

Improve reliability using Hotelling T^2 technique in a liquefied natural gas plant

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Abstract : *A method for improve the reliability in a gas liquefied plant using Hotelling T^2 is showed in this paper. The stationery work in this manufacture facilities during a few moths in a year involve a heavy duty service of gas diesel engines and ammonia gas plant for processing the methane gas and extract the condensate fluid of it. Then, a predictive maintenance plan is necessary to prevent a possible malfunction or shut down of the plant and avoid an operational cost increased.*

We are just sampling the signals from the plant when its working in optimal condition and then we will compare the next incoming data from the machinery versus the previous historical data set. An statistical process control algorithm Hotelling T^2 based for monitoring the condition of gas engines and ammonia gas plant will be implemented.

Keywords: *Gas Plant Process Control, Historical Data Set, Hotelling T^2 method ,Predictive Maintenance.*

INTRODUCTION

An in-control set of process data is a necessity in a multivariate control procedures. In this case a collection of 26 variables from the liquefied gas plant was recorded in order to establishment a predictive maintenance plan . The temperatures from natural gas spark engine motor, multiplier gear box and ammonia refrigeration gas plant pressures and temperatures was sampled 4 times each 1 hour.

Such a data set, often labeled historical, baseline, or reference, provides the basis for establishing the initial control limits and estimating any unknown parameters. However, the construction of a multivariate HDS is complicated and involves problem areas that not occur in a univariate situation (such as isolated diesel engine or general purpose machinery).

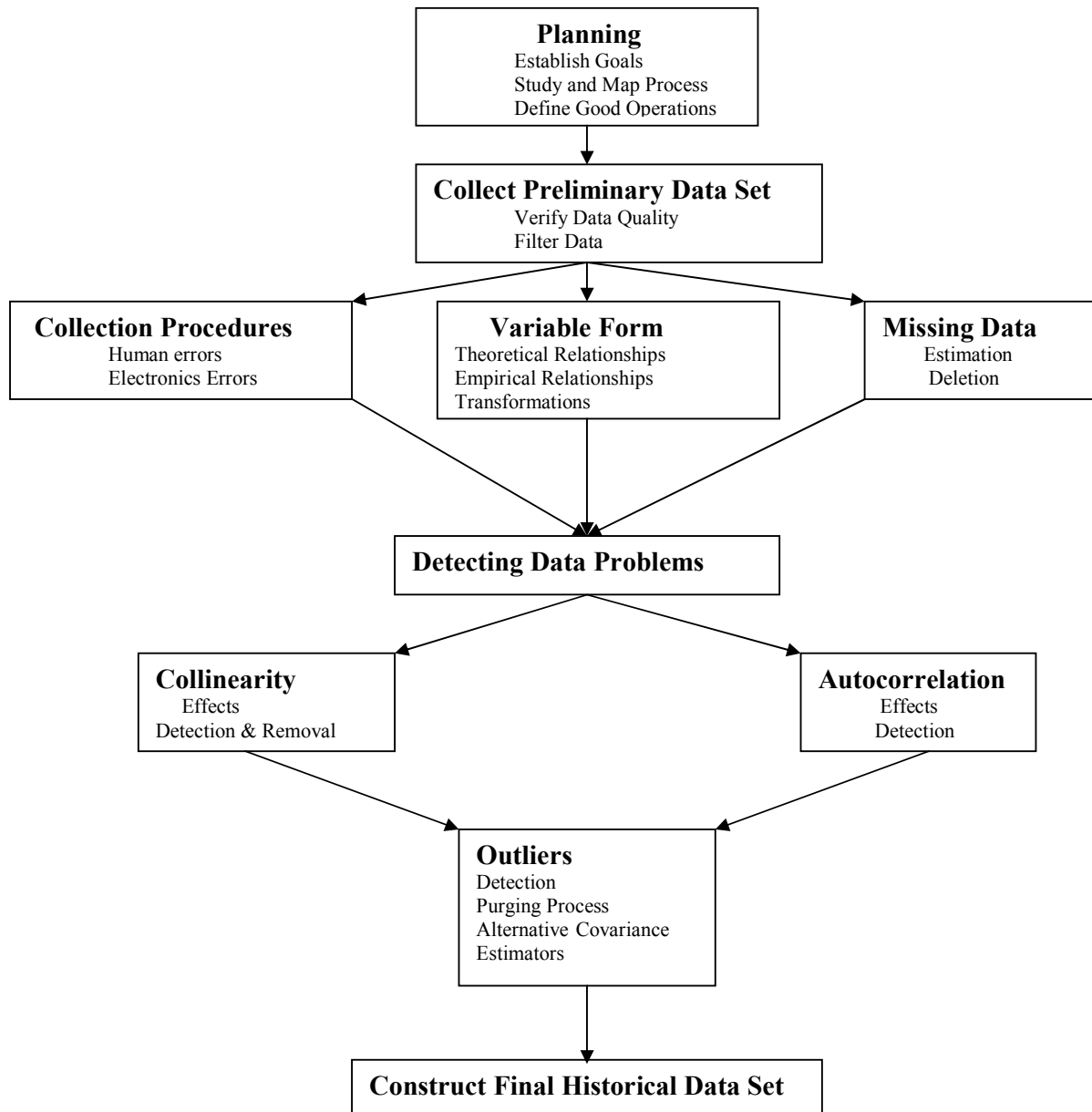
We development of the HDS is referred to as a Phase I operation. We are using it as a baseline to determine if new observations conform to its structure is termed a Phase II operation. The parameters estimates are used to construct a preliminary control procedures whose major porpoise is to purge the original data set of any observations that do not conform to the structure of the HDS. The nonconforming or atypical observations are label outliers. After the outliers are removed from the preliminary data set, new estimates of the parameters are obtained and the purging process is repeated . This is done as many

times as necessary to obtain a homogeneous data set as defined by the control procedure. After all outliers are removed, the remaining data is referred to as the HDS.

MATERIAL AND METHODS

The variables analyzed were the follow: the 12 cylinder exhaust gas temperatures (left side and right side) from a spark gas engine, the six temperatures of multiplier gear-box lube oil; fit it between the engine and gas compressor and pressures a temperatures from the ammonia refrigeration plant. The rpm of the natural gas compressor was monitored also. It was taken 100 samples of them All devices are at the REPSOL GAS & OIL CO. facilities in Bermeo-Bizkaia-Spain and they are used for management the liquefied natural gas from the deep hole which it is stored to process plant for cleaning and condensating.

Firstly, we constructed the HDS using the guidelines showed below



“Fig. 1”

A correlation analysis and control X-bar, R Chart were used for detecting both correlations and outliers.

HDS for the first 6 variables and 20 samples is showed in (table 1):

Pos	TI-1964 °C	TI-1966 °C	TI-1968 °C	TI-1970 °C	TI-1972 °C	TI-1974 °C
0						
1	559,22	552,6	541,76	528,34	514,39	485,86
2	557,26	552,8	541,76	527,96	514,39	485,48
3	559,98	554,56	541,55	528,54	514,78	487,41
4	560,95	554,15	542,31	529,51	514,98	489,35
5	559,6	553,77	541,55	528,75	514,78	485,86
6	557,46	553,01	541,35	527,58	513,63	484,31
7	557,08	552,8	541,17	527,58	514,39	488,38
8	558,25	553,39	540,59	528,16	514,6	484,69
9	556,11	554,56	541,17	528,75	514,6	486,45
10	557,84	553,59	541,76	527,58	514,6	488,38
11	559,39	553,39	542,31	528,54	514,78	487,21
12	554,94	553,59	541,17	528,54	514,98	486,06
13	553,01	552,42	541,35	528,34	514,39	481,96
14	557,46	553,39	541,76	527,96	515,19	485,65
15	553,97	552,8	541,93	528,54	514,6	487,21
16	559,22	553,39	543,11	528,93	514,78	485,48
17	559,8	554,15	541,93	528,34	512,08	487,21
18	557,84	553,39	542,52	528,54	512,08	484,31
19	559,39	553,59	542,31	527,58	513,43	487,41
20	559,98	553,59	543,11	528,93	515,95	488,58

Table 1

Considering to be this process a continuous steady-state process where the observation vector are independent and the parameters of the underlying normal distribution are unknown and must be estimated. We assume the process is being monitored by observing a array of 32 new samples of liquefied gas plant parameters $X' = (x_1, x_2, \dots, x_p)$, on p variables at each time point. The T^2

Hotelling's value associated with X is given by: $T^2 = (X - \bar{X})' \times S' \times (X - \bar{X})$; where the common estimates \bar{X} and S are obtained from the HDS. Here, the T^2 statistic follows the F distribution. For a given $\alpha = 0,05$, the UCL is computed as:

$$UCL = \left(\frac{p \times (n+1)(n-1)}{n(n-p)} \right)_{F(\alpha; p, n-p)},$$

where n is the size of the HDS and $F(\alpha; p, n-p)$ is the α th

quantile of $F(\alpha; p, n-p)$.

CONCLUSION

Signal interpretation requires a procedure for isolating the contribution of each variable and/or a particular group of variables. As with univariate control, out of control situations can be attributed to individual variables being outside their allowable operational range

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