UNIVERSITI PUTRA MALAYSIA

AN EXPERT SYSTEM FOR TROUBLE SHOOTING - AUTO WIRE BONDER MACHINE

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By

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Thesis Submitted in Fulfilment of the Requirement for
the Degree of Master Science in the
Faculty of Engineering,
Universiti Putra Malaysia

May 1997

To my Beloved, Wife and Parents :

you are the reason for all of this.

ACKNOWLEDGEMENTS

I would like to acknowledge my project Chairman, Dr Shamsuddin bin Sulaiman, Mr Ir Mohamed Daud and Mr Mohd Rasid Osman, member of Supervisory Committee from the Department of Mechanical and System, Engineering Faculty of Universiti Pertanian Malaysia (UPM) for their guidance, and sharing of their invaluable knowledge and experience with me

I would like to thank Dpak Department of Motorola Semiconductor Sdn Bhd for granting me the opportunity to conduct this project in the department Sincere appreciation is expressed to Mr K H Tee, Mr T C Lim, Mr K Parthipan and Dpak Front End technicians for their sharing of working experience and support To Engineering Faculty, UPM, and the many others who have made contributions, please know that you have my thanks

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LIST OF ABBREVIATIONS

AES	Advisor Expert System
AI	Artificial Intelligence
DEC	Digital Equipment Corporation
DOS	Disk Operating System
EES	Evaluation Expert System
FINEST	Fuzzy Inference Environment Software with Tuning
FNAC	Fine Needle Aspiration Cytology
FPS	Fuzzy Production System
GPS	General Purpose Problem Solver
HAES	Harmonics Analysis Expert System
HTM	Hierarchy Transformation Method
JAL	Japan Airlines
KES	Knowledge Engineering System
KIS-III	Kawasaki Inference System III
LIFE	Laboratory for International Fuzzy Engineering Research
LISP	List Processing Language
MSSB	Motorola Semiconductor Sdn. Bhd.
O-A-V	Object Attribute Value Triplets
OCAP	Out of Control Action Plan

OGIS	Osaka Gas Information System
PC	Personal Computer
PES	Preparation Expert System
PM	Preventive Maintenance
PROVANES	Proposal & Evaluating of Anesthesia Plan
SIA	Singapore Airlines
SMPS	Switched Mode Power Supply
TCM	Total Control Methodology
TPDES	Thermal Performance Diagnostics Expert System
TPM	Total Productive Maintenance
UPM	Universiti Putra Malaysia
UTM	Universiti Teknologi Malaysia

Abstract of thesis submitted to the Senate of Universiti Putra Malaysia
in fulfillment of the requirements for the degree of Master of Science.

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May 1997

Chairman : Dr. Shamsuddin bin Sulaiman

Faculty : Engineering

An expert system to trouble shoot auto wire bonder machine has been developed at Dpak product line, Motorola Semiconductor Sdn. Bhd., Seremban. This expert system is to provide a systematic and analytical procedure to trouble shoot Delvotec 6830 auto wire bonder. A rule-based expert system using backward chaining method is developed to guide the user during trouble shooting wire bond defect. The expert system collects information from the user on the wire bond defects by asking various questions. When the expert system reached to a conclusion, the recommend adjustment procedure and corrective action will be shown on the PC. This expert system, running on a personal computer (PC), is programmed using Vp-Expert Shell, it captures the domain expert knowledge in wire bonding process into the knowledge base. Knowledge for this system is elicited from the domain expert

through interviews and discussion, other sources of knowledge are from manufacturer operating manual, Total control Methodology (TCM) file and literature. The aid of this expert system is to improve bonding quality by reducing production yield loss.

Abstrack thesis yang dikemukakan kepada Senat Universiti Putra Malaysia bagi memenuhi keperluan untuk Ijazah Master Sains.

AN EXPERT SYSTEM FOR TROUBLE SHOOTING - AUTO WIRE BONDER MACHINE

Oleh

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Mei 1997

Pengerusi : Dr. Shamsuddin bin Sulaiman

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Jabatan Dpak di Motorola Semiconductor Sdn. Bhd. telah memperkembangkan satu sistem pakar untuk mesin pendawaian Delvotec 6830. Sistem pakar ini bertujuan untuk memberi langkah-langkah sistematik memperbaiki mesin Delvotec 6830 kepada juruteknik-juruteknik syarikat tersebut atas. Sistem pakar jenis peraturan ini diperkembangkan menggunakan cara "backward chaining" dengan bantuan Vp-Expert. System pakar memperolehi maklumat dari para juruteknik melalui soalan-soalan yang dipaparkan pada komputer. Apabila ia mencapai keputusannya, langkah-langkah memperbaiki mesin pendawaian akan dipaparkan pada skrin komputer. Pengetahuan dan kepintaran sistem pakar ini diperolehi melalui perbincangan dengan pakar-pakar mesin dan rujuk dari buku. Sistem pakar ini bertujuan untuk meninkatkan kualiti pendawaian.

CHAPTER 1

INTRODUCTION

Project Background

In semiconductor industry, production equipment and machinery have depended heavily on the use of human expertise for maintenance and repair. In order to maintain this expertise, considerable effort is required to train the work force. However, human expertise is difficult to transfer, document and at times can be unpredictable.

In some situation, expertise is not available on a reliable and continuing basis. Experts are expensive, scarce and in high demand. It is also very easy to lose expertise through separation, job transfer and retirement. Knowledge based expert system has merged in the field of artificial intelligence (AI) with strong potential and capability for reducing training cost, maintaining consistent expert knowledge and improving productivity and the quality of the task performed (Jackson, 1992).

completion of troubleshooting and repair in a timely manner. Skilled maintenance staffs, apart from using test procedures and maintenance manuals, use heuristic's way to solve machine problems. It is this "beyond procedure" type of knowledge that enable them to perform at an exceptional level. When the experts are confronted with a problem, they analyze the problem in a structured manner rather than randomly trying all possible alternatives. This expertise characteristic has driven the use of expert system in trouble shooting procedure.

Auto wire bonder, model Delvotec 6830 is used for aluminum wedge bonding process by the Dpak product line. Dpak product is a power transistor manufacturing line. It includes the process of assembling and testing Dpak power transistor. Dpak power transistors are mainly used in automotive industry as a controlling device for Auto-braking-system (ABS), ignition system and power window.

This expert system is providing systematic trouble shooting guide for the machine operator and technician. With least experience on the wire bonder, untrained technician will be able to repair machine by following the instructions from the expert system.

Objectives

The objectives of this project are :

(i) Develop machine trouble shooting expert system for Delvotec auto wire bonder model 6830. This expert system is able to diagnose machine problem thus recommend precise and systematic trouble shooting procedure.

(ii) To document and transfer expertise knowledge into knowledge data base for permanent resident. Proper documentation of expert knowledge will lead to reduction in machine repair time.

(iii) Transferring of minor maintenance skill to machine operator through Total Productive Maintenance (TPM) concept. Expert system is expected to instruct operator to follow instruction on expert system and to perform minor trouble shooting.

Problem Definition

High machine down time and yield loss in manufacturing has become a concern in Motorola recently. These high down time will increase production cycle time and delivery of product to customer is delayed. From Motorola Corporate vision "Total Customer Satisfaction", and Motorola Seremban vision "To be the best

in the eye of our customer through people process", the requirement to satisfy customer with high quality product is the key goal for every employee in Motorola (Dpak, 1994).

At a glance, wire bonding process is simple in concept (just to connect a wire between die and lead frame), but probably it is the most critical process in manufacturing of semiconductor component. This aluminum wire bonding process has the common defects such as lifted pad, lifted post, broken wire, cratering etc,. The yield losses break down data for period of Jan - Mac '94 and April - June '94 is as shown on Table.

Table 1 : Yield Loss Breakdown for Dpak Wire Bond Process

Reject Mode	**Reject Code**	**Jan - Mac 94 (Unit)**	**April - June 94 (Unit)**
Lifted Pad	KE	53,902	59,812
Lifted Post	KF	14,564	18,113
Catering	6M	334	1,116
Misplaced Bond	3H	1,722	3,438
Others	OT	774	514

(Source : Dpak Process Engineering Department, 1994)

In wire bonding process, various machine settings are the main factors to obtain good bonding and bond ability. These variables include the setting up of clamping system, cutter, wedge, wire clamp and transducer system. Each particular

part on the wire bonder machine will contribute in improving productivity and quality. When a machine creates wire bond defects, a technician will try with his/her own way to repair the wire bonder. This trouble shooting technique and analysis varies from one another due to their different experience, expertise and knowledge. As a consequence, this creates inconsistency and non-analytical way of trouble shooting. If a wrong part is being aligned or the set up is incorrect, a simple problem that can be solved within minutes will become a severe problem that ends up with long hours of machine down time.

In addition, training an expert requires time, cost and man power. From experience, to train a technician for handling wire bonder equipment required time. In order to attain effective knowledge transferring, documentation of trouble shooting procedure is the key factor. However, this is seldom done and thus knowledge tends to wipe off when the expert changes job function. New technicians have to start all over again. If the knowledge and findings are properly documented, it would reduce unnecessary learning cycle time.

In this project, personal computer (PC) based expert system using the software programming method is developed to address the above concerns and difficulties. This expert system is providing an analytical and systematic way for machine trouble shooting. By keying in required information into the PC, the expert system will recommend corrective action to a problem. This would substantially reduce machine down time and yield loss. The knowledge base of the system will not disappear with the change of job function of the expertise. Through the expert

system, the skill transferring and training of a technician is much easier where the technician can perform certain repairing job with the help from the expert system. Technician can perform better trouble shooting skill with minimize coaching and training (Chorafas, 1990).

CHAPTER II

LITERATURE REVIEW

Expert System

An expert system is a computer program that emulates the behavior of a human expert in a well specified, narrowly defined domain of knowledge. It is based on an extensive body of knowledge about a specific problem area. Characteristically this knowledge is organized as a collection of rules which allow the system to draw conclusions from given data or premises. It captures the knowledge and heuristics that an expert employs in a specific task. Expert system are typically used in situation where expertise is either scarce, unavailable, or expensive; where time and pressure constraints are involved; where there is a need to document or preserve knowledge before one retires or leaves the company; and where one wants to verify one's knowledge (Luger et al., 1993) .

The British Computer Society's Specialist Group has definition on expert system : An expert system is regarded as the embodiment within a computer of a knowledge-based component, from an expert skill, in such a form that the system can offer intelligent advice or take an intelligent decision about a processing function. A

desirable additional characteristic, which many would consider fundamental, is the capability of the system on demand, to justify its own line of reasoning in a manner directly intelligible to the enquirer. The style adopted to attain these characteristics are rule based programming (Jackson, 1992).

Parasaye and Chignell (1993) defined expert system as a program that relies on a body of knowledge to perform a somewhat difficult task usually performed only by a human expert. The principal power of an expert system is derived from the knowledge the system embodies rather than from search algorithms and specific reasoning methods. An expert system successfully deals with problems for which clear algorithmic solution do not exist.

Expert System Languages and Tools

During the 1970s, most expert systems were developed on powerful workstations, using languages such as LISP and PROLOG. This left the challenge of developing systems in the hands of the select few who could afford the platforms and had the patience to learn the complexities of the available languages. However, these languages are versatile and very effective when developing logic-based system from scratch. (Maus et al., 1992)

Expert System Languages

LISP is one of the oldest general-purpose languages Developed at MIT by McCarthy in 1958 Its unique features give the programmer the power to develop software that goes far beyond the limitations of other general-purpose languages such as COBOL and Pascal LISP allows programmers to represent objects like rules and nets as list - sequence of numbers, character strings or other lists It provides them with operations for splitting lists apart and for making new lists by joining old ones LISP code is usually executed directly by a LISP interpreter (Busbach et al , 1993)

CONCOR, an automatic verification tool for Expert Systems was developed at University of Edinburgh using LISP language It is used to detect all inconsistency and incompleteness errors in rules and chains CONCOR also can discovers self-conflicting rules and chains (Camarena et al , 1993)

PROLOG basic idea is to express statements of logic as statements in programming language The proof of a theorem using these statements could be thought of as a way of executing those statements Thus logic itself could be used directly as a programming language PROLOG has the additional advantage of having a very powerful inference engine in place Therefore, the algorithm used in PROLOG is more powerful than the simple pattern-matching algorithms commonly used with LISP in production-rule representations of knowledge (Dauboin, 1993)

PROLOG's basis in logic provides its distinctive flavour Because s PROLOG program is series of statements in logic, it can be understood decoratively, that is, it can be understood quite separately from considerations of how it will be executed Traditional languages can be understood only procedurally, that is, by considering what happens when the program is executed on a computer PROLOG allows a program to be formulated in smaller units, each with a natural declarative reading In addition, PROLOG's built-in pattern-matching capability is an extremely useful device (Muller et al , 1993)

An exmple of PROLOG-based system A system is designed by Bernhardt et al (1993) as part of an off line programming environment for industrial robots It combines heuristic reasoning and data base retrieval techniques to derive a welding schedule Welding schedules is then passed to a diagnosis module The integration of planning and diagnosis techniques allows an iterative optimization of the technological parameters of the welding process

Expert System Shell

During the 1980s, the proliferation of personal computers and the introduction of easy to use expert system software development tools called "shell" has happened A shell is a programming environment that contains all of the necessary utilities for both developing and running an expert system It is simply a collection of programs that the user can build an expert system without needing to know a symbolic

language. A shell can be extremely useful in developing expert systems for a specific application. Some examples of the expert system shell are VP Expert, Level5, Guru, KES and etc. Some shells are developed to a specific area. For example, there are shell for diagnostic systems, shells for configuration and shells for scheduling. (Turban, 1995)

A study has been carried out by Johnson et al. (1994) to compare similarities and differences of 5 expert system shells, namely, TIRS, ESE, Knowledge Tool, KEE and OPS5. They has compared these shells parameter characteristics, frame characteristics, procedure characteristic, question characteristics, production rule characteristics, chaining invocation options and etc. From the findings, it shows that rule information could be reused between shells, but it is unlikely that a set of production rules could be moved freely between shells unless severe restrictions have been used to limit the features that were used when the rules were defined. However, this type of restriction would generally not be acceptable because it eliminates many of the competitive advantages built into each shell.

For developing fuzzy control systems and fuzzy expert systems, there are several shells such as Fuzzy Productin System (FPS) and Fuzzy Inference Environment Software with Tuning (FINEST) has been developed in Laboratory for International Fuzzy Engineering Resarech (LIFE). FPS allows both forward and backward reasoning while FINEST is a GUI-based shells using an extended fuzzy reasoning method with tuning facility and all knlwledge is represented by units. (Umano et al., 1994)

Development of Expert System

Expert system were developed by the Artificial Intelligent community as early as the mid-1960s. The General-purpose Problem Solver (GPS), a procedure developed by Newell and Simon (1973) from their Logic Theory Machine, was an attempt to create an "intelligent" computer.

The shift from general-purpose to special-purpose programs occurred in the mid-1960s with the development of DENDRAL. DENDRAL infers the molecular structure of unknown compounds from mass spectral and nuclear magnetic response data. The system uses a special algorithm to systematically enumerate all possible molecular structures; it uses chemical expertise to prune this list of possibilities to a manageable size. Knowledge in DENDRAL is represented as a procedural code. (Feigenbaum, 1988)

It then followed by the development of MYCIN. MYCIN was developed to aid physicians in diagnosing meningitis and other bacterial infections of the blood and to prescribe treatment. Specially, the system's objective is to aid physicians during a critical 24-48 hours period after the detection of symptoms, a time when much of the decision making is imprecise because all the relevant information is not yet available. Early diagnosis and treatment can save a patient from brain damage or even from death. MYCIN was developed at Stanford Medical School in the 1970s by Dr Edward H. Shortliffe. The program's record of correct diagnoses and prescribed treatments has equalled the performance of top human experts. (Cai et al., 1993)