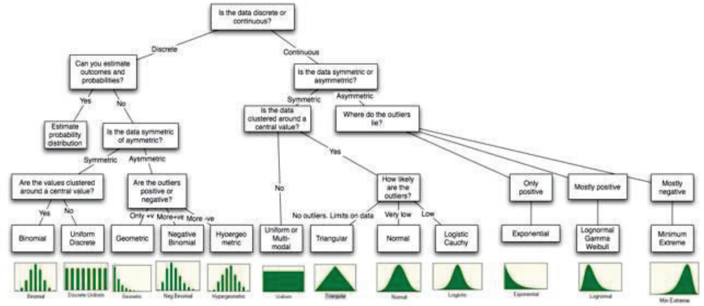


Figure 5 Typical data distributions in theory allow use of just a few parameters to model data.
Source:
http://pages.stern.nyu.edu/~adamodar/New_Home_Page/StatFile/statdistns.htm on 13-09-2013.

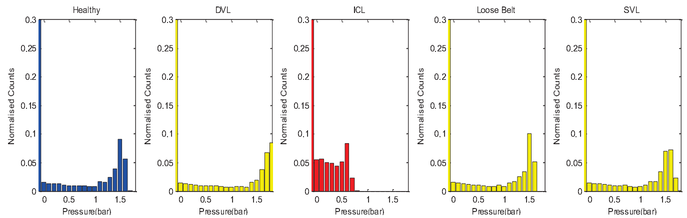


Fig.6 In reality data distributions are complex and require more detailed exploratory investigations to establish suitable models.

Summary and future work.

Whilst partitioning the data by number segment and clustering segment means and kurtosis proved effective in determining an elementary rule for assigning to fault case through examining the first stage pressure measurements this was ineffective in the case of the vibration methods and would not be robust should a sequence of faults develop. On the other hand clustering algorithms based on the raw data would, if computationally possible, put too great a burden on resources.
Future work is to focus on identifying the distributional characteristics of the data , estimation of distribution parameters (location, scale and shape), multivariate modelling and subsequent sensitivity analysis.

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