A TWO STAGE ELECTRO SERVO VALVE MODELING USING HyPneu

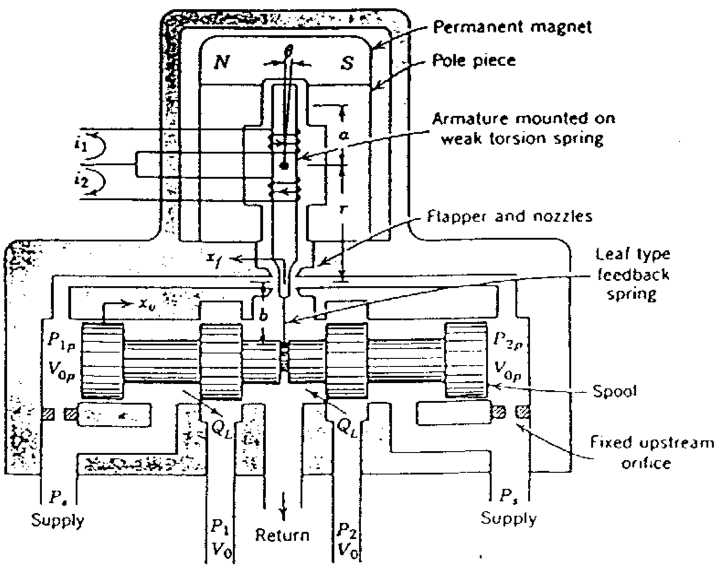
1. Description:

Two stage servo valves are designed to over come the disadvantages of limited flow capacity and instability that are inherent in single-stage servovalves. Two stage servo valves with position feed back are the most common type. The position feed back is achieved in three basic ways:

- Direct position feedback
- Force feed back using spring to convert position to force
- Placing stiff spring directly at the spool ends.

A two stage servovalve with flapper-nozzle pilot stage and force feed back is shown in Fig 1. A positive current difference causes a torque on the flapper which moves it to the left, increasing pressure on left side of the main spool and decreasing pressure on the right side of the spool . The spool then moves to the right and continues to move until the torque on the flapper due to the feed back balances the torque due to the input current. At this point the flapper is approximately centered between the nozzles, but, spool has taken a new position directly proportional to the input current. Modeling of this type of servo valve is in general very complicated unless all the design information are made available. There are two approaches that can be adopted to model this servovalve using HyPneu. They are:

1. Using transfer function block diagram for linear model.
2. Using actual electro-hydro-mechanical components for non linear model.



It is essential to know the individual components of the servovalve with their functional characteristics. The basic components are:

1. Torque motor
2. Hydraulic amplifier
3. Valve spool

Torque motor:

Torque motor consists of an armature held between a set of permanent magnets. The DC current in coils causes increased force in diagonally opposite airgaps setting decentering force on the flapper that is attached mechanically to the armature.

Hydraulic amplifier:

This mainly consists of nozzle-flapper assembly and a flapper chamber. While the flapper is rigidly joined to the armature fluid continuously flows from supply pressure through inlet orifices, past nozzles into flapper chamber and then return to tank. Rocking motion of armature/flapper throttles flow through one nozzle or the other. This diverts flow to either side of the main spool causing pressure differential.

Valve spool:

Spool slides in sleeve or directly in valve body. The force required to move the spool is directly proportional to the pressure differential created by the flapper/nozzle. Hence, the spool balance itself against the torque generated by the armature. Spool motion to either side of null allows fluid to flow from supply side to load side through port openings. Thus flow is maintained at the rate proportional to the valve opening.

Method 1. Block diagram analysis:

HyPneu can create block diagram using transfer functions in order to study the dynamic response of the servovalve. The HyPneu schematic of the above servovalve is shown in Figure 2.

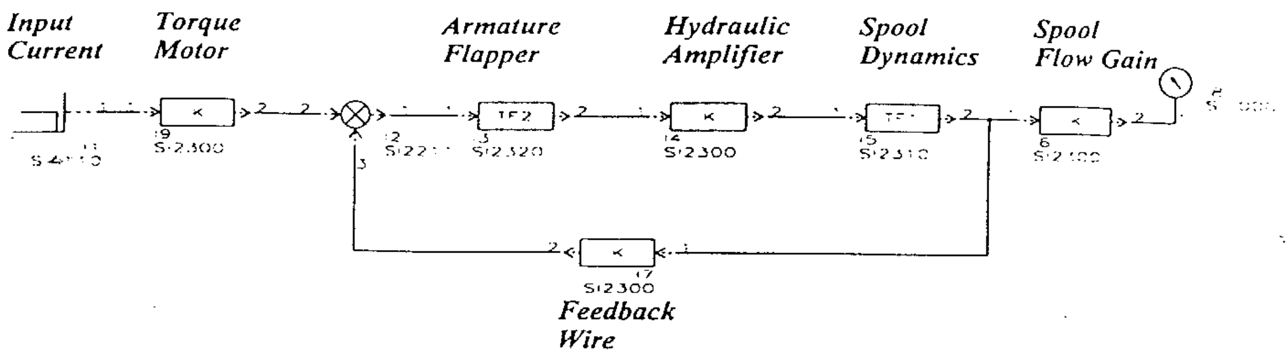


Figure 2

The above block diagram can be discussed briefly as follows indicating the functional value of each icon representing the servovalve component.

HyPneu Icon	component description	Value*
SI4110 I1	Step input signal to study the response	10
SI2300 I9	Torque motor gain	0.025 in.lb/ma
SI2211 I2	Torque summation	gain 1 & -1
SI2320 I3	Armature/flapper dynamics (2nd order system) $(1/k_f)/(1+(2\zeta/w_n)s+(s/w_n)^2$ where: w_n-natural freq of 1[st] stage, $\sqrt{k_f/I_f}$ ζ damping ratio of 1[st] stage, k_f - stiffness of armature/flapper.	k_f=115 in.lbs/in $I_f = 4.4\times10^{-6}$ in.lbs/in/sec^2 W_n=815 Hz; ζ=0.4
SI2300 I4	Hydraulic amplifier flow gain	150 in^3/sec/in
SI2310 I5	Spool dynamics (1st order system) = 1/As where: A= spool end area	A= 0.026
SI2300 I7	Feed back wire stiffness	16.7 in.lbs/in
SI2300 I6	Spool flow gain for the system	1030 in^3/sec/in
SI100 I8	gauge	

*Value adopted from Moog Type 30 Nozzle-Flapper Flow Control Servov

The above system can be simulated to obtain the dynamic response. This is shown in figure 3.

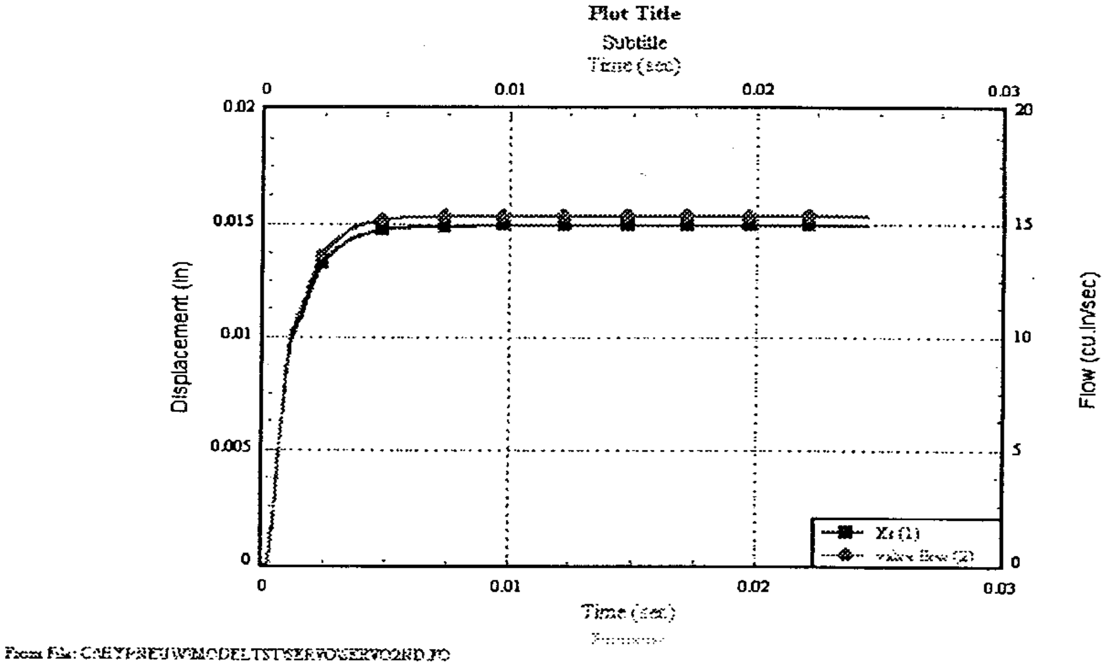


Figure 3.

Method 2. Hydro-mechanical component:

In this method, both stage 1 and stage 2 of the servovalve has been represented by using hydraulic and mechanical components. The HyPneu schematic of the above servovalve is shown in figure 4.

In the figure 4, the hydraulic amplifier part has been represented by actual flapper SI6552 and nozzles SH5520. Nozzle area varies corresponding to the flapper displacement and create a differential pressure across the spool ends represented by SH3122. This results in spool displacement, and this is sensed by the displacement sensor SI1332 that generates the feedback signal for the torque motor as well as signal to the valve area function generator UI4320. The main valve ports are represented by a set of orifice SH5510 connected in a bridge circuit. The signal from the area function generator determines the orifice area and accordingly fluid will flow through the valve depending on pressure drop across the valve.

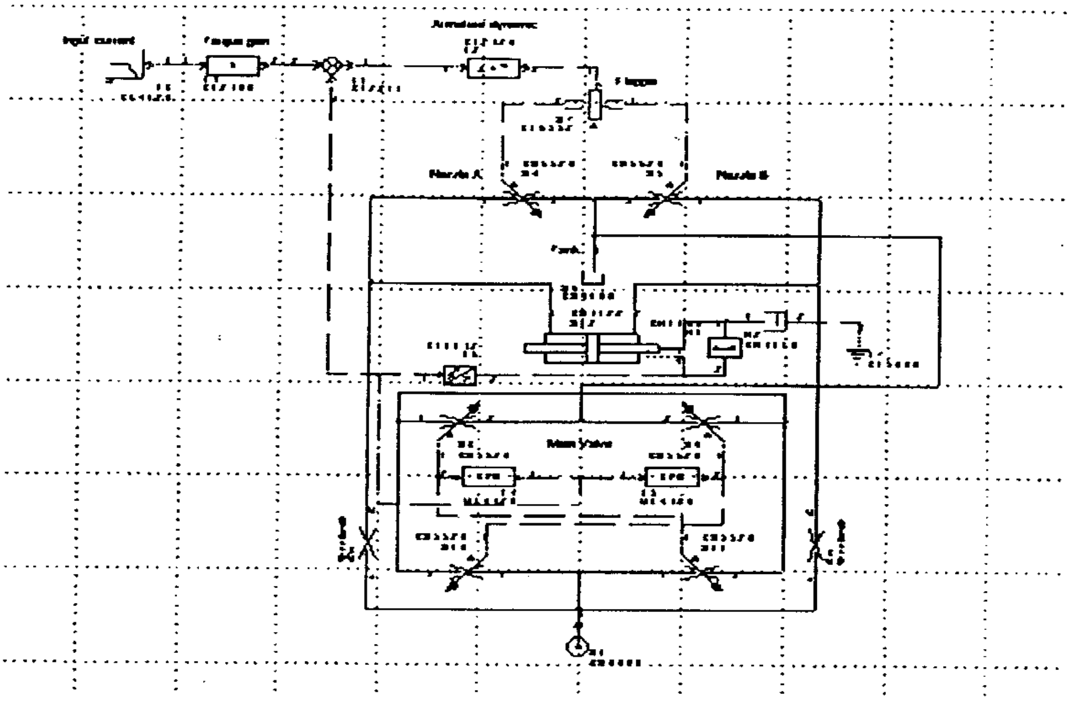
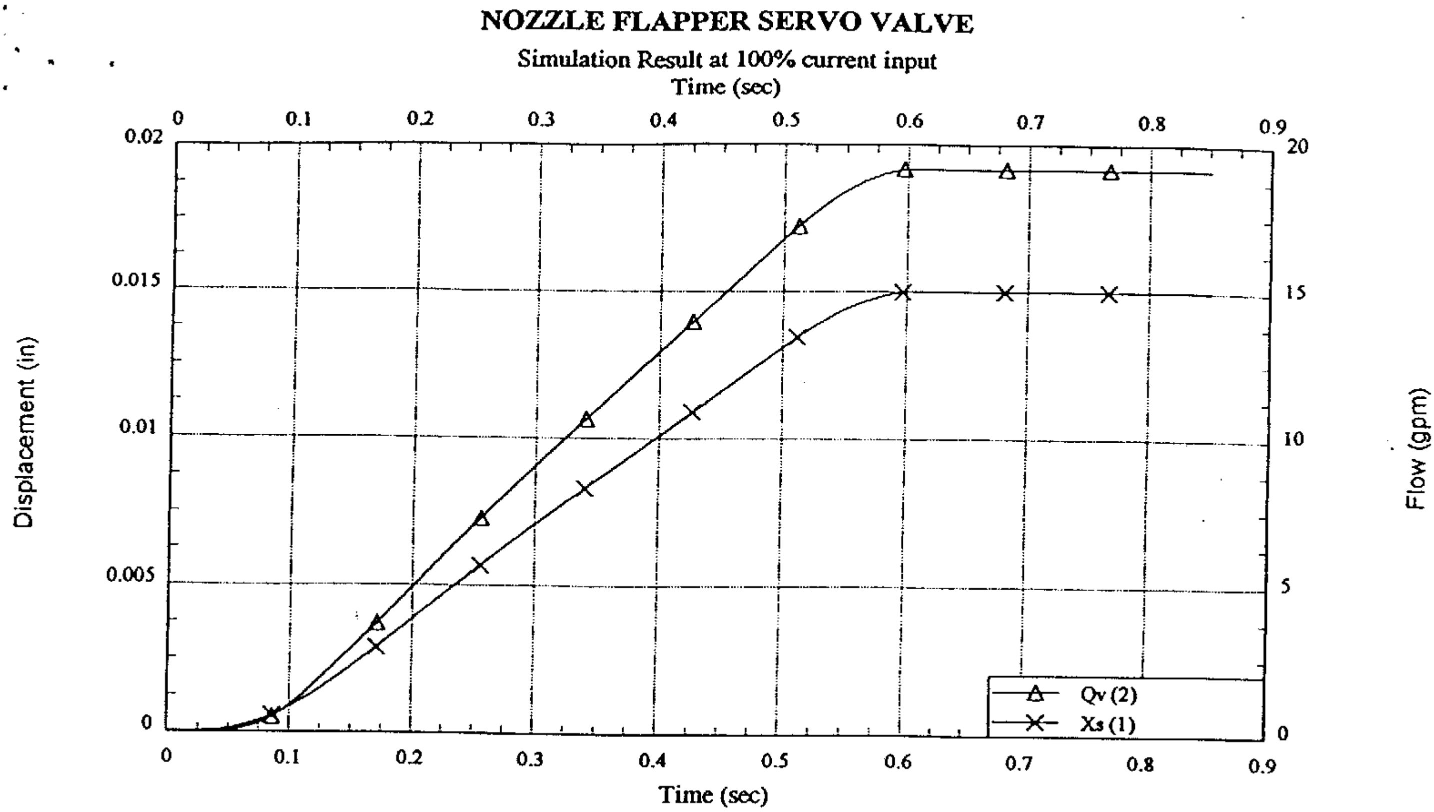
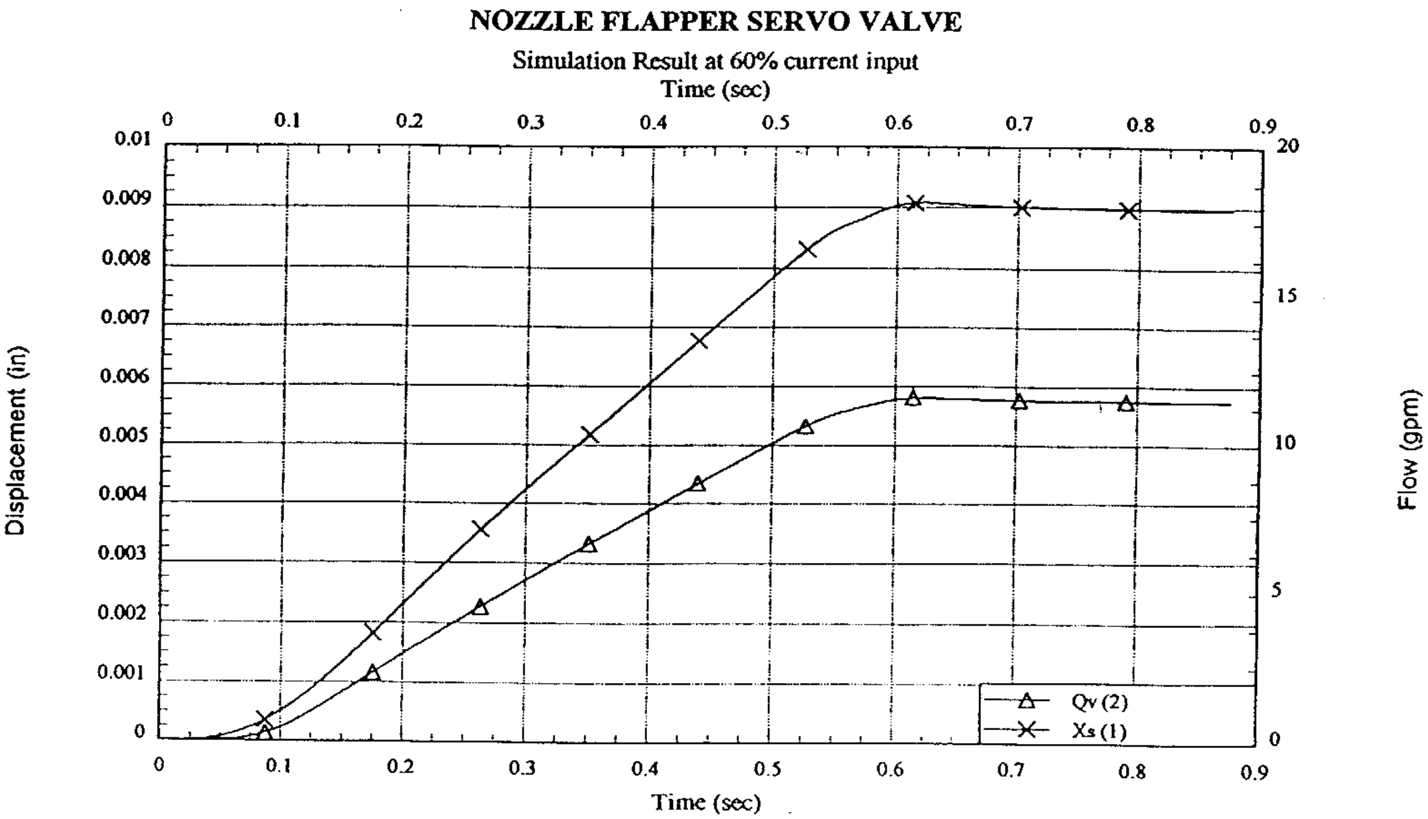


Figure 4

The simulation result of the above model is plotted and shown in Figures 5 and 6. These performance curves can be compared with the actual test data and model can be validated. In the above second method there are some wise engineering judgment and assumption may have to be done in-order to obtain the desired result since most of the dimensional data are not readily available for modeling. However, so long as the final result well with in the expected level, this model can be used to incorporate in any given system to study the overall system response.





Footnotes

F ile: C:\HYPNEUW\MODELTST\SERVO\FLP@6MA.FO

維美系統顧問公司