June 22, 2011 (Wednesday) 55th EOQ Congress

CONCURRENT SESSIONS — **Wednesday 8:30 – 12:30**
KEMPINSKI HOTEL CORVINUS — **Erzsébet tér 7-8, Budapest V.**

REGINA BALLROOM II. — Wednesday 8:30 – 10:30

19.1. QUALITY IN THE AUTOMOTIVE INDUSTRY

Session Chair: ***Balázs Németh****, Kvalikon Consulting, Hungary*

10.00 Multivariate Methods for Process/Product Development and Monitoring
László Heinold, AIB-Vincotte Hungary Ltd., Hungary
Brad Swarbrick, CAMO Software AS, Norway

Heinold, László (Hungary)

Electrical Engineer (MSc), graduated at the Technical University of Budapest, Hungary. Till 1999 as owner of Szenzor-Metrológia Ltd. he was responsible for developing quality management systems for calibration laboratories according to standard EN 45001 and the related quality management system according to ISO 9001 and he also delivered lectures in various upper grade metrological courses. In 1998 he worked at Det Norske Veritas Magyarország Ltd. as registrated quality lead auditor executing certification and periodical auditing of quality management systems according to the ISO 9001/2 standards and also audited large Hungarian firms. In the last decade he worked at T & T Quality Engineering Ltd. and Germanischer Lloyd Hungary Ltd. as public sector quality manager, lead auditor and certification unit manager. Today he is business unit manager, trainer and auditor at AIB-VINCOTTE Hungary Ltd. with the following responsibilities: implementation of quality management softwares at the software business unit; auditing, consultation and training; on-site consultancy mainly in automotive companies on data collection and evaluation systems through Statistical Process Control (SPC) with special regard to quality costs as well as measurement system analysis.

Multivariate Methods for Process/Product Development and Monitoring

Brad Swarbrick: Vice President Business Development, *CAMO Software AS. Nedre Vollgate 8, Oslo, Norway, 0158.*

Heinold László: Software business unit manager, *AIB-Vinçotte Hungary Kft. 1143 Budapest, Semsey Andor u. 25.*

Manufacturers worldwide are constantly seeking new ways to improve the quality of their processes and products whilst maintaining the lowest possible production costs. The two seem to be opposed to each other and as the saying goes "cheaper is not always better" Recently, the pharmaceutical industry in the USA is working under the paradigm Faster, Safer, Cheaper to produce the best healthcare products using the best processes and maintaining suitable operational costs. Does an approach or methodology exist that can lead to such benefits?

Industries such as the telecommunications and the automotive industry have taken an approach to quality improvement called lean six sigma, with Toyota being the most notable of the car manufacturers. The ability to streamline manufacturing processes and minimise cost, energy and waste represents massive benefits for any industry, however, there is an upfront effort required to attain such benefits. This effort must be focussed on collecting the right data at the right points in a process such that quality decisions are proactive rather than reactive.

Six sigma as an initiative has helped all industries that have taken this path to better understand the fundamental measurement systems they use and to monitor them in a consistent and systematic way, mainly through the use of control charts. There are, however, limitations to measuring process outputs and quality attributes on a single variable basis, i.e. they don't take into account the relationships between the single measured variables. Why is this important? Many process and quality failures are not the result of the obvious, but are related to the interaction of two or many process variables acting simultaneously that are detrimental to quality.

To better gain insights into process variable relationships, manufacturers are forced to answer the fundamental question, "why do we do it this way?" The methodology of Design of Experiments (DoE) is a key tool for both the research and applied engineer/scientist for understanding the relationship between process variable settings and quality.

Based on sound mathematical principles, DoE allows analysts to gain the maximum amount of information from their data through a minimum of exactly defined experimental routines. DoE methodology exists for understanding and optimising process and formulation/product based problems. DoE methodology can lead to faster times to market for new products with a higher assurance of product robustness and reliability.

How does it benefit industry? In many cases manufacturing processes get to the point where they can only be "tweaked" so much before any changes, no matter how well intended, will never achieve the desired level of performance. To meet this challenge, the next evolutionary step from the six sigma initiative is the Design for Six Sigma (DFSS) approach. The main aim of DFSS is to learn from the original six sigma studies and then redesign the process using DoE as the cornerstone. The Greenfield redevelopment of a process is intended not to carry the baggage of the past process to the new one, but to use the best available information and avoid the mistakes of the past.

When such initiatives are launched and the necessary changes implemented, in most cases, the collection of more data will be the result. Large data volumes can become quite daunting and the analysis of such data seemingly impossible to most engineers and analysts. Consequently, more often than not a company's most valuable source of continuous improvement – it's wealth of data – just resides in data historians in the hope that one day it will be extracted and interpreted.

This is where the field of Multivariate Data Analysis (MVA) plays such a crucial role in future manufacturing efforts relating to delivering on the faster, safer and cheaper goal. Until recently, the ability to rapidly analyse large volumes of data was limited by the unavailability of powerful computers and software tools with the capability of analysing and visualising the data. Using an oversimplified description, MVA allows viewing of complex data from a point of view that shows the greatest information contained in it, i.e. it converts large volumes of data into a pictorial view such that it is most easily interpreted. From a quality perspective, MVA allows the simultaneous monitoring of many variables and models them in such a way as to establish a pattern. The pattern of the data is established such that it is representative of a system that meets its desired capabilities. New data collected in real time is compared back to the pattern in the MVA model and if there is no difference, the process is deemed to be capable of performing its task.

MVA enjoys many industrial applications from the rapid analysis of quality in the petrochemical, pharmaceutical and agricultural sectors right through to sensory analysis of seat comfort in the automotive industry and the optimisation of welding processes for increased product durability. When used in conjunction with DoE, MVA can be used to monitor and control the process parameters deemed critical to quality and adjust them in real time using predictive modelling such that a deviation can be corrected before it becomes a problem.

This paper presents some of the fundamental principles behind the DoE and MVA approach to the improvement of process and product quality particularly in the automotive industry. Some practical examples are presented and detailed including the definition of a roadmap to using the current best practice methods DoE and MVA have to offer.

Automotive examples

In the automotive industry there are several processes DoE and MVA approach can be used. Such processes are for example injection moulding which is a rather common process regarding the plastic part of the cars, and welding which is also a very common and very crucial process with plenty of significant and crucial characteristics.

Producing a part with injection moulding technology is a process when at the same time we deal with several process parameters to yield products characterised also with several product characteristics – at least the several dimensional characteristics. These characteristics and/or process parameters although may have interactions. If we want to keep such process „in control”, traditional univariate control charts – because of the interactions - may not assure this efficiently. This is a classical application area of multivariate methods like DoE and multivariate process monitoring. In the given example we can see a welding process of an automotive supplier, which was examined and optimised with DoE methodology.

Usually DoE is used to find optimal settings with regard to quality that is to find the optimal manufacturing parameters that yield the best available quality. Nevertheless a manufacturing parameter can also be of interest with regard of cost and productivity. This can mean that it is possible to find a solution which is altogether better than the actual one. This better state can be defined as an optimum among the best quality, the lowest price and the shortest cycle time.

In this example we can see the method applied in a company which main activity is the production of welded and stamped automotive bodywork components for the automotive industry, including metal finishing and surface treatment.

The essence of the production profile is that once the sheets and rolls of steel of different qualities and a thickness of 0.50-5,00 mm are cut into the right size and shape, the cold forming, pressing, punching, calibration and further cutting of the components are performed on presses of the required output and dimensions, either by single-step or progressive technology.

The components prepared this way are then assembled and fitted with the necessary binding elements by highly skilled welders on resistance welding machines and on welding robots.
Some pieces are galvanised in the last work phase.

The optimalisation was made on a welding process with a 40 kW welding machine.

The goal of the optimalisation was to find the optimal settings with regard to quality, productivity and cost.

At the welding there were four paramater wich could be set: pressure, current, how fast the current is raised to its final setting (timing), and welding time.

The original settings of the welding were:

Pressure	*Welding current*	*Power up timing*	*Welding time*
2 – 3 bar	*47 – 49 [%]*	*3 – 8 (periods)*	*7 – 15 (periods)*

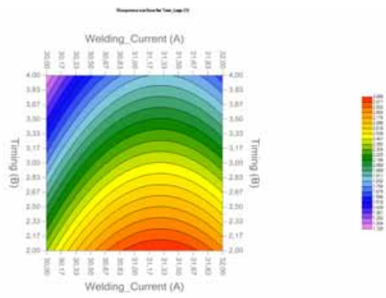
With theese old setting the quality of the welding were quite good, but the yield could be developed further.

After executing the experimental design we were looking for new settings with better welding quality, fewer current and shorter times.

The new settings were better with regard to every targeted aspects, that is quality, cost and productivity, namely: the quality of the welding became slightly better, while it were produced with lower welding current and shorter welding times.

The new settings of the welding were:

Pressure	*Welding current*	*Power up timing*	*Welding time*
4,5 bar	*31 [%]*	*3 (periods)*	*8 (periods)*



In total these mean that the cost of the current became approximately 35% lower, while the welding time became approximately 33% fewer, in such a way fulfilling the paradigm Faster, Safer, Cheaper to produce the best products using the best processes and maintaining suitable operational costs.

After this optimalisation step it is also possible to maintain the result with additional multivariate methods, like multivariate process monitoring, that is to keep the process at its best stage regarding quality, cost, and productivity.

The above example nevertheless is quite simple compared to for example injection moulding processes when our target is to keep several product characteristics in their specification limit, and – at the same time – to do it with the least cost, and maximum productivity. Multivariate methods are a very effective help for such processes – the more the challenge because of the number of parameters and characteristics – the bigger the benefits of the methods.