Chapter 10

Summary, Discussion and Outlook

10.1 Summary

During this thesis, a test for the detection of steps on the mean value of a process has been developed and it has been applied to an industrial-scale's output reading in order to implement a counting scale.

The first step was the statistical analysis of the measurements provided by the scale. This analysis made us refuse the hypothesis of a Gaussian distribution, so an empirical approach to the real PDF has been developed that enables the probabilities and delay times calculations needed for the test design. Two different adjusting methods have been tried to perform the PDF approach. Finally, the use of Spline curves has been chosen among them due to the liberty they offer to free set bound conditions and due to fact that they are much easier to evaluate.

After that, an statistical test for the sample mean has been chosen among some short-listed options. Control limits related to the variance of the process had to be set to ensure an specific significance level depending on the sample size used to calculate the sample mean. The optimal sample size and control limits have been calculated to minimize the maximal expected delay-time of the response.

Due to the huge range of values the variance of the process can take, the test was found not to behave properly, so a self-adaptive test has been developed that on-line estimates the current variance of the process and automatically adapts its parameters for an optimal accomplishment of the counting. Later, a variation called *double-queue algorithm* has been introduced to improve the estimation of the variance in the case of induced ground vibrations.

All versions of the test have been tried over real data and results have been graphically shown.

10.2 Discussion

Depending on the application for which they are designed, counting scales may implement many different characteristics and abilities like: different-weight-units counting, low or high maximal number of units, detection and correction of

impulsive-disturbances, intelligent correction of the expected unitary weight or alarm function for detection of defective pieces. Each characteristic determines some aspects of the algorithm to be used.

After the last modification (the double-queue algorithm), the definitive test proposed in this thesis can be defined as a *self-adaptive statistical-control test applied to the sample mean with low-pass-filtered on-line estimation of the mean and the variance and with use of a double-queue algorithm for the variance estimation under ground vibrations*. This is a long definition describing some specific features selected and joined in an unique algorithm for the specific problem we are facing.

Results have proved the suitability of the test and its ability to carry out the proposed task in different specified conditions with the required accuracy. However, some other features should be added as well to improve the behavior of the test in unexpected conditions (presence of defective units, small changes on the expected unitary weight, impulsive disturbances...). Besides, even for the same case as here, some other algorithms can also be used to perform the counting. For example, as it has been said, a multi-level Hinkley detector has been tried in the same scale in the HTWG Konstanz with some success. Thus, some different algorithms should be tried and compared in different conditions in order to improve their behavior by combining the best features of each one. Next section includes some propositions for a further research.

In conclusion, this thesis presents a first partial solution for a wide problem that requires further studies. It must be longer tested, improved and completed by combining its features with those of other algorithms. However, and for sure, this thesis is a good start point that covers most of the most important requirements for an industrial counting scale, it can already be put to use during further research and it serves as base-algorithm for later enhanced versions.

10.3 Outlook

The study of the statistics explained in chapter 9 is proposed in this thesis for a further research. They could be used to find steps on the weight reading and it is even possible that the height of the peaks provides a reliable enough estimation of the weight increment, so the number of units fallen at the same time can be directly determined. The use of the NSE can help to correct the value of S^2 during ground vibrations. However, to ensure these options are feasible, a deeper study of both statistics is needed that includes confidence intervals and significance levels as functions of the standard deviation and sample sizes N and N_2.

Besides, these statistics are useful, as it was already said, to segment data series during the initial parameters estimation and, furthermore, to identify and possibly discard segments affected by vibrations. This would provide more accurate results in an automatic, faster and easier way not even having to worry that the process is stationary or that units are not falling into the scale.

Finally, the same proceeding can be applied to the study of the statistical distribution described in chapter 5. The first hypothesis used there can now be reviewed and data can be selected being sure that they correspond to stationary situations. By doing this, the PDF will probably have a different shape without

lateral peaks and that could possibly lead to an improvement of the test.