2. Relief Valve Design

A critical component in a hydraulic system is the pressure relief valve. Such a valve is a part of every hydraulic system. The mission of the pressure relief valve is to protect a hydraulic circuit from excessive pressure. To a hydraulic system designer, the relief valve is simply a pressure limiter. When he analyzes his hydraulic system from an overall performance standpoint, the relief valve can be represented by very simple characteristics. As shown in Fig. 2.1, the simplified characteristics of a pressure relief valve includes the cracking pressure and the inlet pressure when the valve is passing full flow. In the simplified representation the pressure/flow curve is assumed linear.

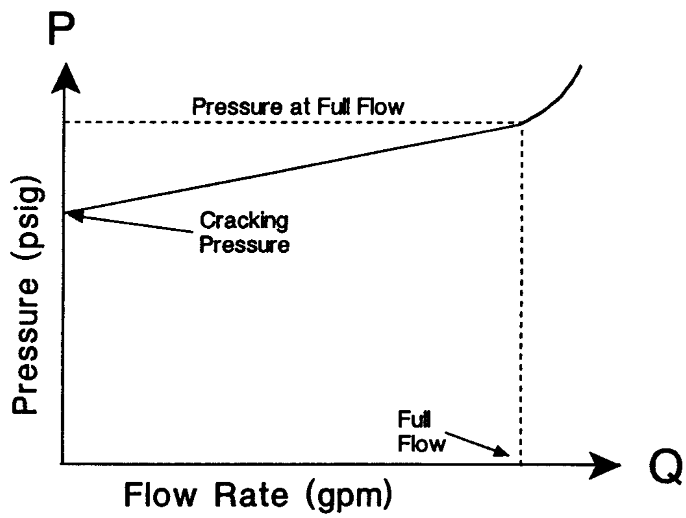

Figure 2.1. Simple Characteristics of Pressure Relief Valve.

The pressure relief valve designer; however, must be concerned with the internal configuration of the valve. Therefore, the simplified characteristics, while they are important, are not adequate for his purposes. To provide an example which illustrates the use of HyPneu in the design as well as the analysis of a pilot operated relief valve refer to Fig. 2.2. In this design, the pilot section is a spool type valve. In many pilot operated relief valves, the pilot stage is a poppet. However, this example is a very large valve which led to the use of a spool pilot. The inlet pressure is acting on both sides of the main poppet in the steady state operating mode. When the inlet pressure reaches a value which is sufficient to compress the pilot spring, the pressure on the inlet side of the main poppet is vented to tank and the poppet opens thus effectively limiting the inlet pressure. Orifice A and Orifice B provide main poppet damping during cracking and reseat operation.

In order to simulate the operation of the pressure relief valve shown, a HyPneu schematic must be developed and a system must be used the HyPneu schematic is shown in Fig. 3. As can be seen from the figure, the system is supplied fluid by a fixed displacement pump (SH1110) operating at 1800 rpm, which has an output flow at that speed of 225 gpm. The system load is represented by a variable orifice (SH5120) actuated by a signal generated by SI4125.

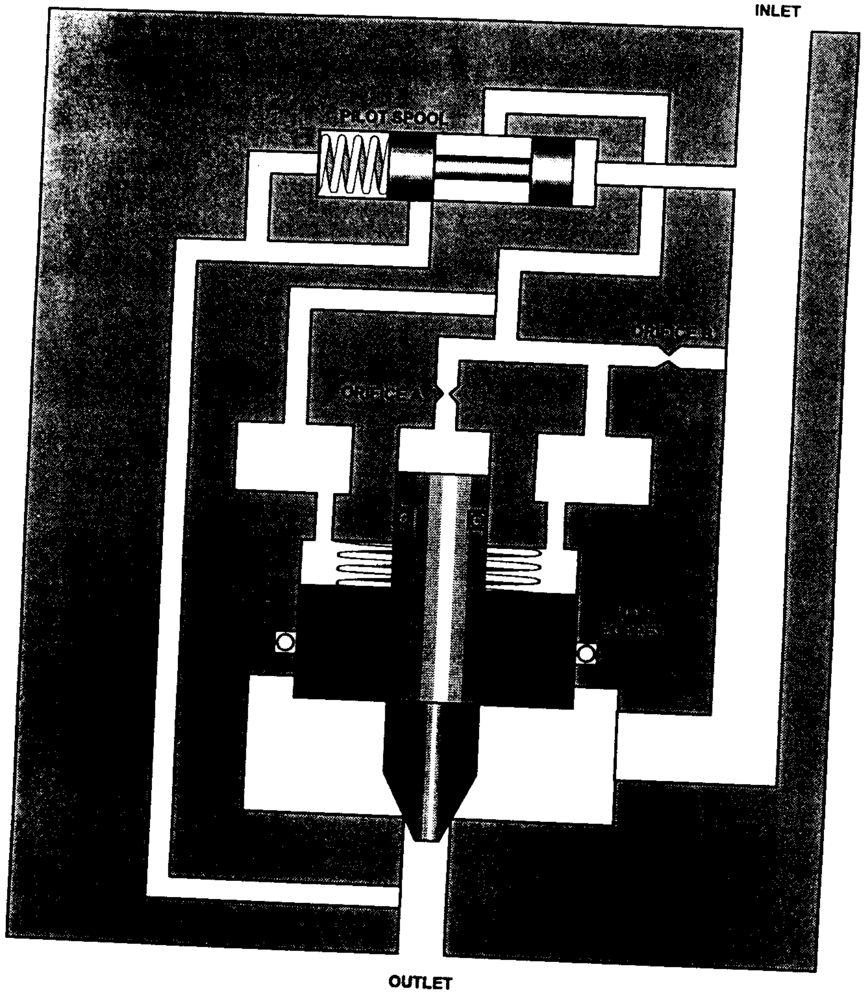

Figure 2.2. Pilot Operated Pressure Relief Valve.

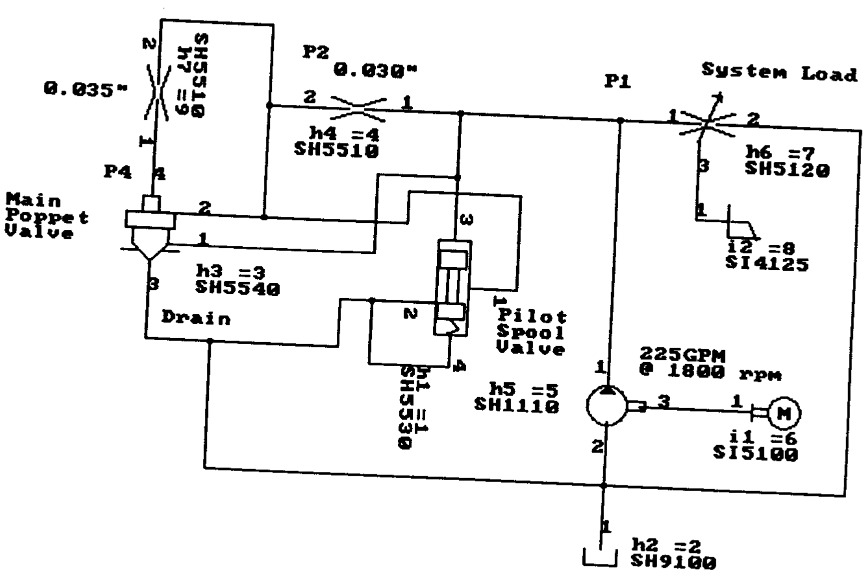

Figure 2.3. HyPneu Schematic Relief Valve Design.

The pilot spool valve was represented by model SH5530. The parameters which can be varied in order to optimize the design are as follows:

- Flow discharge coefficient
- Spool diameter at sensing end
- Spool diameter at drain end
- Spring constant
- Spool stroke
- Damping coefficient
- Spool weight
- Spring preload

The poppet valve is modeled by SH5540 which provides access to the following parameters

- Flow discharge coefficient
- Poppet angle
- Three poppet diameters
- Spring constant
- Spring preload
- Damping coefficient
- Poppet weight

The two control orifices are both represented by SH5510. It should be noted that all of these generic elements used to form the pressure relief valve model are all in the HyPneu component library.

The pressure relief valve was simulated under two sets of conditions. In one set of conditions, the load valve was closed gradually while in the other set of conditions, the load was closed instantly. The results of the first condition (gradual load) are shown in Figs. 2.4 and 2.5 while the results of simulation under the second condition (instant load application) are shown in Figs 2.6 and 2.7.

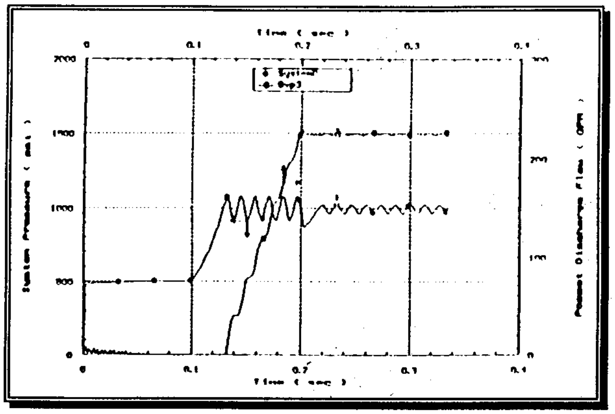

Figure 2.4.
Load Valve Closed Gradually
from 0.1 sec. to 0.2 sec.

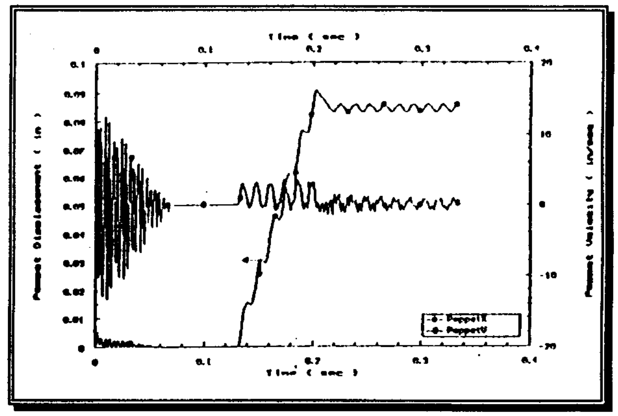

Figure 2.5.
Load Valve Closed Gradually
from 0.1 sec. to 0.2 sec.

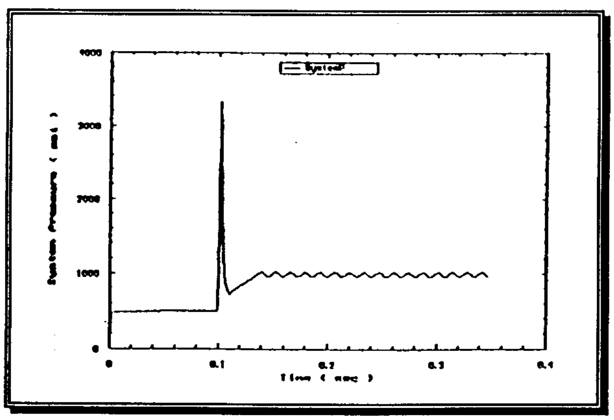

Figure 2.6.
Load Valve Closed Instantly
at 0.1 sec.

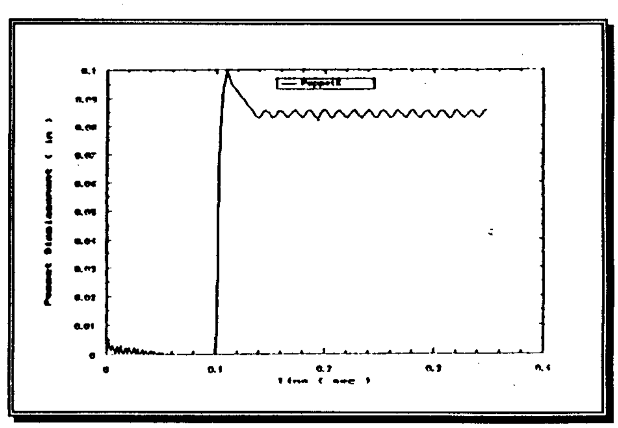

Figure 2.7.
Load Valve Closed Instantly
at 0.1 sec.