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Improved performance of Fluid Power System using Updating Knowledge-Based System

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ABSTRACT

Fluid power system plays major roles in modern industry. In much heavy industrial equipment and machine (stationary and Mobil), power transfer is mainly provided by a fluid power system. Reliable operation of hydraulic system can only be ensured through proper design, effective maintenance and continuous monitoring.

The rapid growth in the development and application of Information technology and artificial intelligence technology hold great potential for enabling the distributed and intelligent fault diagnosis. A knowledge based expert system will employ situation-action rules (production rules) to diagnose a failure and subsequently identify specific component or units which caused the failure.

Diagnosing problems with fluid power system usually requires personnel with extensive experience or education.. Diagnosis of problems with recommendations from a computerized assistant would be highly useful.

The present work develop and implement an export system (Hdro- diagnosis) for this paper describes the development and implementation of Hydro-Diagnosis, an expert system for diagnosis of Hydraulic circuit and for recommendation of corrective action.

Key words: Expert System, Fluid power, Fault diagnosis

الخلاصـــــة

تلعب المنظومات الهيدروليكية على مختلف انواعها ودرجات تعقيدها دورا أساسيا في عملية نقل الطاقة في معظم المكائن والمعدات الصناعية الثابتة منها والمتحركة. ومع ازدياد الحاجة الى استخدام هذه المنظومات وازدياد درجة تعقيد المعدات المستخدمة لهذه المنظومات وتنوعها ، دفع بالحاجة الى ضرورة المحافظة على عمل هذه المنظومات بصورة مستمرة لضان استمارية الأنتاج والتقليل من احتمالية التوقفات التي قد تصيبها.

أن التطور السريع الذي شهده كل من قطاع تكنولوجيا المعلومات وتكنولوجيا الذكاء الصناعي وفر امكانية عالية للتمكن من التشخيص الذكي للأعطال في الدوائر الهيدروليكية الشائعة وبالتالي سرعة تحديد الاعطال وايقاف الخلل في العنصر او الدائرة ومن ثم توفير الأسلوب الأمثل والأسرع لمعالجته. أن عملية تشخيص الأعطال في المنظومات الهيدروليكية يتطلب عادة الأستعانة بخبير متخصص بعمل الدوائر الهيدروليكية او الاستعانة بنظام برمجي يكون أكثر عونا في حالة غياب الخبير.

يهدف البحث الى بناء نظام معلوماتي –محوسب يعتمد على مبدأ تشخيص العطل في أجزاء وحدات الدائرة الهيدروليكية وتوفير الحلول اللازمة لمعالجته لأعادة المنظومات الى عملها موفرة بذلك عاملي الكلفة والوقت.

1. INTRODUCTION

Machine breakdown and maintenance delays are large contributors to lost production and increased operating cost in different sectors of industry. In recent decade an extensive research was done to apply an expert system technology to diagnostic and predictive maintenance [1].
With increased demand for availability in fluid power system applications, it is becoming increasingly cost effective to specify in-built diagnostics as part of the system design. Diagnostic information can be used as an aid to manual fault finding or as part of a wider architecture for system monitoring and control [2]. The task of a diagnostic system is to read data manually or through an interface from one or more sensors or gauges to establish information regarding the fault condition of a plant (Fig. 1).

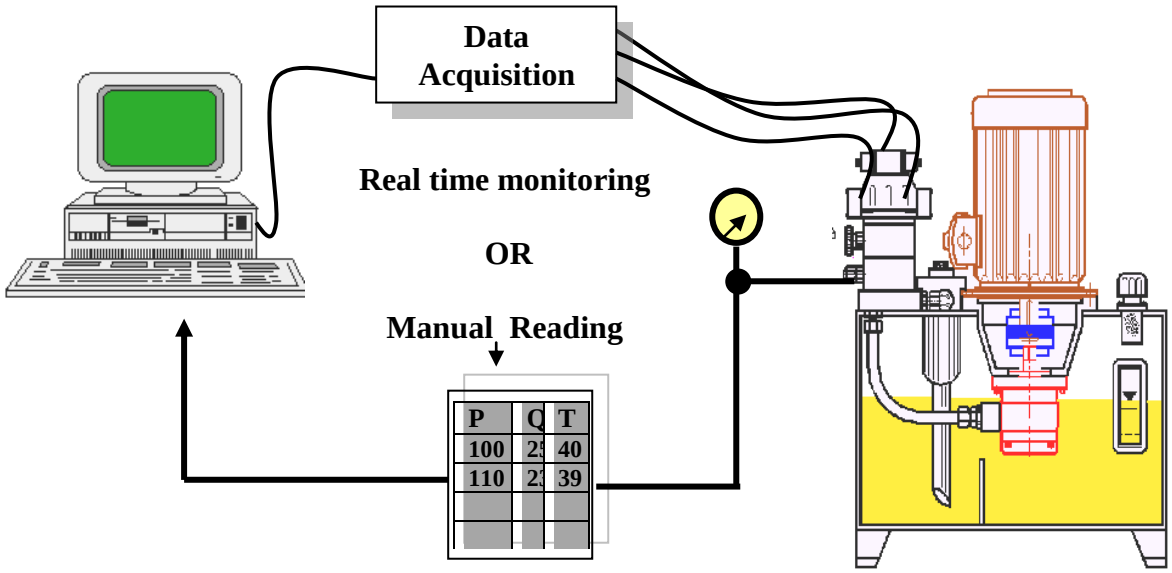


Figure (1) Fault monitoring in fluid power System

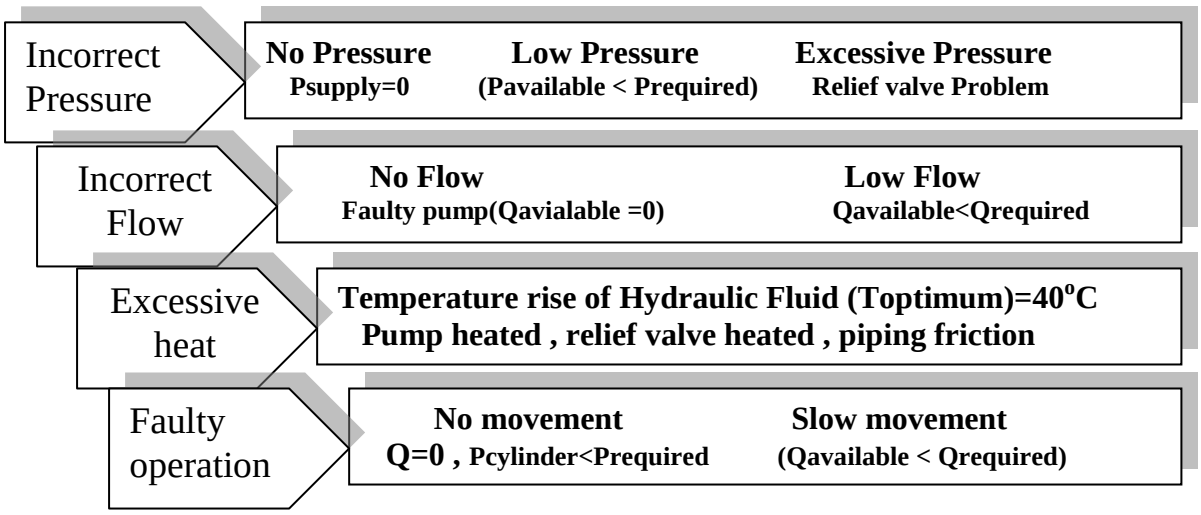
Fault diagnosis for hydraulic circuit relied on human intervention to recognize small problems such as vibration and noise, and personal experience to obtain solution in the past days. With the rapid development of high technologies in the world, the industrial equipments become more and more complicated and sophisticated. Fault diagnosis for industrial equipments is facing serious problem due to distributed and collaborative industrial activities. In hydraulic applications there is a growing trend toward information technology and artificial intelligence technology [3].

2. FLUID POWER SYSTEM

Fluid power is the technology that is concerned with generating, controlling and transmitting power using pressurized fluid.

It is normally consist some hydraulic component and hydraulic unit such as (supply unit, control unit, cylinder, piping network…etc) which connect together to form a hydraulic circuit**.**

The main parameters which should be checked and tested by measuring instrument (Pressure , Flow and Temperature) with an pressure gauges or pressure transducers , Flow meter and temperature gauge or temperature sensor. Figure (2) shows the main problem which normally expected to happened during the operation of hydraulic system.



P=pressure , Q=flow rate T=Temperature

Figure(2) Common Faults and Problem in Hydraulic System

3. THEORY OF FAULT DIAGNOSIS OF HYDRAULIC CIRCUIT

The general step of fault diagnosis of Hydraulic circuit is shown in Fig.(3) Where some of product faults comes from the manufacture which should be tested before connect to the fluid circuit.

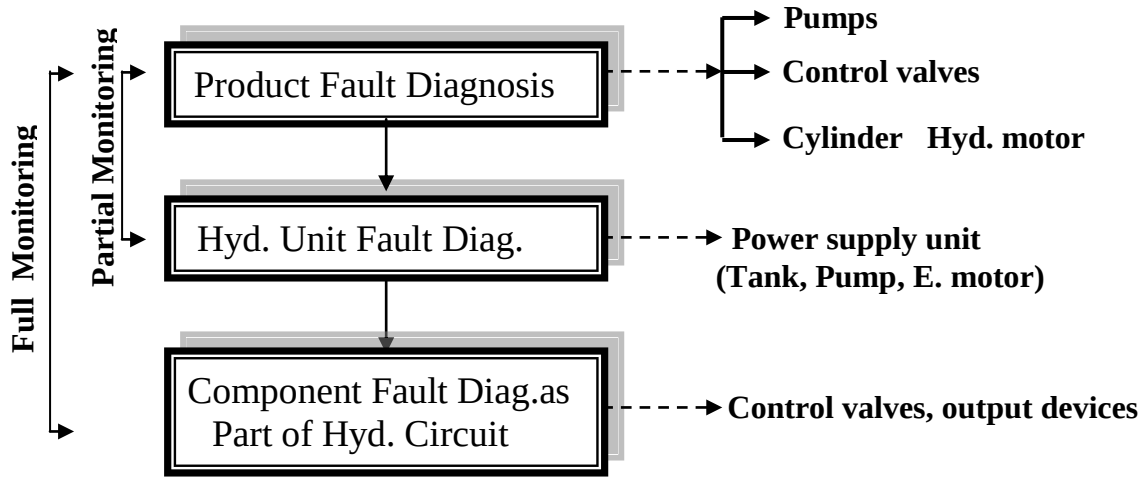


Figure (3) Step of Hydraulic component and circuit Diagnosis

So the main steps of Fluid power circuit diagnosis can be summarized by

1- Separate hydraulic component fault diagnosis
2- Separate hydraulic unit fault diagnosis
3- Complete hydraulic circuit fault diagnosis

4. EXPERT SYSTEM AND FAULT DIAGNOSTIC STRATEGIES

Increased interest in problem-solving decisions in the area of engineering leads to an increased demand for expert system applications. So, experts are needed at each installation to diagnose problems with hydraulic circuit. These may be engineers with formal, training,

experienced operators, experienced maintenance personnel or consultants.. In absence of the expertise from the work location an alternative means which should be available to give the solution for the detecting faults. Expert system is considered as this very active and useful technique to replace the absence of the experts [4].

Expert systems are computer programs that incorporate a large amount of knowledge in a very specific field and are used to give advice or solve problems [5-6]. These incorporate knowledge of experts and attempt to simulate the reasoning process**.**

Figure (4) shows the main component of expert system which interact together to reach the required goal.

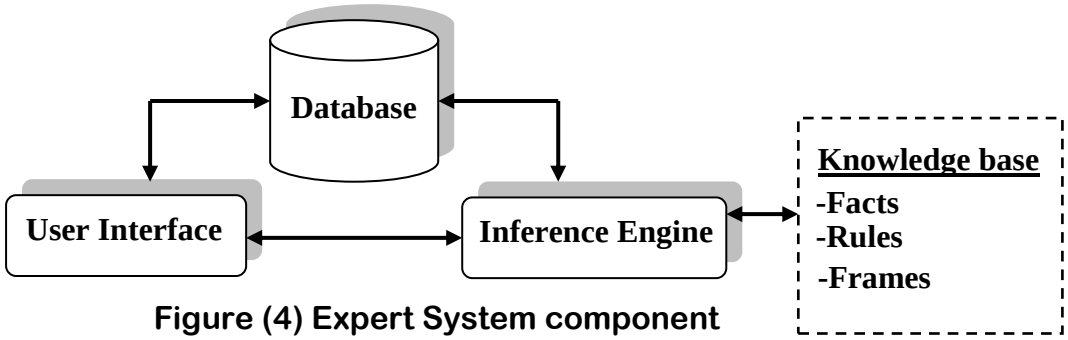


Figure (4) Expert System component

The first component is a database that contains information about each hydraulic component and its predicted operational and physical faults. The database can either be an adaptation of an existing database or created by the user. The second component of the program, the user interface, contains visual prompts for the user to enter information, provides help information on system program use and program assumptions, and provides access to the database.

The third component, the inference engine calculates the appropriate actions to be taken based on belief network logic. These three components produce information that enables the user to catalogue hydraulic component information, fault diagnosis, and select an appropriate maintenance or rehabilitation procedure.

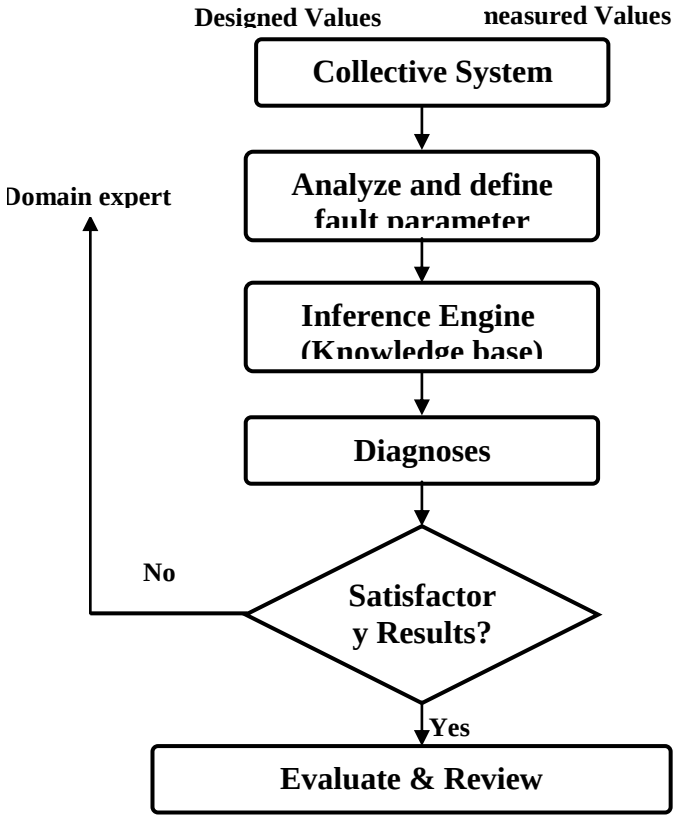


Figure (5) Diagnostic

Analysis means to find the source of the problem by determining what type of problem it is, identifying possible causes, and then shows various solutions to confirm which one has caused the system to malfunction (Fig.5). A knowledge based expert system will employ situation-action rules (production rules) to diagnose a failure and subsequently identify specific component or units which caused the failure. Inference engine mechanism applies backward and forward chaining strategy and first depth search technique for decision making [7].

SOFTWARE DESIGN _ [Hydro-Diagnosis]

For decades , Fluid power system maintenance engineer (Expert) have been asked to accurately and quickly specify the operational faults and find the right solution for it. For a simple system , the expert may be able to accomplish this task using a trail and error approach or his long experience but for complex hydraulic circuit the job going harder and takes more time to finish the job. Domain experts are always not available at any time and are limited in their number.

The alternative means of quick prediction of a complex fluid power system operational fault is the personal computer with an effective software package. The use of personal computer for data acquisition has been overwhelming in most fluid power laboratories and industrial locations. The major function of the PC is to be a house of measured parameters (P,Q,T) and the information which get it from the expertise for the most expected faults and their solutions.

Hydro-Diagnosis is an expert system designed and built up to diagnose the operational faults of hydraulic circuit which depends on the comparison between the design values and the actual values and to provide the right solution to these problems. The programming language of the system software is Visual basic6 and its operation platform is windows xp. A large database of expected faults and its solutions has been built inside the program and it can be used for specific predicted fault. The system software includes fault detection and diagnosis expert system main program and other sub-program which covers the component maintenance guide and a graphic representation for the stored data. The main menu of the package is shown in fig.6.

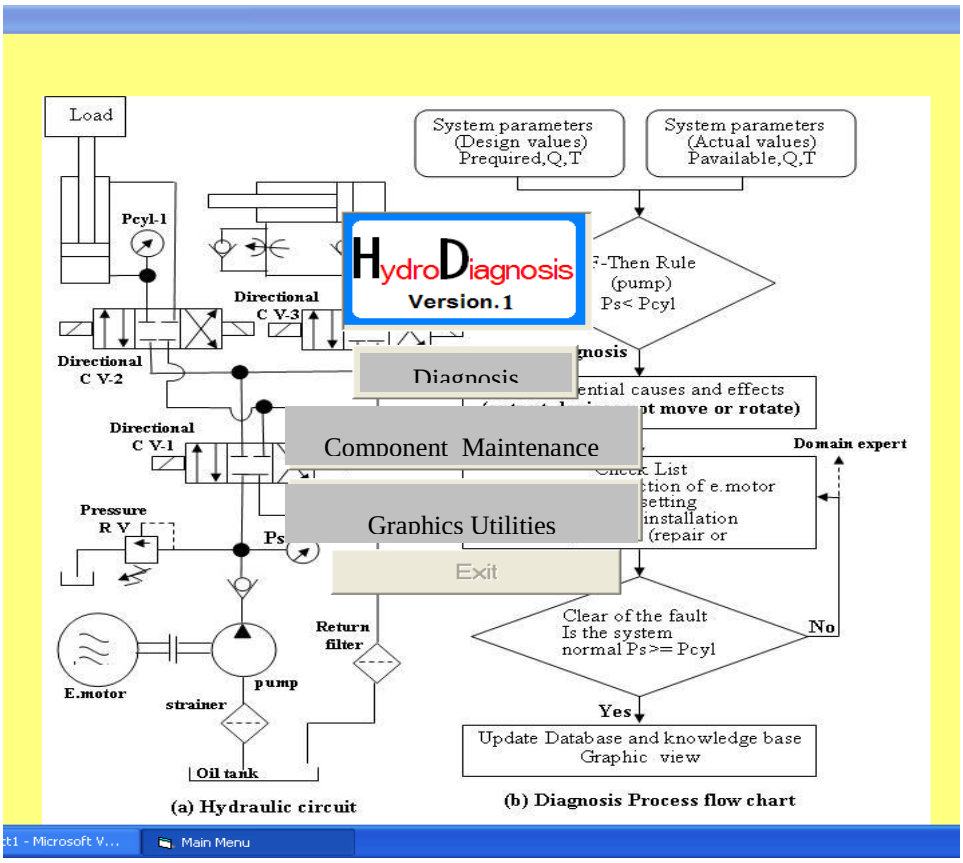
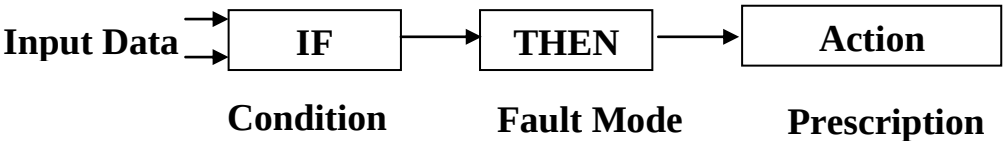


Figure (6). Hydro-Diagnosis Software

Diagnostics:

In this main program a traditional IF-THEN rule used which each rule will give the fault prediction , action and solution as shown later in the section of (SAMPLE OF RULE BASE). In the present work the system will ask the operator to provide the diagnosis parameters like Pressure, flow rate and temperature at different point of measurement in the system. It is very important that the operator should try to enter the right values for each point of measurement in order to get accurate fault diagnosis.



Component Maintenance : The Hydro-Diagnosis also include a procedural aiding expert system that provides a detail information ,explanation and rule maintenance to the user of any part of the component**.**

Graphic Representation : One of the options available to the user in this package is data recording .This capability allows the user to represent the performance of the hydraulic circuit operation in graphic ways (Figure 7) which help the user to have an idea of system operator at a specific period of time. It also able to archive the data for future reference

Ps	Pcyl	Q	Ts	Tr
100	97	25	40	45
102	98	25	40.5	44
100	97	25.5	41	45.5
104	99	26	40.5	44.5
102	98	24.5	40.4	44.5
103	97	25	40	45.5
101	98	25	40	46
102	99	25.25	40.5	47

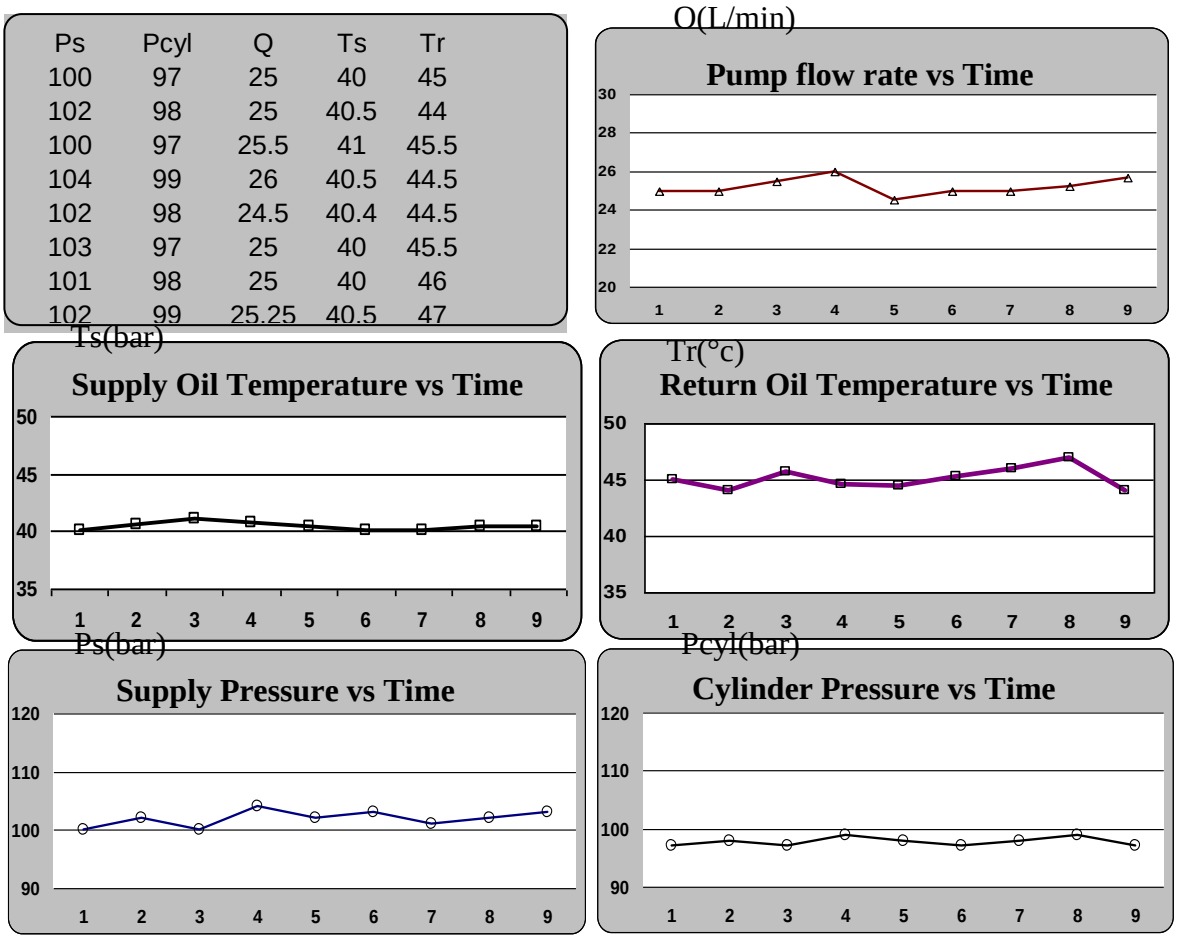


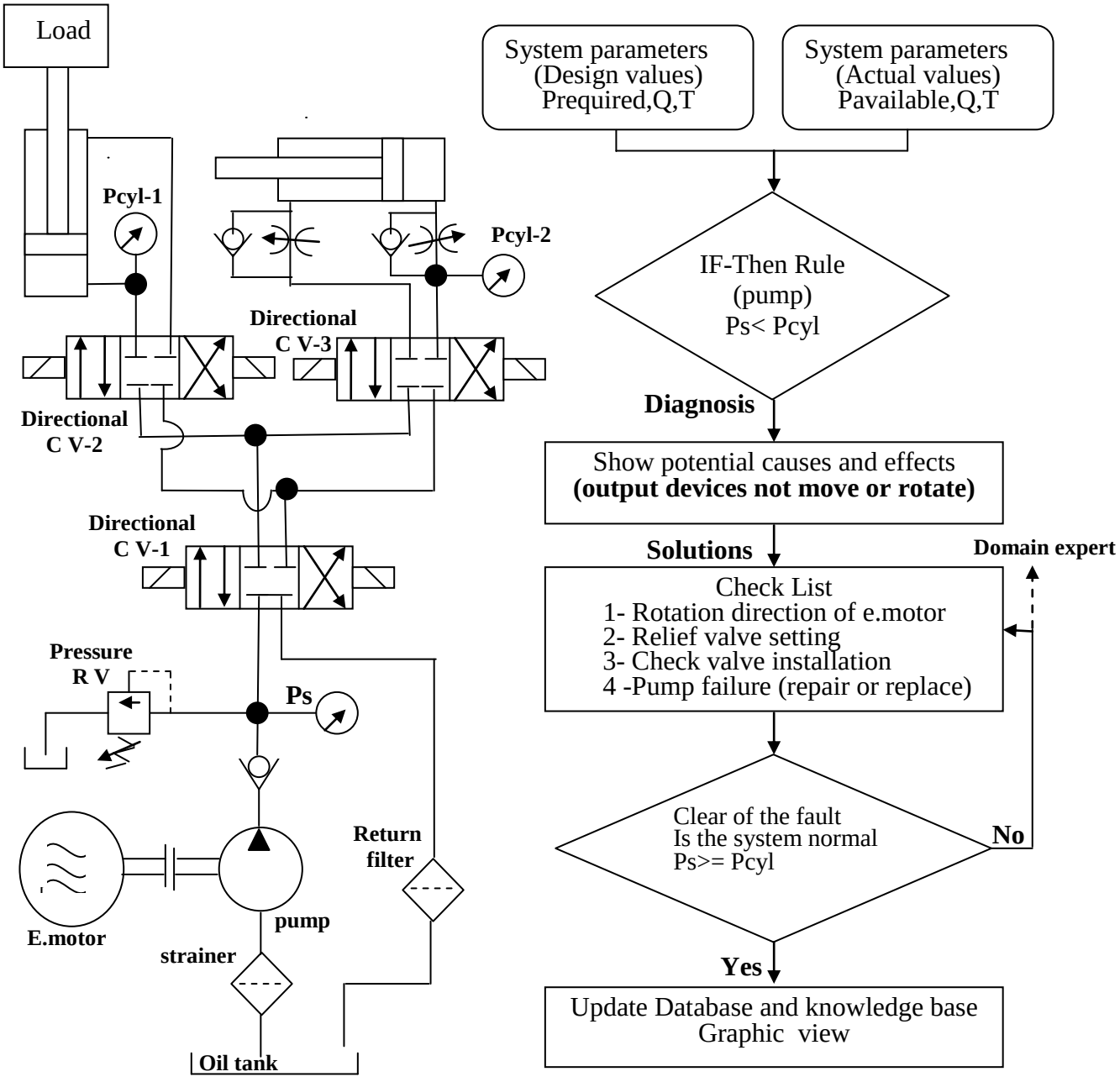
Figure (7) Pressure – Flow – Temperature Charts

5. SAMPLE OF RULE BASE

Low pressure is one of the common faults of fluid power system. Pump wearing, relief valve performance has direct connection to the pressure. In fluid power industry, it is necessary to identify and locate fault causes while the fault effects are always known for the poor operation performance. Figure 8 shows the diagnosis process.

$$\mathbf{Ps = P_{cyl} + \triangle P_{losses}}$$
$$\mathbf{P_{cyl} = F/A_{cyl}}$$
$$\triangle \mathbf{P}_{losses} = \triangle \mathbf{P_{piping}} + \triangle \mathbf{T}_{throttle}$$

Ps = supply pressure (bar)
P_{cyl}= Cylinder pressure
F= external load (kg)
A= cylinder Area ($cm^{2)}$



(a) Hydraulic circuit **(b) Diagnosis Process flow chart**

Figure(8). Diagnosis Process

6. CONCLUSIONS AND recommendation

Early failure detection in fluid power system is an important issue in prediction maintenance. This paper presents the fault prediction and diagnosis process of a knowledge-based diagnostic system that is able to predict and diagnose faults in hydraulic systems. Applying the expert system (Hydro-Diagnosis) increase the productivity and decrees operating cost by reducing the frequency of physical and operational failures and repair times. The package has an advantage of self developed knowledge-base by allowing the expert to add a new solutions which is not included earlier in the data-base .Also , (Hydro-Diagnosis) has a graphics utilities which attached to the main program to offer an overall evaluation of system performance at any time. The packages offer an ability to treat the fault detection of many systems within the same installation while mot of the papers which is found in literature are related to a specific single machine and application.

It is important to mention the further research is needed to complete the development of Hydro-Diagnosis software to use on a PC network which covers a large numbers of fluid power systems within the same installation.

Modify the developed package **(Hydro-Diagnosis)** to interact with the On-line monitoring features which allows to visualize the states or values of any component parameters during the system operation. This technique can be achieved by using a suitable number of sensors which help to give immediate main parameters values and an instants diagnosis will appear and an immediate action will take place to return the system to normal operation.

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