SOLDERING PROCESS SIMULATION AS A CONCURRENT ENGINEERING TOOL

by

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ABSTRACT:

The implementation of Concurrent Engineering (CE) methodology can involve philosophical changes in an organization as well as the introduction of tools to facilitate communications between design and manufactuing personnel and improve producibility. The use of computer simulations to model equipment utilized in manufacturing electronic assemblies can greatly reduce the cost of product development. Through the use of a simulation which allows the user to model a soldering process, it is now possible for the board designer to determine the producibility of a design prior to the design being completed. Optimization of the simulation for the soldering equipment in a particular factory will allow the simulation to accurately predict the appropriate parameters for the soldering system and pass these parameters directly to the factory. Establishing a parameter file for each board during the design phase eliminates the requirement for the manufacturing engineer to run sample assemblies and thus reduces the design to delivery time of the product.

INTRODUCTION:

The use of Concurrent Engineering (CE) methodology requires the design and manufacturing engineers to work closely on the development of new products. In trying to improve the communications between these two groups, one of the key problems lies with the time constraints placed on engineers. There are usually more development projects at a company then there are manufacturing engineers to work efficiently on each project. The presently accepted method for building a new product consists of having the design engineers layout the product with some help from manufacturing engineers in regards to overall producibility. Once the design is at a stage where it can be prototyped, the manufacturing engineers will build sample product on the manufacturing equipment to develop appropriate process parameters. The results of the sample runs will provide feedback for the design engineers to modify the assembly as required to improve the producibility of the assembly.

The cost of developing manufacturing processes in both labor hours and cost of experimental product has increased dramatically in recent years due to both increased labor costs and the higher costs attributed to increased complexity of designs. A means of reducing the high development costs by reducing both the amount of product required in the development effort along with a reduction in the time required for development will serve to dramatically reduce the overall cost of process development. The use of simulations in the mechanical and electrical design areas have been employed for many years to reduce the necessity for actual experimentation on live assemblies, however, manufacturing simulations are only recently being looked at to model actual PWA assembly equipment.

Current process development consists of multiple runs through equipment in order to determine the precise parameter settings for a particular assembly. In the case of InfraRed reflow, it may take 5-10 runs to narrow the parameters to the final acceptable values while it may take 3-5 runs on the in-line cleaning system. After each run, the results must be evaluated and decisions made regarding changes to the process parameters.

The use of simulations to determine producibility factors as well as manufacturing equipment parameters will allow us to identify the critical areas of a design prior to actually starting to assemble hardware. We will be able to identify wether a particular design can be assembled using our current factory equipment and processes and also how to set up that equipment if the design is acceptable. The use of simulations between manufacturing and design will greatly enhance the concurrent engineering scenario and improve our ability to field more reliable designs in a shorter amount of time.

SOLDERING SIMULATION:

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This paper is concerned with the development of a computer simulation which is capable of determining the optimum parameter settings for reflow of a printed wiring assembly (PWA) utilizing an InfraRed reflow furnace.

The initial process simulation is an off-line module driven by information from the completed design package. The purpose of the simulation is to simulate the IR soldering process and its interactions with the product in order to predict initial process parameter settings for the equipment. The parameters will be passed to the equipment as required through a LAN and post-processed at the IR furnace PC to be accessible by the IR furnace software.

Inputs to the simulation for defining the equipment will include:

* number of heating zones
* maximum allowable zone temperature
* minimum allowable zone temperature
* maximum allowable temperature differential between adjacent zones
* values for boundary conditions in each zone
* maximum allowable belt speed
* minimum allowable belt speed

The simulation will be able to back-calculate values for boundary conditions in each zone based upon inputs of time and temperature coordinates for a previously run profile.

The optimization routine will be run with user inputs for specific time at temperature selections and the optimization routine will attempt to modify parameters to meet these requirements.

<u>HOW TO USE THE SIMULATION</u>:

The board design (from a CAD system) is translated and pulled into the thermal modeler portion of the simulation package. The design is checked for accuracy to insure that the simulation is operating on the correct information.

The analysis control parameters such as system units, finite element parameters, ambient conditions, and default non-thermal component data are input through the soldering simulation modeler menu. The type of analysis (as identified by the three options previously mentioned is also input from this point in the program.

Process control parameters to include: conveyor belt data, heating zone temperatures, reference board temperature location, and desired profile information are input through the soldering simulation modeler menu.

Boundary conditions for the heat transfer mediums are input through the soldering simulation modeler menu.

Once the inputs to the thermal modeler and soldering simulation modeler have been completed, the soldering simulation analyzer is called up to perform the actual simulation/analysis. This operation is time consuming and may take quite a while to run.

Upon completion of the analysis run, the thermal modeler is used to view the results of the simulation. It is possible to look at either of the two output options mentioned earlier from this point in the program.

Once the results of the simulation have been approved, a process control file is created through the soldering simulation modeler and placed on the local area network (LAN) for access by the IR controller (an IBM compatible PC).

The post-processor software is run on the process control file from the IR controller PC and at this point, the IR software will recognize the parameters generated by the simulation. The IR can now call up the required profile and the PWA can be run through the furnace in order to perform the soldering operation.

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OBSERVATIONS:

The CAD interface seems to be one of the driving factors in this project. There is such a variety of CAD packages being used that there is virtually no common data format which can be used to translate information between design and manufacturing. Although many post-processors are available to move data between packages, it is extremely rare to be able to get all of the required data from one system to another.

The speed of the simulation is a factor to be considered. Due to the large number of calculations and the hardware platform being used, the simulation could run for anywhere between 10 minutes and several hours. The integrated solution must be able to be run in the background and perform the passage of information without someone providing direct interfacing during the actual run.

The question of who actually maintains the simulation is still unanswered. The actual software and hardware must be kept current and in good working order. There is also parametric data which is used by the simulation that must be kept accurate. A team consisting of an expert in the hardware/software aspects along with a manufacturing engineer who is intimately familiar with the process itself should be formed to maintain the overall simulation. The manufacturing individual will also be responsible for updating the simulation's parameter (boundary condition) library when a new piece of equipment is being tested with the simulation.

CONCLUSIONS:

The use of a soldering simulation will greatly increase the productivity of the process engineer by allowing the definition of process parameters for a specific design to be established prior to actually assembling any hardware. Savings in both labor hours and materials costs will be instantly realized upon use of the simulation. The design engineer will also benefit from the simulation since it will now be possible to predict whether or not a design is producible before money is committed to actually ordering materials. This particular simulation is generic with respect to belt fed furnaces in that it can be used to simulate not only soldering furnaces, but also thick film ovens, adhesive cure systems and any other similar piece of equipment.

The use of the simulation will, however, increase the need for manufacturing personnel trained in the use of simulations and able to conceptualize how additional simulations should be generated. Use of a single simulation is beneficial, yet the end goal is to be able to simulate the entire series of processes being used to assemble a PWA.

The simulation process is very cost-effective when compared to the expense of building physical models, performing iterative product test and evaluation, and physically moving parameters from the simulation output to the IR PC controller.

FUTURE WORK:

Eventually, we would like to integrate the simulation such that the designer can simulate process interactions in much the same way they simulate for thermal analysis, thus allowing instantaneous decision making with regards to design considerations and their potential impact on manufacturing on the available factory equipment. Simulations can also be written for new equipment prior to purchase and installation to determine how the equipment will work with our product designs.

DESIGN REQUIREMENTS:

The data being downloaded from the CAD database and the PCDB must be post-processed into a format compatible with the "neutral files" as designed by Pacific Numerix. These files are relatively easy to understand ASCII files which provide all of the information required to run the simulation.

Prior to actual use of the simulation for a given piece of equipment, the actual values used by the simulation for boundary conditions must be verified through actual experimentation. The simulation has the capability to back-calculate these conditions but additional verification must be performed to insure the validity of the calculations.

The hardware platforms must all be compatible with the existing factory data networks to insure that the information can be passed between systems.