Component Design

Many hydraulic components are composed of several different basic elements. In modeling these components, two approaches may be taken. One approach, which is the most wide-spread, consists of building one large model for the complex component and including all of the basic elements. The second approach is to model the basic elements and then join them together as a system to form the complex component. The system designer is concerned primarily with the first approach since he is not going to redesign the component. However, the component designer must consider each element of the component in an effort to produce the most effective interaction.

1. Pressure Compensated Pump

One of the more complex components widely used in hydraulic systems is the pressure compensated pump. The analysis of the characteristics of a hydraulic system which incorporates a pressure compensated pump using HyPneu can be accomplished as shown in Fig. 1. Using this approach, no details of the internal pump design are known. The pressure compensated pump in this HyPneu analysis is modeled using only catalog type information concerning the performance of the pump.

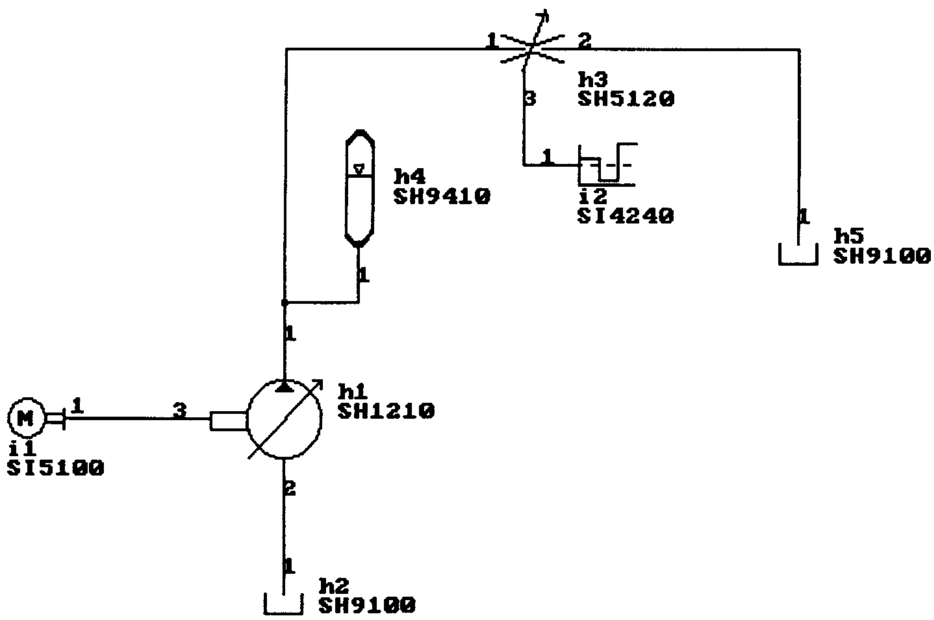

Figure 1.1. System Designers Approach to Pressure Compensated Pump.

From a component designers point of view, the system shown in Fig. 1 is not adequate. As can be seen in the schematic shown in Fig. 2. the pressure compensated pump actually consists of a pumping mechanism (pistons, swash plate, and cylinder block), a swash plate actuator, a control valve, orifices, and a relief valve. The configuration of the pumping mechanism will determine the maximum displacement of the pump. The control valve is used to supply destroking flow to the swash plate actuator when the pressure setting is reached while the size of the orifices will be critical in the response and stability of the pump. The relief valve setting determines the outlet pressure at which the pump will destroke. It should be apparent that an analysis of the system shown in Fig. 2 would be important to a component designer since he can evaluate the parameters of all basic elements which make up the pressure compensated pump.

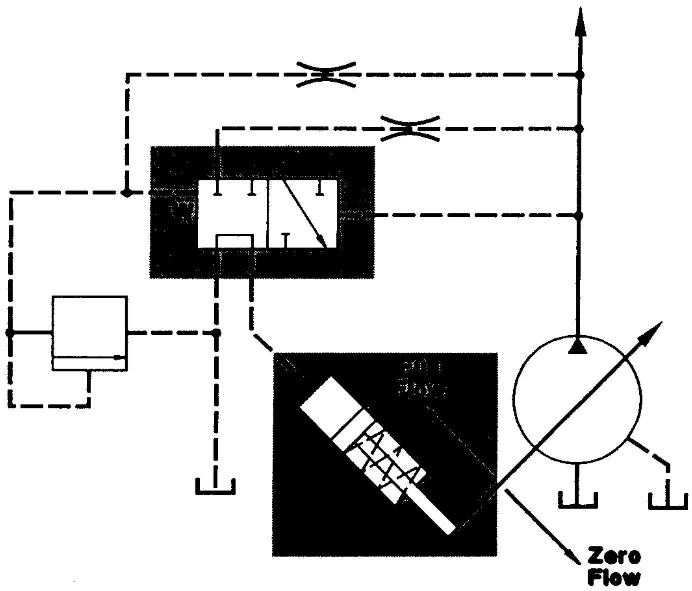

Figure 1.2. Pressure Compensated Pump Schematic.

In order to analyze the system shown in Fig. 2 using the HyPneu program, it is necessary to identify each of the elements from within the HyPneu component library. Obviously, the reservoir, accumulator, and system load valve are all part of the system external to the pump and can be described by the models identified in Fig. 1. The pumping mechanism can be represented by the model for the universal variable pump (SH1200) however, port 4 of this component must be connected to a signal element and not the mechanical output of a cylinder. The two orifices can be modeled effectively by SH5110 while the relief valve model can be found to be SH4131. However, there is no model in the HyPneu component data base which can be used to represent the control valve or the swash plate actuator as they are shown in Fig. 2. Therefore, it is necessary to alter the approach somewhat.

It should be noted that the directional control valve shown in Fig. 2 is a 4-way, 2-position valve. However, only three ports are used and therefore, the valve can be modeled as a three-way, two-position valve. The closest component model in the HyPneu library is a three position, three-way valve with the work port connected to the tank in the neutral position (SH7332). This valve is activated by a +Ve to -Ve signal. Therefore, when the input signal is +Ve the valve will function as shown in the left-hand box. When the input signal is zero, the valve will assume the centered or neutral position and a -Ve signal will place the valve in the right position. Therefore, component model SH7332 can be used for the direction control by providing a signal type input instead of a pilot pressure and insuring that the signal input is always between zero and a -Ve.

Providing a signal type input to the control valve requires the use of two hydraulic pressure transducers called AHP (SI1110). One of these transducers will sense the pressure upstream of the relief valve and change the hydraulic pressure to a signal while the other transducer will perform the same operation on the pump outlet pressure. These two signals are then summed using SI4320. Notice that when the output of the summer is zero or less the output of SI4320 is zero. Since this output is the input to the control valve, this means that the valve will receive a zero input until the pump outlet pressure exceeds the relief valve setting (on a steady state basis). Refer to Fig. 3 to observe the HyPneu circuit for the pressure compensated pump.

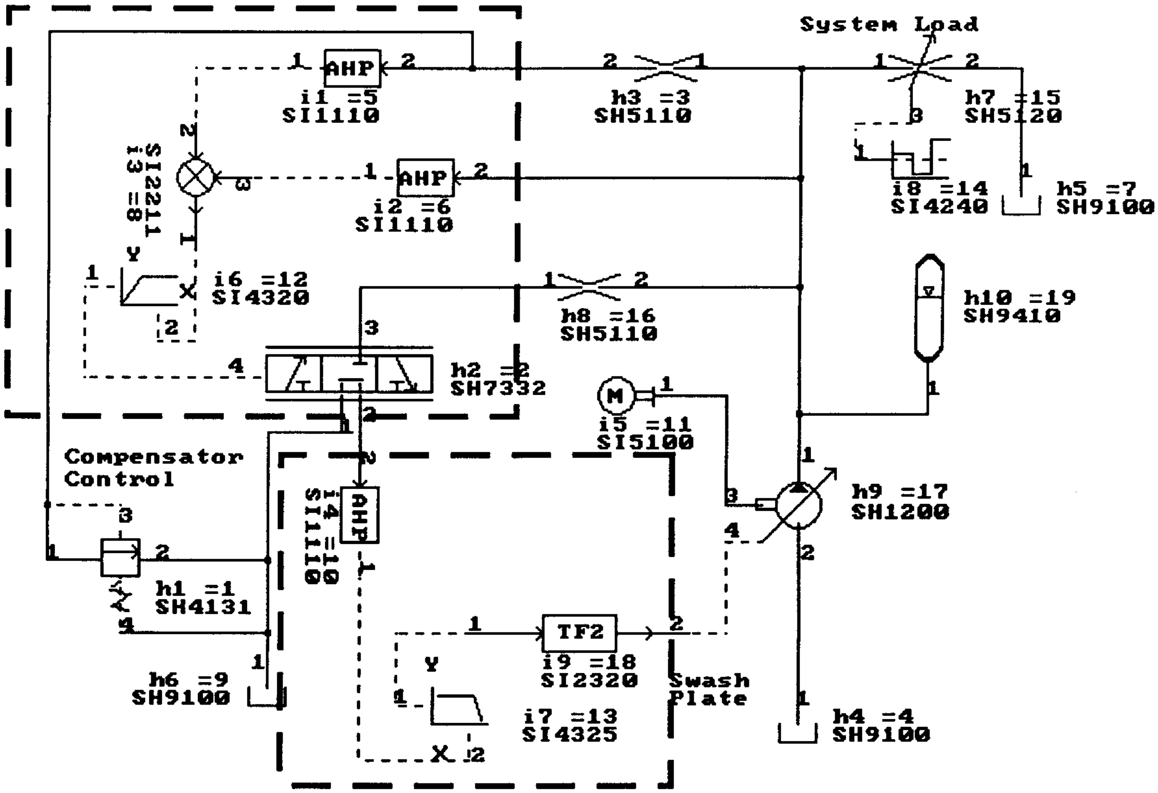

Figure 1.3. Circuit Design for Pressure Compensated Pump.

In addition to the control valve, some creative circuit adaptation must be used to provide the pump displacement input. The universal variable displacement pump model SH1200 can be used for the basic pumping component. However, to alter the displacement, the model requires a signal type input. Therefore, a cylinder cannot be used between the hydraulic signal out of the control valve and the displacement varying mechanism on the pump. This problem is solved by transducing the pressure output from the control valve to a signal with an AHP (SI1110) and modifying the output of the transducer by model SI4325. This signal then can be connected directly to the pump model SH1200. However, the dynamic influence of the displacement varying mechanism would not be included if a direct connection is made. To solve this problem, HyPneu provides several transfer function models. As can be seen in Fig. 3, a second order transfer function model SI2320 has been used to represent the dynamics of the springs, cylinder, and masses normally used in the configuration of the displacement control

For reference purposes the system shown in Fig. 3 was simulated and the results of the simulation are shown graphically in Fig. 4. In this simulation, the pump displacement was such that the maximum flow was approximately 10 gpm. The pressure compensator was then set at about 3100 psi. Then the system load valve was closed to provide a 2000 psi system pressure for the first 2 seconds. The system load valve was rapidly closed. At the four second point in the simulation, the load valve was quickly opened to a position which provided a system pressure of 100 psi. It can be seen in Fig. 4 that the pressure compensated pump performed very well under these conditions. In addition, the pump designer can now change any of the parameters and evaluate the effect of such changes.

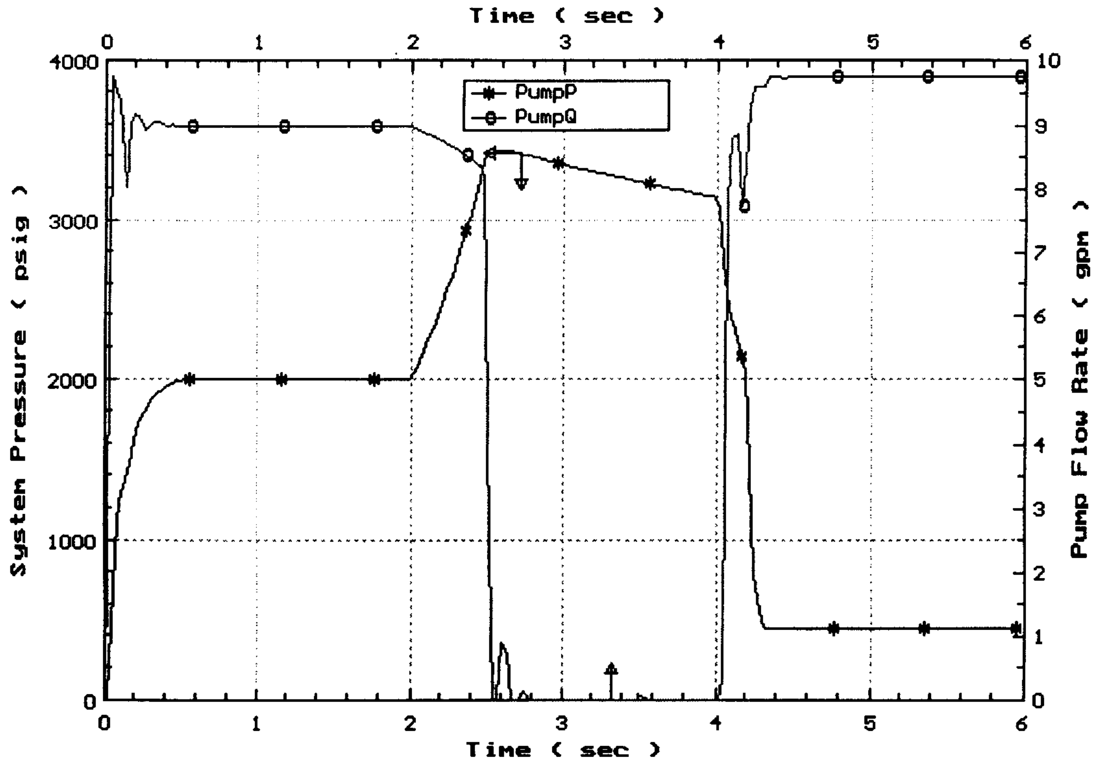

Figure 1.4. Pressure Compensated Pump Simulation Results.