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Computerized hydraulic Circuit Design by using Expert System Technology

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Abstract

The design of fluid power system which becomes more sophisticated needs good expertise in this domain. This work is based on prototype development to show feasibility of integrating the field of expert system and its application of hydraulic system design. The prototype developed in this work can be used as a design tool (for expert user) and an educational tool (for inexpert user).

The first main key of this work is the ability of the development prototype of changing the required power unit type according to the different loads attributes and the designer limitations. The second key is the ability of prototype of sizing of components of the system according to the loads quantities parameters.

Also the developed prototype helps the user to get a complete circuit design with low component expenditure and still achieve the requirement function.

الخـلاصـــــــة

نظرا لازدياد درجة تعقيد تصميم منظومات السيطرة الهيدروليكية والذي يحتاج إلى خبرة جيدة في هذا المجال. تم العمل على تطوير برنامج حاسوبي يعمل على توظيف خصائص ومفاهيم النظم الخبيرة في تصميم المنظومات الهيدروليكية. إن البرنامج الحاسوبي الذي تم إعداده من خلال هذا البحث يمكن اعتماده بموثوقية عالية في تصميم الدوائر الهيدروليكية للعاملين في حقل المنظومات الهيدروليكية ولمختلف مستوياتهم في هذا الحقل، إضافة إلى إمكانية استخدامه كوسيلة تعليمية للمستخدم الغير خبير.

إن الجزء المميز الأول في هذا البحث هو عملية إصدار دوائر هيدروليكية متكاملة من خلال إعادة تدقيق التصاميم داخل البرنامج بعد أن يتم اختيار وحدة تجهيز الطاقة المناسبة للمنظومة. أما الجزء المميز الثاني فهو إمكانية البرنامج من تعريف الحجم المناسب لكل عنصر من عناصر الدائرة الهيدروليكية بناءا على مواصفات الأحمال.

وكذلك فأن البرنامج الحاسوبي الذي تم إعداده من خلال هذا البحث يساعد المستخدم للحصول على تصميم دائرة متكاملة بأقل عدد ممكن من الأجزاء مع ضمان أداء نفس المتطلبات.

1. Introduction

Fluid power is the technology that deals with the generation, control, transmission of power using pressurized fluids. The relationships between the system components which represent the fluid power system are represented graphically by a hydraulic circuit. The purpose of the circuit is known by understanding how each component works in the circuit. In general, hydraulic system is designed by a fluid power engineer who has acquainted a good expertise in this domain.

The design of hydraulic control systems becomes more sophisticated today because the demand for high performance from these systems has increased. On the other hand, the wide speared availability of microcomputers and the growing power of these machines have made them an integral tool for many design engineers. The fluid power area is no exception of developing a computer software which covers the optimum circuit design [1,2].

2. Design Concept

Design has been defined as a search process in which a satisfactory design solution is produced from a number of alternatives. This produced solution (model) satisfies some given specifications. In general, the design process has been classified into two classes:

1) Creating new design models for new problems.
2) Modifying old design models to fit new problems.
3) The prototype of this study deals with the first class.

In order to get the best circuit design, a number of factors should be taken in consideration such as; knowledge on the function and the behavior of individual components, and knowledge on systematic behavior when such components are inserted into a hydraulic circuit.

3. System Graphical Representation

Hydraulic system is represented by a diagram which shows relationship between the system components and how a hydraulic circuit is built up. The system components are shown as symbols and connected to one another accordingly. Pipe connections are drawn as lines. The sequence of functions of a hydraulic system can be seen from the circuit diagram.

4. Expert Computing System

An expert system can be defined as "an intelligent computer program that uses knowledge and inference procedures to solve the problems that are difficult enough to require significant human expertise for their solution" [3]. It typically has a set of (if-then) rules which forms the knowledge base, and a dedicated inference engine, which provides the execution mechanism. The methodology implemented in this work can be represented graphically as shown in **Fig.(1)**.

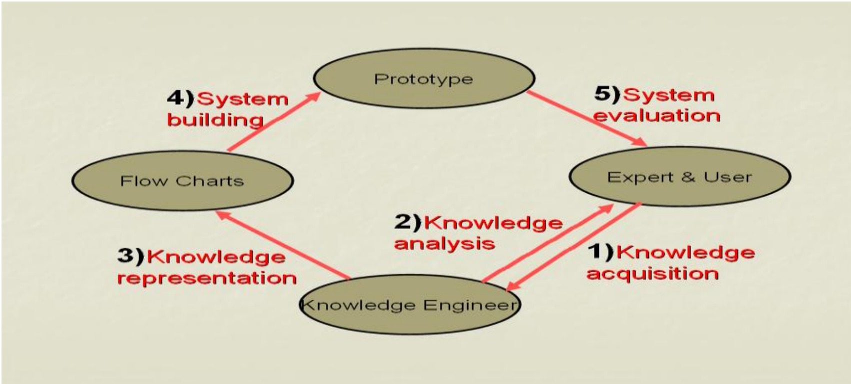

Figure (1) The methodology

The contain and function of the above components can be summarized, as follows:

a) Knowledge acquisition: This is the first step to build the required knowledge base, and it consists of literature review and expertise elicitation. **Figure (2)** shows typical knowledge acquisition process.

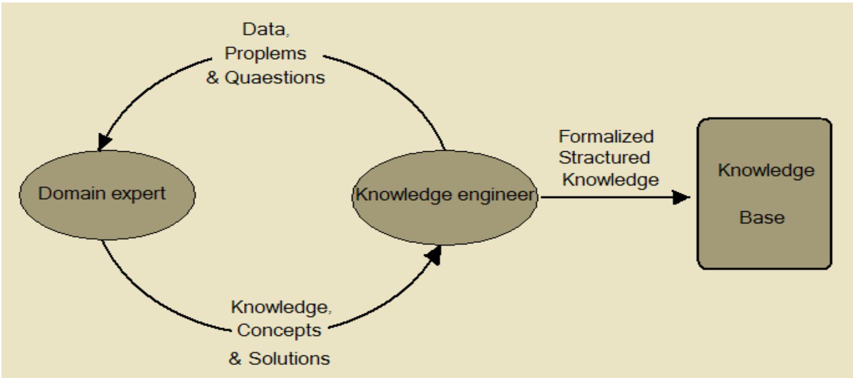

Figure (2) Knowledge acquisition

b) Knowledge analysis: The collected knowledge is analyzed iteratively in order to be ready for representation.

c) Knowledge representation: The analyzed knowledge base is represented in forms of flow charts and packages to be computerized as an expert system. In general, production rule, shown in **Fig.(3)**, is the most popular method used in the practice [4]. The important step of hydraulic system design is to put the components into proper positions using a circuit diagram. To simplify this step, a graphical frame has been used to identify the positions of the system circuits, as shown in the **Fig.(4)**.

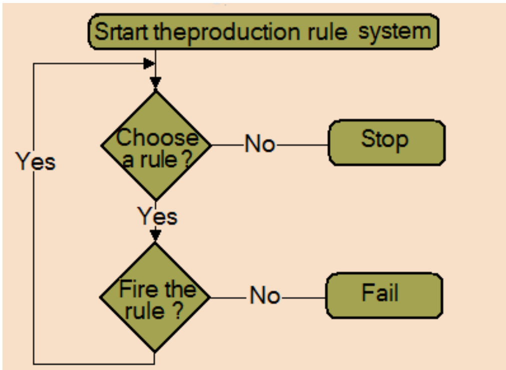

Figure (3) Production rules

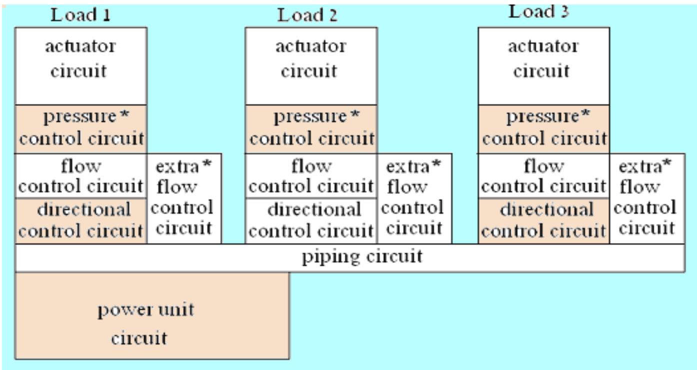

Figure (4) Graphical frame

d) System building: In this step, a computer environment, represented by visual basic programming language is applied to the knowledge base in order to develop an advisory expert system. The prototype expert system which will be developed by this study will be applied to design the hydraulic control systems. The prototype will be named "***HydroDes***".

5. Computational Work

5-1 System Description

The "***HydroDes***" program is composed of a set of rules that define the necessary circuits based on the Load Attributes, as described by the user. These attributes are included in a high-level language, i.e. without requiring specific knowledge of hydraulics. Based on some principles of hydraulic system design and expert suggestions, the load requirements, that have to input to prototype, have been identified. Every input parameter has a role in identifying the suitable option one circuit or more. Hydraulic control system is made up of these circuits that perform specific functions in the overall operation of a machine, i.e. a sub-function of the complete system. One of these rules, for example, is motion description which has roles in choosing the flow control circuit and the extra control circuit. This knowledge is represented as a flowchart, as shown **Fig.(5)**, to demonstrate the roles of this parameter of these circuits. Then, all the production rules are represented as flowchart, as shown in **Fig.(7)**.

For the system has loads greater than one, the sequence of circuits generation for one load is repeated as number of the loads in the hydraulic control system. To make prototype put these circuits, and others, into proper positions, the graphical frame detailed in **Fig.(4)** has been used.

The piping circuit depends on No. of loads and whether any load has an extra control circuit or non, as shown in the **Fig.(6)**.

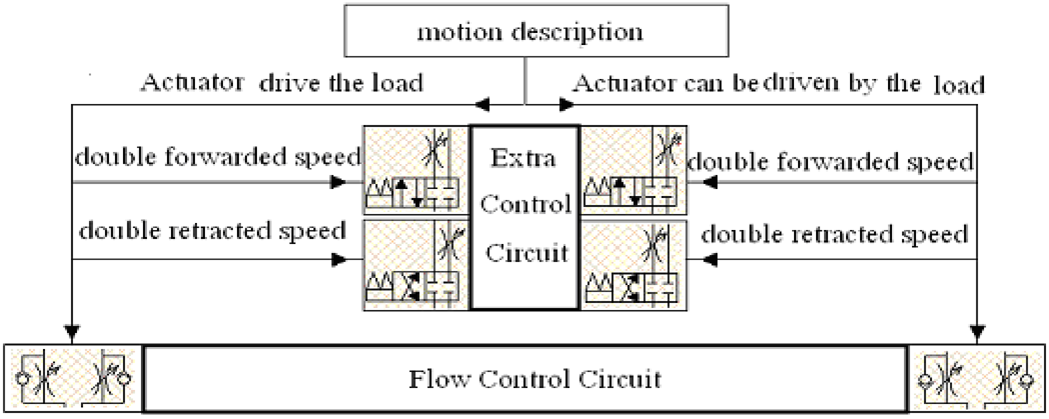

Figure (5) Role of motion description in choosing the circuits

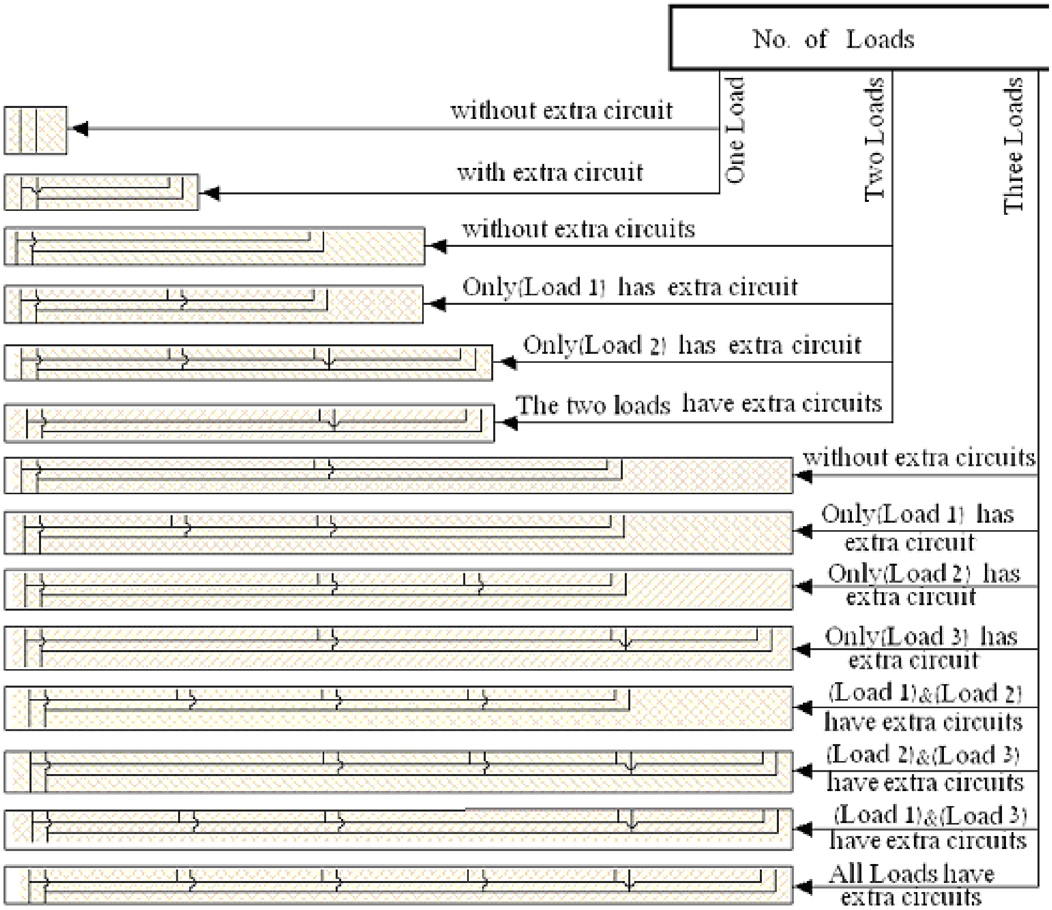

Figure (6) The effective parameters to choose the piping circuit of semi-automatic systems

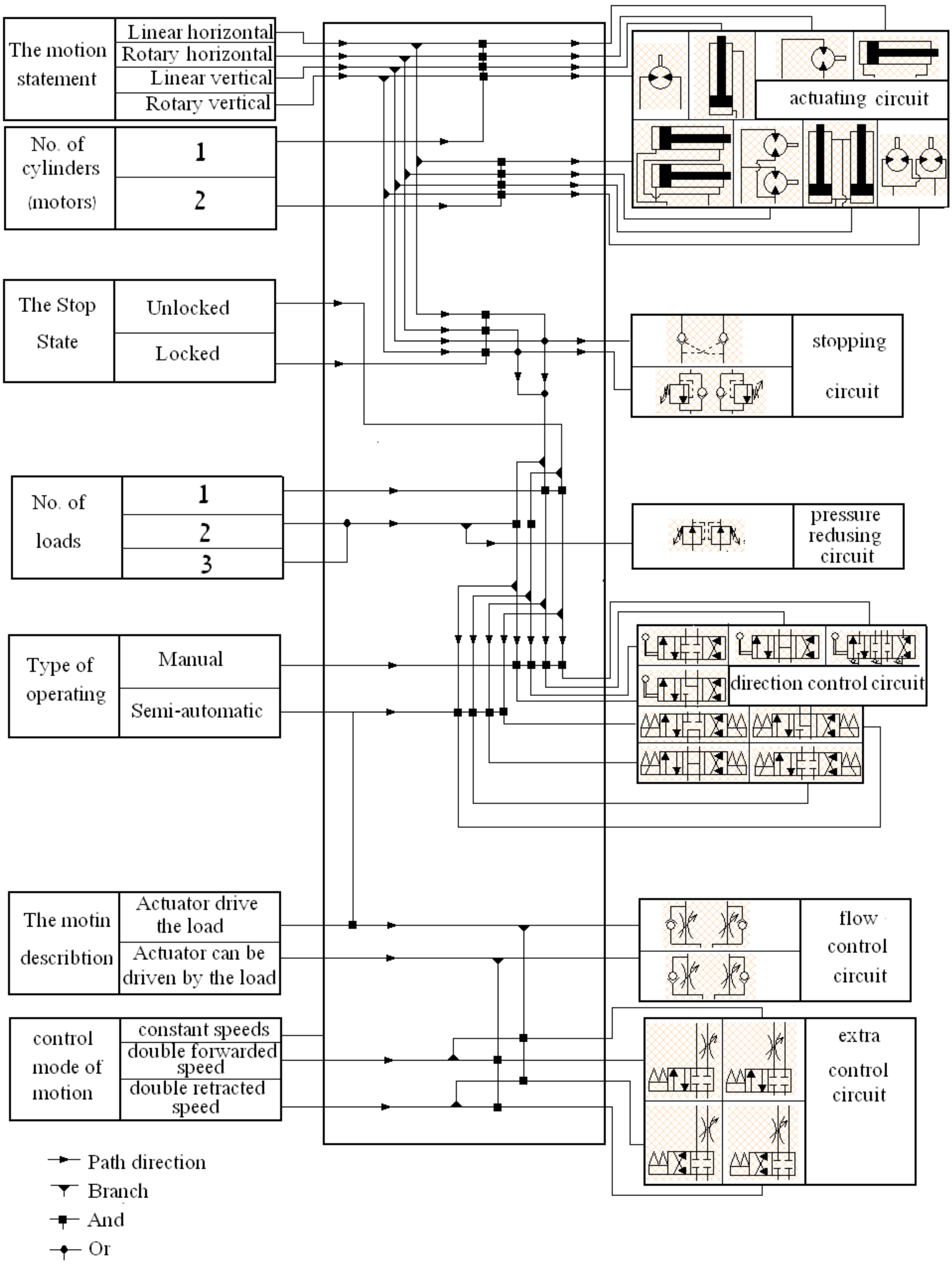

Figure (7) Paths structure of diagram generation of hydraulic control system

5-2 System Presentation

The system core is developed in Visual Basic. It runs under WINDOWS98 as well as next issues. As shown in **Fig.(5)**, the system has the following steps:

1. General information: Input (No. of loads, user experience, operating type).
2. Loads definitions: Input (qualitative attributes defined by the user).
3. System generation: As soon as circuits generation (when rules fired according to the different loads attributes), the system diagram as well as components list is displayed.
4. Power unit changing: One of the five options can be selected. This is done by one of the followings:
   - Choosing according to circuit's diagrams for expert.
   - Choosing according to circuit's aspects for inexpert.
5. System sizing: To present the specifications of the components list, user can size the system. This is done by one of the followings:
   - For expert: Input the suitable system pressure and then input the load quantities parameters.
   - For inexpert: Choose application and type of the hydraulic system to display the suitable system pressure and then input the loads quantities parameters.
6. Diagram saving: Through "File" menu, the user can save the system diagram as a picture with extension".bmp.

All interactions of the user are performed in a very simple form, through dialog boxes, as shown later. In the next sections, user interfaces of the prototype are explained in more detailed. **Figure (8)** shows steps sequence of the program usage.

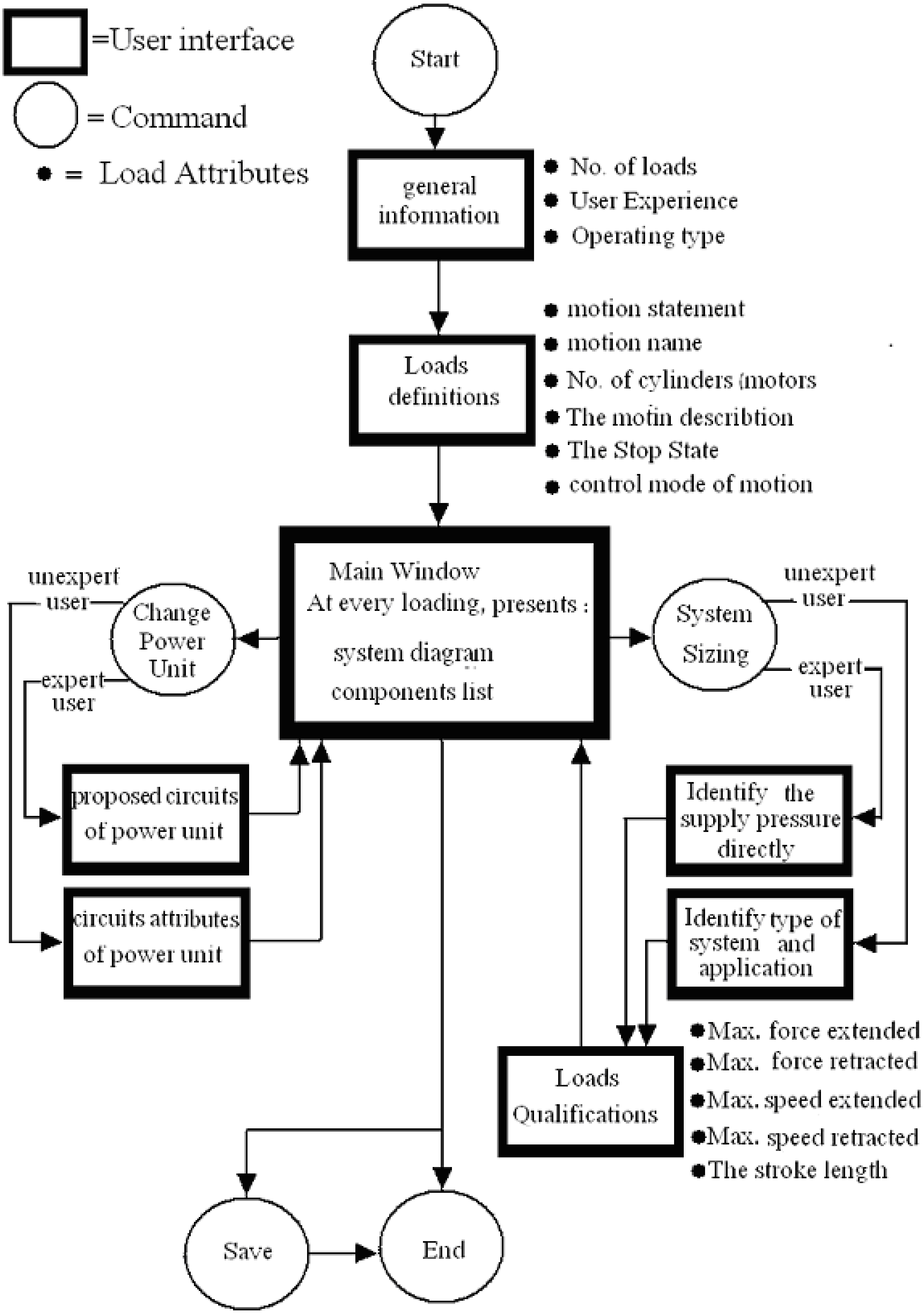

Figure (8) Program steps sequence

6. Discussion and Conclusions

The nature of special area of hydraulic system design requires more knowledge about the domain from the knowledge engineer to communicate effectively with the expert and capture a wide area of his experience. Many expert systems in the domain of hydraulic system design have been developed in the previous years, but they do not automatically generate a circuit for consideration by the user. The similar system is (Silva1998).

The knowledge based on personal experience is more difficult to formalize and express than knowledge base formal training. Experts often cannot articulate reasons for their behavior in the form of standard rules. At the end of development processes of prototype, the expert becomes more capable of organizing his knowledge.

7. References

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