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Real time statistical process advisor for effective quality control

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Abstract

An advisory decision support system has been presented in this paper. This system helps in collecting statistical data and thereafter analyzes the enormous volume of data and aids in making quality related decisions. In contrary to conventional SPC applications where the analyzed results have to be interpreted by quality control specialists, MES based unmanned manufacturing environments require automation of the interpretation process. The developed advisory system helps in selecting and designing control charts based on various cost, rule or heuristics models. The system also provides interpretation expertise by configuring and applying various rule sets. On violation of these rules, signals are generated by the system and the expert system advices for appropriate remedial actions. Thus the system acts as an advisory support system.

Keywords: Manufacturing execution system (MES); Advisory support system; Statistical Process Control (SPC)

1. Introduction

The basic goal of using quality control techniques is to streamline the manufacturing system by minimizing the occurrence of quality related problems. Most of the time, problems related to quality of products have many controllable sources, be it the vendors of raw materials, equipment used to process such materials, methods used for processing, the personnel involved or any other specific source as identified by the organization. Such factors usually affect the quality at any stage of the production process and hence, there has been an ardent need to monitor those problems effectively and efficiently through proper design and deployment of an appropriate quality and process control system.

In the present day context, the three basic functionalities of statistical process control system, i.e. specification, inspection and control [2] are to be expanded so as to make the manufacturing processes more competitive. From time to time, various methods have been suggested to design the appropriate control charts for specific processes [8,3] and interpret those charts for maintaining the quality of the materials or products manufactured by the processes [1,6,7]. However, it is

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realized that in order to achieve the desired objective of capturing the process data on real time basis and for on-line interpretation of those data, an integrated approach is to be undertaken. This will ensure the maximum effectiveness of the quality control function in a manufacturing organization under the manufacturing execution system (MES) environment [5]. In this paper a modular and integrated software architecture is proposed and developed. It uses the generic methods to address various problems of quality control and facilitates mapping of the unique quality requirements of the manufacturing organization. The modules of the developed software primarily use statistical techniques to interpret the data captured during various stages of the manufacturing processes. Different objective methods are used to analyze the enormous volume of the generated data and aid in making quality related decisions. It will have the ability to respond to any request for quality clearance to be provided for either the raw materials procured or finished products produced. It also helps in systematizing the data collection procedures at various identified qualities related checkpoints and thus aids in effective troubleshooting. The quality control module addresses to the above-mentioned areas of concern in a very comprehensive manner and raises alarms whenever out-of-control situations occurred. It also ensures discipline in the data collection procedures and helps in breaking down and analyzing the complex quality control system by assigning costs at the various stages of the manufacturing process [4,6].

2. Business case for development of the system

The business case for development of such an advisory system is first envisioned at a semi-automated manufacturing plant in India that produces industrial reduction gearboxes. One of the costliest processes identified in that manufacturing plant is the bevel gear hobbing process. The gear hobbing machines are attached to a central supervisory and data acquisition (SCADA) system server, which usually monitors various machine parameters. The existing state of quality control is that Excel based statistical tools are used at the raw material and final inspection stages. The process parameters are monitored manually and decisions are taken based on the rule of thumbs. There is no infrastructure for collection of data related to various dimensional features of the gears on a real time basis. At that point of time, it is decided to develop and implement an appropriate SPC environment in the plant to minimize scrap and rework.

3. Design and logical structure of the system

After analyzing the required functionality of the advisory system, five logical modules are subsequently designed. The modules are segregated based on their functionalities to be provided. The designed high level data flow diagram (DFD) is shown in Fig. 1. For effective implementation of the system, a suitable database is also designed and developed, by incorporating various objects of the DFD. The functional modules of the advisory system are as follows:

a) data definition,
b) data collection,
c) chart design,
d) chart display, and
e) chart interpretation.

The data definition module provides the functionality of defining the specifications of different variables and attributes related to the manufacturing processes. The data collection module helps in providing an integrated software and hardware architecture to collect the relevant data on real time basis. The collected data have two broad classes, i.e. data related to the measurement of dimensional variables or attributes and data related to the costs of the manufacturing processes. Thereafter, the data are to be plotted on the quality control charts. Before doing so, an appropriate control chart is to be selected and designed. The chart design module provides this functionality. The chart display module simply displays various types of control charts, like mean, range, fraction or proportion defective chart etc. After the data are plotted on a control suitable chart, the chart interpretation module provides the functionality of interpreting the data.

4. Physical structure and components of the system

Based on the designed logical architecture, the developed system is physically implemented in the