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الملخص العربي

استخدام الحاسب الآلي في ضبط جودة أنابيب الغاز الملحومة باستخدام نظم الخبرة

يرتبط التطور السريع في الصناعة ارتباطا وثيقا بالتقدم في الهندسة الإنتاجية مما يتبع ذلك التركيز على زيادة الإنتاج مع جودته . لذلك اتجهت الدراسة إلى زيادة جودة اللحامات في أنابيب البترول , حيث أنه زيادة نسبة اللحامات المرفوضة والمعيبة ينتج عنها سوء استخدام الموارد المتاحة سواء كانت (موارد بشرية – خامات – معدات – وقت ...) مما يؤدى إلي خفض الإنتاج .ونخلص مما سبق أن استخدام الحاسب الآلي بواسطة نظم الخبرة في الدراسة التشخيصية لحصر وتصنيف عيوب اللحام وإيجاد الحلول لخفضها من أفضل الطرق المستخدمة في تقليل عيوب اللحام وكذلك اللحامات المرفوضة .

والبحث الذي بين أيدينا تمت فيه دراسة تشخيصية على حالة عملية وذلك لفحص وتحليل عيوب اللحام ومعرفة أسبابها لتقليلها و ذلك في خط أنابيب غاز (خط الازدواج 16 بوصة – مشروع رأس بكر/ السويس) على البحر الأحمر بطول 190 كيلومتر تقريبا , في صورة أنابيب طول كل منها يتراوح بين 11 : 13 متر وعدد اللحامات في هذا الخط حوالي 15000 لحام .وقد أجريت الدراسة على اللحامات آلتي تم لحامها باستخدام القوس الكهربي بالطريقة اليدوية طبقا للمواصفات القياسية لمعهد البترول الأمريكي **A. P. I.1104**
وقد تم اختبار هذه اللحامات بواسطة الاختبارات الغير الاتلافية طبقا للمواصفات القياسية لمعهد البترول الأمريكي .حيث تم اختبار كل اللحامات (بنسبة 100٪) بالاختبار البصري والفحص بالأشعة التصويرية , وفى حالة ظهور عيوب عند الفحص فانه طبقا للمواصفات القياسية السابقة يتم تصنيف العيوب بحيث يقطع اللحامات المرفوضة ويعاد إصلاح اللحامات المعيبة وآلتي يعاد فحصها مرة ثانية .

وفيما يلي ملخص لطريقة البحث :-

1- تم تجميع البيانات الخاصة باللحامات وذلك بالمتابعة الفعلية واليومية لعملية اللحام (وتسجيل نتائج الاختبار الغير اتلافى)عن طريق تقارير قراءة الأفلام.
2-تم تسجيل البيانات بالطرق الإحصائية لسهولة دراستها .
3-تم تحليل هذه البيانات بواسطة الأساليب الإحصائية(مثل خرائط ضبط الجودة) وذلك باستخدام الحاسب الآلي بواسطة نظم الخبرة .
4-تم دراسة نتائج التحليل وآلتي أشارات آلي وجود ثلاثة عيوب رئيسية أثناء عملية اللحام .
5-تم دراسة الأسباب آلتي أدت آلي ظهور هذه العيوب أثناء المشروع ووضع الحلول والبدائل لتقليل تكرار حدوث هذه العيوب .
6-تم إصدار التوصيات اللازمة لتفادى حدوث هذه العيوب مرة أخرى .
7-تم اقترح طريقة للمتابعة الدورية للمشروعات المماثلة باستخدام الحاسب الآلي بواسطة نظم الخبرة .

هذا كما قورنت نتائج الدراسة العملية الحالية بنتائج بعض الدراسات النظرية والعملية السابقة .

حيث أظهرت المقارنة تقاربا جيدا بين النتائج الحالية والنتائج السابقة .
حيث أن الدراسة الحالية ساعدت في معرفة العيوب الرئيسية أثناء عملية اللحام ومحاولة وضع الأسلوب الأمثل لاكتشافها وتحديدها وتصنيفها ومحاولة تقليلها أثناء العمل يوم بيوم في المشروع أو المشروعات المشابهة, مما يؤدى آلي تشخيص مشاكل الإنتاج وإيجاد الحلول لها لزيادة الإنتاجية .

تقع الرسالة المقدمة في ستة فصول بالإضافة آلي الملخص والأبحاث المنشورة السابقة(المراجع) والملحق وذلك على النحو التالي :-

الفصل الأول :- مقدمة للبحث وتحديد المشكلة مجال البحث مع عرض لأهم الأبحاث المنشورة في نفس مجال البحث .

الفصل الثاني :-الأساسيات الخاصة بالأجزاء الرئيسية في البحث مثل اللحام بالقوس الكهربي- لحام الأنابيب-الاختبارات الاتلافية.

الفصل الثالث :-مقدمة عن نظم الخبرة .

الفصل الرابع :- يقدم برنامج الكمبيوتر الخاص بهذا البحث ويعرض إمكانيات البرنامج ويشرح ذلك بالتطبيق في الحالة العملية محل البحث

الفصل الخامس :-مقارنة بين الطريقة الحالية والطريقة المقترحة لضبط جودة أنابيب الغاز الملحومة باستخدام نظم الخبرة.

الفصل السادس :- النتائج والمناقشة , ويحتوى على عرض وتحليل للنتائج آلتي تم الحصول عليها . الخلاصة , وتحتوى على أهم النتائج المستفادة من البحث .

ABSTRACT

The present research employs an expert system with a view to increase the welding quality. Its major aim is to produce a better welding quality so as to reduce the production costs, save time and spare the effort exerted in treating the common welding defects. This is a fundamental issue due to the tremendous technological and economic progress in industry that dominates the modern age. Thus, preventing the welding defects has become urgent in this respect in order to increase productivity by reducing production cost and increasing the welding quality. The major part of this study is an experimental one applied to the duplication of Gas pipeline (diameter 16 inches and length about 190 Kilometers) Ras Bakr / Suez project. After welding manually by shielded metal - arc welding according to API. 1104 (American Petroleum Institute), they were tested by radiographic test according to specific code. If any defects appear they must be repaired and retested according to API code. The result of analysis is that hollow - bead, slag inclusion and porosity are the most common welding defects. They represent 73 % ; Hollow - bead 32% ; slag inclusion 23% and porosity 18% of the total welding defects. The result of studying defect's location is that two of the welding defects (hollow - bead and porosity) are located between 2:30 and 4.00 O'clock position and between 8.00 and 10:30 O'clock position. Welding in these positions is difficult and needs skillfully trained welders. Slag occurs in different positions. Its common cause is carelessness in deslagging a previous layer of welded metal. Therefore, proper cleaning and deslagging are essential prior to welding any additional beads. The previous method is introduced in computer software by using expert systems to give feedback day by day.

Therefore, this saves time and effort which could be spent in calculating and controlling welding quality to reduce production cost.

This research is divided into six chapters as follows :

Chapter 1 A historical review of pipelines welded by shielded metal -arc welding and its quality.

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Chapter 3 An introduction for expert systems including definitions, types and applications.

Chapter 4 Introduces a computer program which describes the developed software.

***Chapter* 5** The traditional and the proposed methods.

***Chapter* 6** Discussion and conclusion.

LIST OF ABBREVIATIONS

Here is a list of the abbreviations used in this research

AI	Artificial intelligence
AWS	American welding society
B.th.	Burn through
c	fraction rejected
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C/o	Cut out
DC	Direct current
dk, di	Are defects
dzC	total number of defects in cap
dzF	total number of defects in filling
dzR	total number of defects in filling
Ex.pen.	Excess penetration
Ext. uc.	External under cut
F.	Filling
FASMA	Failure and scheduled maintenance analysis
H.B.	Hollow - bead
In. uc.	Internal under cut
k	Number of rejected
L.C.L.	lower control limit
L.R.F.	Lack of root fusion
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lcl	lower control limit
LOC	location
n, i, c,and z	Are counters
NDE	Nondestructive eveluation inspectors
NDT	Nondestructive testing
nji	Number rejected for i
njt	Total number rejected
nsi	Number inspected for i
nst	Total number inspected
P	Porosity.
PM	Preventive maintenance
Po	Standar fraction rejected
R	Root
R.D.	Root defect
RCM	Reliabilaty-centred maintenance
S	Slag
S.1,2	Slag between first pass and second pass
S.M.A.W.	Shielded metal arc welding
SIMS	Steamline inspection management system
UCL	Upper control limit
WDF	Welding data files are these files which have special format which can tin welding inspection results

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Mansoura University
Faculty of Engineering
Indust.Prod. Engineering Dept.

COMPUTER - AIDED QUALITY CONTROL OF WELDED GAS PIPELINE USING EXPERT SYSTEMS TECHNIQUE

By

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B.Sc. Mech. Design and production Engineering
Mansoura University

A thesis
Submitted In Partial Fulfillment For The Degree of
Master of Sciences
In
Industrial Engineering

1997

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

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Thesis Title: Computer -Aided Quality Control of Welded Gas pipeline using Expert System Technique

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Finally, I pay tribute to those who willingly gave help to the research.

The researcher
Hany I. Shafik

ABSTRACT

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CHAPTER ONE

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INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

In recent years the importance of quality management systems has been recognized in most major contracts involving welded fabrication and quality assurance has become a mandatory requirement in the majority of cases.

The reasons for this development are largely historical and followed a succession of expensive and potentially catastrophic failures. Welding is a complex technology and in any welding process (including mechanised processes) the quality of the weld is a function of the interaction of the large number of variables, not all of which are controlled to the extent that is desirable. The difficulty of completely controlling the welding process means that most welds will contain some defects even if no errors are made in selecting the materials, joint design or welding procedure. Also the continuous improvement in non - destructive testing methods means that such defects are increasingly likely to be detected. This situation leads, first, to a need to understand the cause of weld defects and how to prevent their occurrence as far as is possible. Obviously any fabricator's aim must be preventing the production of defective welds. However, the difficulty and the cost of consistently producing welds without any defects is such that we must come to terms with the fact that welded structures produced at an economic cost may contain a proportion of weld defects.This experimental study had occurred on duplication of Gas pipe line (diameter 16 inches and length about 190 Kilometers) Ras Bakr / Suez project. After welding manually by shielded metal - arc welding according to API 1104(American Petroleum Institute) , they were tested by radiographic test according to specific code. If any defects appear they must be repaired and retested according to API code.The proposed method is introduced in computer software by using expert systems to give feedback on a day to day basis. This saves time and effort which could be spent in calculation and welding quality control and consequently reduces production cost.

1.2 Literature Review

As regards the papers based on welding quality control, Dilthey,Ulrich ,Oster,Martin, Georges and Damian [4] made a good survey on Mechanized gas - shielded metal - arc welding of root passes without weld pool backup. A system is described for gas - shielded metal - arc welding, with which workpieces with single -V weld preparation and variable groove width can be welded in the gravity position without support of the weld pool. For this, the energy input is controlled by specific parameter adaptation in such a way that for gap widths of between 0.5 and 3 mm .the root pass can be welded reliably and with constant root side drop - through. For the tests a robot system is used. It is fitted with an external oscillating mechanism, which can produce weaving patterns which are freely programmable. At the same time the welding speed is varied by computer.

Jeremy [5] discusses one of the latest studies which has been performed by Price. They reduced fabrication costs and improved some projects economics. High - quality defect-free welds can be deposited in API Grade 5L x- 80 steel pipeline with pulsed gas - metal - arc welding (GMAW) and shielded metal arc welding (SMAW) processes. The newly developed Grade x -80 combines higher yield - strength pipe with thinner wall to reduce fabrication costs.

Stippick [6] describes how to check welding procedures without becoming an expert. Because they are complicated and consist of relatively arcane subject matter, welding procedures overawe too many people responsible for fabricated equipment. But, welding procedures are a necessary part of code fabrication especially for pressure vessels. The logic diagram assists the individual who does not feel qualified to review weld procedures, yet feels that such a review is within their job duties. The diagram applies only to shielded metal arc welding (SMAW) and demonstrates the work to complete a competent review. Follow this system and be confident that a weld procedure meets the requirements of the ASME code and generally conforms to good practice.

Gayer, Saya and Shiloh [7] made a study on automatic recognition of welding defects in real - time radiography. This study describes a real - time radiography configuration for automatic inspection of welds. The optimal geometrical imaging configuration is evaluated and discussed in relation to conventional film radiography. The different methods were applied to various x- ray images of welds and automatic inspection was evaluated and compared with visual inspection.

Mug and Hart [8] made Non - destructive testing for pipeline girth welds. Non-destructive testing(NDT) of girth welds in offshore pipeline is normally carried out by radiography. This has been effective for the detection of weld defects for quality control purposes, especially when the manual metal arc (MMA) welding process is used. The development of potentially viable alternative methods of NDT, namely digital filminess radiography and various ultrasonic systems, the increasing use of mechanized gas shielded welding and the introduction of fracture mechanics, have prompted an examination of how NDT might continue to be used most effectively for determining the quality of pipeline girth welds.

Henrie and Long [9] present effects of wind on radiographic quality of weld metal deposited with low hydrogen S.M.A.W. electrodes. The use of low hydrogen shielded metal arc welding electrodes can be questioned if they are used in wind of appreciable speed. The purpose of the study was to determine the wind velocity at which detrimental effects occur in the radiographic quality of weld metal deposited with low hydrogen shielded metal arc electrodes. It was the intent of this study to determine the wind velocity which caused welds made with low hydrogen shielded metal arc electrodes to be unacceptable when examined by radiography in accordance with the ASME Boiler and pressure vessel code. Data generated during the study will add clarity and understanding to the problem of wind on welding with low hydrogen shielded metal arc electrodes.

Jones [10] made a good study about pipeline welding and inspection methods, a state of the art report. Tremendous progress has been made in steel pipeline metallurgy which has made pipeline stronger, tougher and, as far as the pipe steel itself is concerned, easier to weld. They have now to some extent outstripped the capabilities of traditional welding methods and need to carefully consider the methods of depositing root beads and of manipulating the pipeline on the spread. Also while standard radiographic methods are established as the inspection technique for pipeline welds, they are by no means the best method for detecting root underbead cracks. The use of traditional workmanship standards in assessing the fitness - for - purpose of pipeline structures leads to unnecessary difficulty, expense and can, in some cases, be a direct obstacle to the attainment of high engineering standards. The advent of fitness - for - purpose appendix to API 1104 should be seen as welcome step in the right direction.

Anon[11] presents adoptive welding system (calls the shots) for precision joining .In order to produce consistently high quality welds at a high production rate, it is necessary to exercise extremely close control of the welding process. This is especially true when exotic materials must be welded and when the welds must pass strict radiographic testing. The hulls of nuclear submarines, large diameter pipelines for oil and gas, and nuclear plant containment vessels are only a few examples where high quality welds are required. Because of the difficulty of producing such welds manually, a number of automatic or semiautomatic welding systems have been designed.

Kapoor 12] made a good study on cross - around pipe welding - a case study. Assessing the amount of rework in welding of cross - around pipes used as interconnecting pipes in steam turbines was undertaken to suggest remedial measures for defect prevention. This study revealed that slag inclusion was the major cause of rework. Analysis of performance revealed that the work of a particular group of welders was significaticantly better than that of others. Recommendations leading to control of defects in welding were made. This study was done on crossaround pipe components which were fabricated in one of the BHEL units. These pipes after welding were subjected to 100% radiographic examinations as per code requirements. If, on any of the weld surface defect levels was above the acceptance standard, the job was sent back for rework; it was reinspected. Data were analyzed using p - chart; defect wise indicates the slag inclusion was the major cause of rework followed by porosity. Based on discussions with concerned personnel on Cause - Effect Diagram and observations at shop floor. It was decided that, in due course, this format would be computerized.

Waston [13] presents a design of welding Examination. Where nuclear and conventional power plants, chemical process plants, and refiner require the fabrication of pressure vessels and piping systems which contain many thousands of individual weldments. Fabrication codes and specifications require that many of these welds be examined by nondestructive examination techniques (NDT)such as radiographic testing

(RT) and ultrasonic testing (UT). Advances in the state of the art of NDT have provided the industry with ever-increasing sensitivity of these techniques for the detection of welding flaws. All of these systems are fabricated by welding. For this reason, one must evaluate those variables in welding, or design for welding. which might affect the subsequent NDT. The intent of this study is to point out those areas of construction that can alter examination results or that can complicate these examinations.

Nishifuji, Kastuyuki,Morimoto, mitoshi, Fujimioto, Hideaki, Komiya and Yoshioki [14] have developed a new procedure Quality assurance system by ultrasonic examination for NNK medium diameter electric resistance weld pipe. The new medium diameter electric resistance welded pipe mill built by NNK at its Keihin works has been put into operation. This mill is a fully - automated production line in which computer is utilized to achieve high quality and productivity. The key device in the quality assurance system of this mill is ultrasonic flaw detector of fully automatic on - line type. By linking its flaw detection results with the process computer, a network of quality information control was established. Its information is transmitted to the central computer for its use as technical analysis system data.

Kimura,Tsurugi, Sumimoto, Daigo, Ichihara, Hirohisa, Yoshizawa and Mitsuo [15] present high - carbon steel and alloy steel heavy - walled erw tubes. ERW tubes are taking the place of bars and seamless tube as materials for parts of automobiles and industrial machinery from the standpoint of energy and cost savings. For manufacture of these new tubular products, techniques have been developed for preventing the cracking of high - carbon steel in the continuous casting and tube welding process and for preventing weld defects in alloy steel.

Kimata, Noboru,Ohta, Shozaburo,Suzaki and Hidenori [16] developed a method for automatic gouging by air carbon - arc method . An application to circumferential weld of pipe. On the bases of results of previous fundamental study, circumferential - automatic gouging by air carbon - arc method was applied to the shape modification of root bead in pipe welding by gas - shielded metal - arc method, for preventing incomplete fusion.

Cook [17] develops a method for quality control systems for pipeline welding - a model and quantitative analysis. A conceptual model of pipeline welding quality control (QC) system, and quantitative methodology for estimating the performance of such a system are developed. Although the QC system must strive to eliminate assignable errors, it is impossible to eliminate random errors. Figure (1.1) illustrates the system flow of the key welding activities performed by the welding and NDE inspectors, the activities of higher management are not included in the figure. The EC`s welding process, displayed on the left of the figure, is the production process on which quality is being controlled. Welding may be either mainline, tie-in, repair or double joining, although in the latter case the QC system may be organized a little differently since it is usually performed in a shop environment.

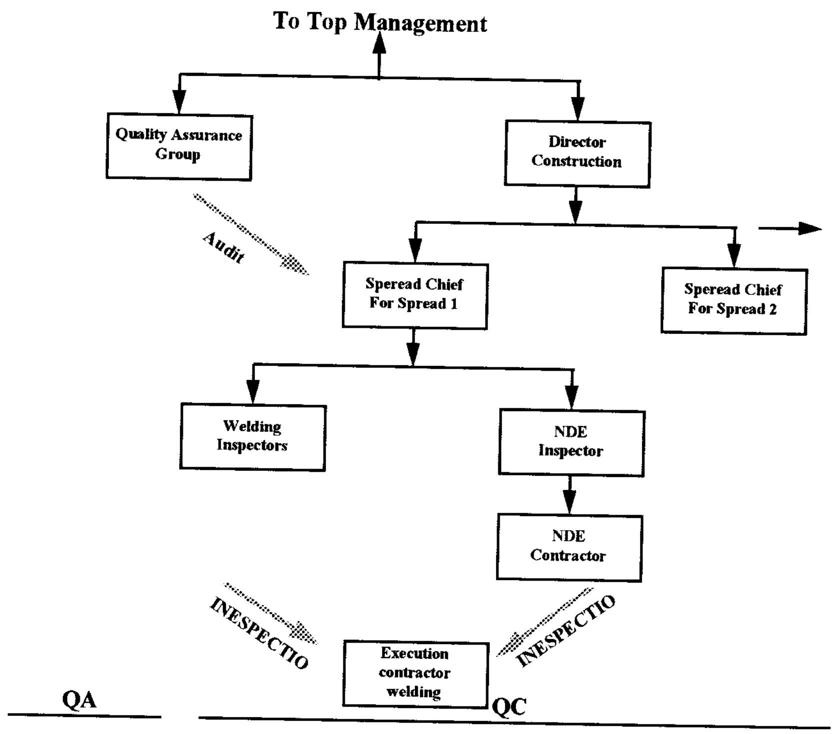

Fig. 1.1 Welding QA / QC organization

All welding comes under the review of the welding inspector, who visually inspects the welds and accepts or rejects them. Accepted welds are first radiographed by an NDE contractor, and then the radiographs are interpreted by qualified radiographic interpreter, who usually is working for contractor. Multiple interpretations may be required. The interpretations are usually signed by the NDT inspector, which constitutes the final acceptance or rejection of weld. All activities in production and QC system are susceptible to error. Welding operations, whether manual or automated produce some welds that are unacceptable under API 1104 .Field weld repair rates averaged about 23% on the Eastern Leg of ANGTS and about 27% on the Western leg, both of which used manual welding. In addition, there were substantial variations among different spreads on the Eastern and Western leg. The low repair rate averaged about 13% ,while the high exceeded 37% Since all the welding and NDE processes or activities are imperfect by their very nature, they will always produce a certain number of chance variations or errors. However , they may also produce some assignable errors if they are not working properly.

A proper welding QC system will quickly discover and eliminate such assignable errors of the different kinds of defects that can occur in pipeline welds. It is often necessary to maintain control charts for each major type of defect, and possibly charts on certain welders, such as those that compose the pipegang, certain types of defects are often ascouted with specific welding tasks or procedures. If the frequency of a particular defect increases, the frequency may often be reduced by a slight adjustment to welding procedures.

Turnell and Marsh [18] present a low alloy steel in oil refinery service. It covered, choice of electrodes, storage and handling of low hydrogen electrode, baking of electrodes to reduce moisture content, control hydrogen levels and preheating.

Ellis [19] describes how increased quality requirements have been accommodated in the manufacture of power generation pipework. An analysis of the work content by operation for a typical 660 Mw turbine generator contract is shown. Details of the following processes are discussed: hot and cold bending of pipe; preparation and assembly of pipe and fittings, welding quality and NDT testing by ultrasonic and radiography.

Still and Rae [20] have studied laybarge inspection of submarine pipelines.Engineering critical assessments were used to reduce weld repair rates.Aspects covered include: type of pipelay vessel;welding procedure; comparison of wet and dry radiography; inspection procedures; selection of inspection personnel and use of fracture mechanics

.

Apakhov and Zheleeznyak [21] made Ultrasonic inspection of the resistance welding of pipes. A new method is worked out for the complex quality control of welded joints. The method consists of ultrasonic flaw detection in combination with selective fractographic analysis envisaging discovery of discontinuities.

Gallant and Hripcsak [22] have developed expert systems for medical diagnosis diagram, an example of expert systems is shown in figure(1.2).Input nodes take the information about the selected symptoms and their parameters. These can be numerical values assigned to symptoms, test results, or a relevant medical history for the patient. In the simplest version. input signals may be the binary value I, if the answer to the symptom question is yes, or -I, if the answer is no. the " unknown" answer should thus be made 0 to eliminate the effect of the missing parameter on the conclusion. With I input nodes, the network is capable of handling that many binary or numerical disease or patient data.

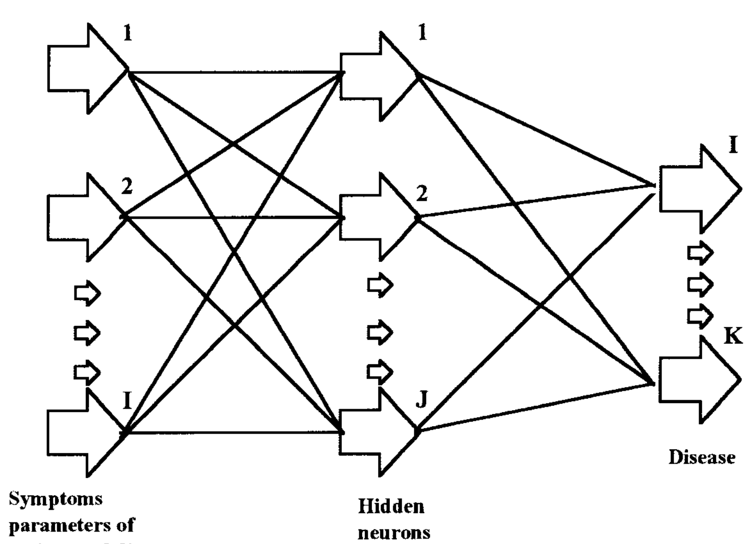

Fig.1.2 Connections Expert System For Diagnosis

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COMPUTER - AIDED QUALITY CONTROL OF WELDED GAS PIPELINE USING EXPERT SYSTEMS TECHNIQUE

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