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APPLICATION OF STATISTICAL METHODS IN ASSESSING THE QUALITY OF WELDING

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Abstract: *Feasibility of using statistical analysis in a manufacturing enterprise. Main starting points in using statistical methods. Analysis of statistical data in ensuring the quality of welding production and increasing throughput. Data collection and classification. Essential parameters of ensuring the quality of welding; assessment methods. The most important criterion affecting throughput in a modern enterprise. Mechanization and automation of welding processes. Modernization of processes, personnel qualification, ensuring quality and production-centred the management as key words in increasing throughput.*

Keywords*: statistical methods; quality of welding; modernization of processes; personnel qualification.*

1. INTRODUCTION

By today, in many manufacturing enterprises there is a growing need for solutions which help to find resources for increasing productivity. Essential instruments are technological parameters related to quality. One possibility to assess the impact of technological parameters on the efficiency of the production process is SPC mediation.
Two approaches of implementation of statistical methods for quality assurance have been developed:
1. **Statistical quality control** (SQS) has been introduced in industry for the purpose of determining if a given component of production (input) is within acceptable statistical methods and the result of production (output) that may be shown statistically, is acceptable to requirements [3].
2. **Statistical process control** (SPC) is the monitoring and analysis of a process using statistical techniques to accurately determine the process performance and preventive or corrective actions required. The elements of this definition will be discussed later, but first of all the need for SPC must be explained and this can be easily done by looking at the industrial scene as it exists today.
A separate paper could be written on this subject, but suffice it to say that the need is a result of major advances in technology, and a greater public demand both for quantity and quality.
The demand for quality is the quality consciousness or awareness that has for too long gathered dust in the minds of company workforces. It is a cornerstone of quality management in general and of SPC in particular.
The benefits of successful implementation are many and far-reaching. Motivation is not only a pre-condition of this success but it is a product of it. A motivation cycle can be created which will improve individual, group, department and company performance as a whole. Considerable reductions in rework costs and an almost total elimination of scrap are not unusual when SPC is operating effectively. It provides knowledge of machine and process capability and performance, enabling an engineer to make confident decisions about equipment requirements, preventive maintenance actions and scheduling, corrective actions and cures. Prevention rather than cure is not only an important quality assurance philosophy but it is the very nature of SPC. It can therefore reduce not only rework inspection but also the first time inspection and associated costs.
The general principles of SPC for industry are given by M. Thomas [1]. The statistical charts for the control of product parameters have been developed and recommended. AN SPC model for manufacturing process is given in [3]. Inputs and as well as their limitations in case of fully mechanized MAG welding are discussed in [1]. Neural control strategies using complicated sensor systems for automated welding methods are given in [4]. The possibilities of implementation of statistical methods for quality assurance in Estonian metal working industry using mainly manual welding processes (MMA, MAG, TIG) are considered in this paper.

2. DEFINITION OF SPC METHODS

This article describes the main features of SPC and suggests implementing the method in case of manufacturing enterprises. The analysis is based on statistical data related to welding technology. The author has looked at both the data related to quality and technological parameters.
SPC methods may be used on the enterprise level or on the technological process level. By M. Thomas SPC is the monitoring and analyses at process conditions using statistical techniques to accurately determine process performance and preventive or corrective actions required [1]. Another approach of process control involves continuous statistical monitoring of all the process inputs and keeping within operating tolerances. An effective SPC indicates how a process is running, delivers early working signals, provides information for corrective actions and assures more stability of product quality, reducing costs of work and scrap.
Despite benefits SPC implementation in industry has many hurdles. Some of them concerning production welding and welding process are:

- welding process parameters (inputs and outputs) to be taken into consideration,
- what the best kind of statistical index are,
- the necessary duration of the sampling period.

3. OUTLINE OF IMPLEMENTATION PROGRAMME AND REQUIREMENTS

There are three major stages which must be fully and accurately completed if SPC is to be successfully implemented. These are:
Stage 1: analysis of the current situation
Stage 2: development and establishment of readiness
Stage 3: implementation of SPC.
For some companies, implementation of SPC is a further step in establishing and developing a good quality system. This, in fact, is the ideal, as SPC on its own will simply not provide all the answers to the company's quality problems. After all, a process uses materials and components for further processing, which must be controlled. It also requires skills, equipment, instruments, procedures for handling, storage, identification, etc., in other words, process controls and many other elements of the quality system are interdependent. These related elements must exist or be considered in planning for SPC. Unfortunately discussion of these elements is not within the scope of this paper but they are clearly defined in *BS 5750*.
Having discussed the importance of statistical control, peripherals to SPC, we must also identify other conditions and requirements that will clear the way and provide a foundation for implementation of SPC. The conditions that exist in a company and need to be examined are as follows:

- Commitment to quality
- Quality motivation
- Quality education
- Communication
- The company culture

Stage 2: Development and establishment of readiness
When a clear picture of the prevailing conditions has been established, work can commence on making the necessary adjustments and meeting any outstanding requirements. These will be the objectives of a programme of actions which will ensure that the following are provided and are complete.
Company quality policy and objectives are clearly documented and made known to all

- The maximum degree of company- wide motivation
- Knowledge and skills
- Good communications
- Analysis of existing problems

The company will be as good as ready for stage 3 if the commitment and objectives are defined and widely understood, when motivation- in particular trust and good communications- is established, also when those are involved know what they have to do and how, and when the first processes on the "hit list" are identified.

4. IMPLEMENTATION OF SPC FOR WELDING PROCESSES

In all processes there will be some degree of variation. It is this variation that we must study in order to understand the process performance at the moment and what is likely to happen. The variation in a process results from two prime causes:
Common i.e. the many small, relatively predictable sources of variation (or chance) that are always present in a process causes.
Special, (i.e. the few irregular causes that are assignable or special to the assignable particular operator, machine or process) causes.
Before the control charts can be established, completed and interpreted, it must be determined if the process is in "statistical control".
Additional inputs for MAG welding prevailing in Estonian metal working industry which may be considered are:
To achieve high quality of welds automated welding system requires on sensor system to monitor the geometry of the weld, as well as the weld pool size and shape. This information is then used by the control system to modify the welding parameters to maintain the required quality and productivity. These welding control systems consisting of vision and electrical sensors are expensive for using in small enterprises.
The input data for MAG welding are:

- welding current (wire feed speed)
- arc voltage
- travel speed.

Control limits for welding process inputs may be established by collecting data from stable and unstable welding operations. The permissible limits for welding current and are voltage are in the range 10-20% given by V. Stenke [2]. These parameters are established for fully mechanized MAG welding. Travel speed of semiautomatic. MAG-welding depends on skills and techniques used by a welder and it is very difficult to keep this welding parameter under control. The stability of this welding parameter may be fulfilled by using welding robots or small mechanization devices.
The main sets of statistical data on the basis of which it is possible to assess productivity in an enterprise are:

- Choice of welding position
- Welding parameters (A.V. m/min)
- Share of defective products per unit
- Welders' qualification

All processes can be monitored.

5. SUMMARY

Like all essential systems, the SPC project must be the constantly monitored and reviewed. The operation of the use on-line control charts, associated methods and procedures will hopefully be reviewed and discussed in the classroom sessions during of the allied training programme. The reviews should include not only the types of charts being used, but also the supervisor and management involvements, effectiveness of interpretation, correct sampling procedures, etc. When projects are well under way with minimal problems, the resulting facts and figures of process improvement can be the motivators for initiating further projects.
Much more could have been written on process control charts and their use, but for the most part this would have needed an accompanying course on statistics. The purpose of this paper, to state it once again, is to emphasize the need for laying a firm foundation for implementing SPC. Some readers will say that they never had to go trough the rigours of such a programme and yet succeeded with SPC. If this is so, it will almost certainly be because many of the conditions and requirements described were already prevalent in their company.
A considerable amount of hard work, over a period of perhaps years rather than months, may be needed for statistical process control to be fully effective. If the procedures are carefully documented with all responsibilities and actions defined, there will be greater assurance that they will remain effective.
SPC is not in itself the answer to the company's quality problems. It is just a tool, albeit a powerful one, in the total machinery of quality assurance. Prevention, control and detection of defects should be everywhere in the company, at every stage and carried out by

everybody. In companies where this is not the case, an SPC programme can be the ideal catalyst for creating the controls previously described.
The results of analyzing features at manual welding process widely used in Estonian industry show that the main welding parameters (inputs) such as welding current and are voltage must be monitored. Other approach is the implementation of modern MAG-welding equipment with computer control and recording. The productivity and the quality of a welding process depend on welding position. The flat welding position is recommended for welding. The welding fixtures must be implemented. Skilled and well trained welders are needed. Skill of a welder influences on welding current and arc voltage during welding operation. In a training process and welders inspection in workshops the tolerances for these parameters must be estimated and controlled. Using small mechanization devices for a travelling welding gun in MAG welding can take under control welding speed.

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