The Use of Artificial Intelligence in PCB Manufacturing

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Based on the concept of a standardised, product-independent and production-independent system for factory automation, this article presents some general thoughts concerning the acquisition of operation data, machine data and quality data for manufacturing and discusses the application of artificial intelligence in the sector of PCB manufacturing. The aim of this system is to achieve data-supported work processes and an uninterrupted flow of information in both directions.

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1. Introduction

An integrated computer-aided production control system which encompasses both product independence and production independence has been planned and realised in order to automate the manufacturing environment. Such control systems have the job of planning production activities and controlling the machines and the production equipment in the manufacturing environment to ensure that the products ordered by the customer can be delivered on schedule. Fig. 1 shows the uninterrupted flow of information from the order and process plan, via the production control system, to the material transformation process on the sensors and actuators of the manufacturing equipment including the acknowledgements required. Besides controlling the information flow, this system provides control of the development, provision and delivery of goods. The hardware and software of the production control system are based on the Y model with interfaces [1, 2] and the reference model of hierarchical production control [3, 4], respectively.

2. Production Control with Preparation and Evaluation Processes

According to the hierarchical structure of the NITS model, with its control functions and interface to the logistics, the production preparation system (with an interface to development) is located “upstream” and the evaluation system (with an interface to the quality assurance system) is located “downstream” (Fig. 2). Preparation and evaluation cover all layers of the control model, which comprises data volumes and time horizons that decrease from the top to the bottom of the diagram.

The product data originating from the product development are entered in the production preparation system. Using another computer-aided process, these data are divided into mechanised and manual working operations of the manufacturing procedure, the machine and process data are added, and the formatted datafiles are classified according to their information (i.e. product, machine or process information) and stored for on-line retrieval. This procedure is used for both manual work processes and machine operations.
The production evaluation system collects data volumes classified as described above in every hierarchical layer of the model and stores them according to the time horizon of the layer in question. A polling and feedback mechanism on every layer of the system ensures short reaction times should a fault occur, even when only small batches are being produced and there is a large product range. Thus, the system permits a permanent monitoring of product and process quality from production to delivery, i.e., throughout the product's entire life cycle.

These data streams can also be illustrated in the form of a Sankey diagram (Fig. 3), where the individual data volumes of the branched streams can be both product-specific and process-specific. Here, it can be clearly seen that the volume of data decreases on the preparation side and increases on the evaluation side while the time horizons decrease; thus, the problems of data gathering and storing during the production evaluation become evident.

The system is now described in more detail to illustrate this. Some tools from the preparation phase are as follows (Fig. 4):

- Graphical editor
- Manufacturing design-rule checker
- Simulators
- Optimisers

The graphical editor is a man–machine interface that permits the processing of the product-specific datafiles, which are loaded into the preparation system for processing according to the procedures mentioned before. The aim of these procedures is to generate formatted product, machine, and process datafiles.

The manufacturing design-rule checker is an auxiliary device that facilitates the work of the developer and work planner by enabling a product-manufacturing check according to given design rules and the working operations designed for this production procedure.

With the aid of simulation calculations and graphics which illustrate the results, the complete production