FPN Simulation Benchmark (2001)

1. Introduction

Simulation activities are understood in different ways. The idea behind this benchmark is that simulation is not a way of solving a system of differential equations with a given set of parameters, but the attempt to deal with a problem through the best possible interaction (synergy) between the analyst and his working tools (numerical codes in this case). The aim of the benchmark is to offer a problem with a limited amount of input data and verify: (1) the approach of different parties to the missing inputs; (2) the dispersion of the overall results provided by different parties. Have fun!

2. Circuit

The proposed circuit is shown in Figure 1. It comes from an actual source (which will be declared after the closure of the benchmark), and refers to the motion control of two cylinders (C1 and C2) which are supposed to have the same geometry and the same functional attributes. Actually, physical and functional symmetry is a more general characteristic of the circuit: in

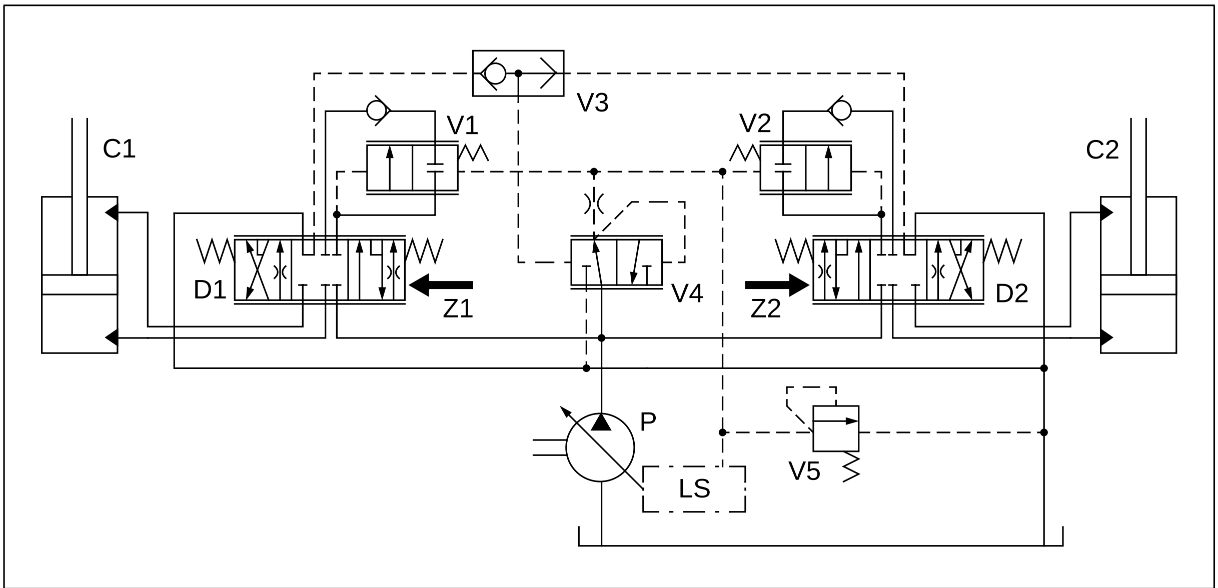

Figure 1: Schematic of the proposed circuit

fact, the directional valves D1 and D2 are equal to one another, and the same applies to valves V1 and V2. The schematic does not include any damping orifices, which should be added by the analyst (if necessary). As to the physical layout, the pump package and the valve network are grouped together, while each cylinder is connected by two 3/4” pipes of the same length (one meter).

3. Components

In the following headings the relevant input data of some components are listed. The missing inputs and the missing components are to be treated by the analyst on the basis of honest (but otherwise free) assumptions about the modeling approach and the numerical data. The relevant assumptions should be stated in the benchmark documentation.

3.1. Cylinders

The cylinders C1 and C2 are double effect units having a bore diameter of 80 mm, a rod diameter of 20 mm, and a stroke of 800 mm (no structural checks are implied by these data). The external interface has two parts: load and inertia. The first part is made of a resistive load which is to be chosen out from the three possible options shown in Figure 2, where the load itself is

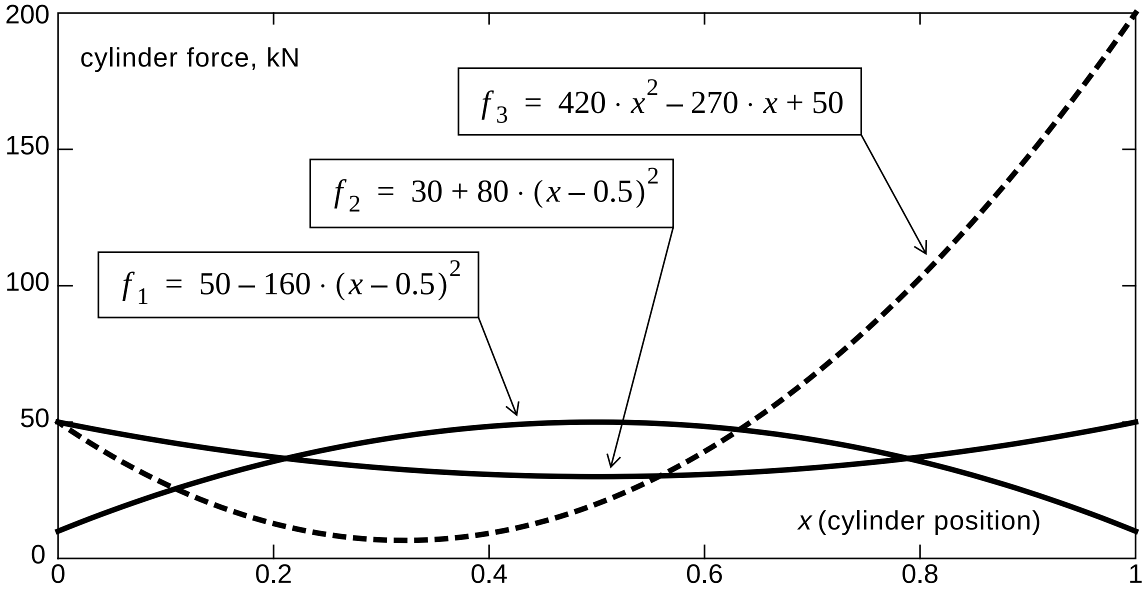

Figure 2: Plot of resistive forces on cylinders

plotted as a function of the cylinder position, being the condition $x = 0$ corresponding to the fully retracted end stop and $x = 1$ corresponding to the fully extended end stop. The second part is made of the inertial load due to a mass of 1000 kg (no gravity effect is to be considered).

3.2. Directional valves

The directional valves D1 and D2 are proportional units, whose position is set by the external variables Z1 and Z2. The full range of these variables is between -1 and +1, but in the simulation experiments of this benchmark only values in the positive range are considered.

The basic characteristic of both valves is the metering function of the internal connection shown with an orifice in Figure 1. Three points of that function are evidenced in Figure 3: (i) point A, which defines a 20% dead-band; (ii) point B, located at $z = 0.6$ and corresponding to 30% of the full metering area; (iii) point C, located at $z = 1$ and corresponding to 100% metering area. The actual value of the full metering area is to be derived from the condition that, when the pump is supplying one valve only (fully open) and the relevant cylinder load is 50 kN, the flow through the valve is 65 dm^3/min. The continuous metering function is not specified, though in Figure 1 a possible form is suggested by the dotted plot and its equation. In order to define the size of the additional paths within the valves, the analyst should consider that the driven cylinders are not expected to operate in presence of overrunning loads.

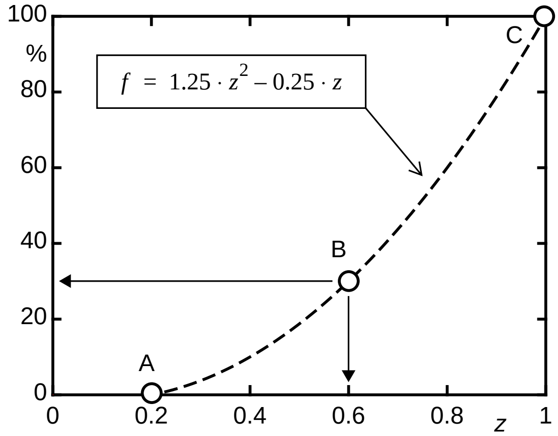

Figure 3: Metering function

3.3. Pump package

The variable pump P is supposed to have a maximum displacement of 50 cm^3/rev and run at 2000 rpm (held constant during the experiments). The nominal pressure of the unit is 320 bar, and its nominal speed is 2300 rpm (these data might be useful if some efficiency models are used). The pump is equipped with a load-sensing or differential pressure controller (LS), whose nominal setting is supposed to be 1.5 MPa. The layout of the control system, not detailed in Figure 1, is left to the analyst (no bleed orifice is necessary).

3.4. Pressure limiter

The pressure limiting valve V4 is supposed to be set at 280 bar.

4. Experiments

Two simulation experiments are considered, labelled as A and B respectively. They refer to different time histories of variables Z1 and Z2, i.e. the position of the directional valves, and different load functions applied to cylinder C1 and C2 (chosen from the three given in Figure 2). The relevant data of both experiments are collected in Figure 4. It is to remarked that no final

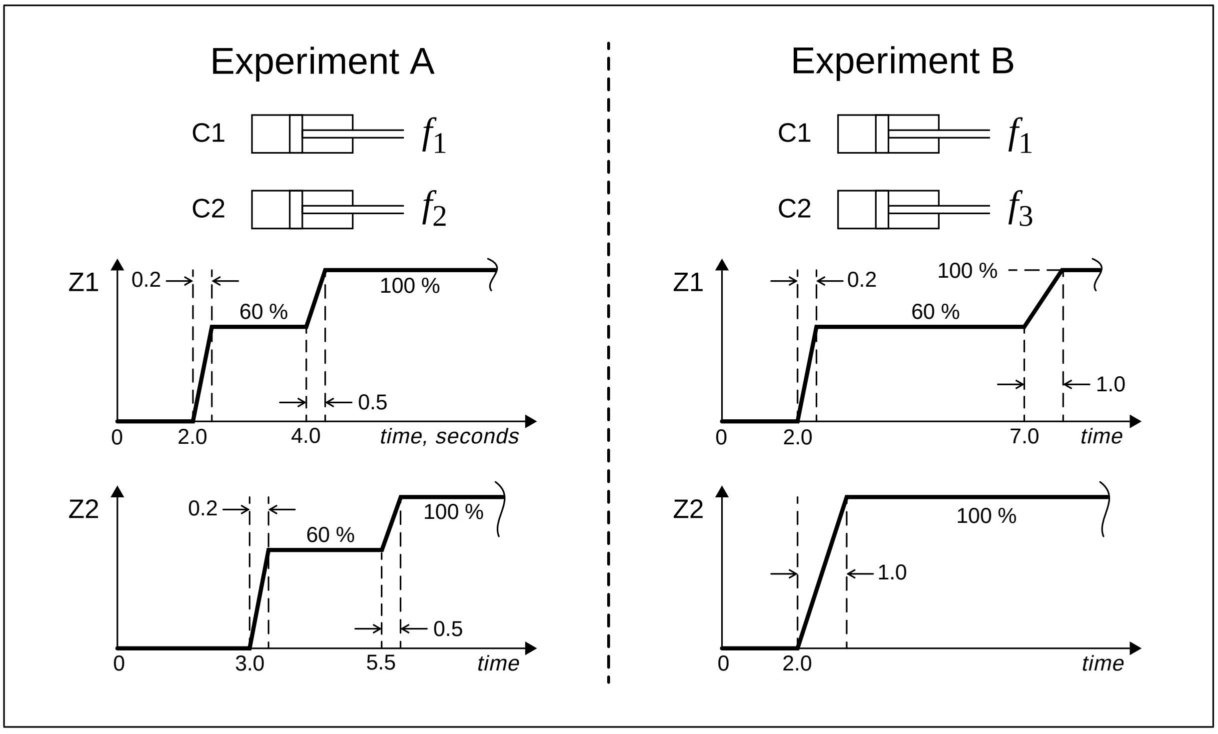

Figure 4: Time histories of the simulation experiments

time is given, because the experiments should be run (with no changes in the metering inputs) until both cylinders come to a stopped condition for some reason. In both experiments, the cylinders start from the fully retracted position.

5. Results

The results to be submitted by the interested parties and then discussed for comparisons and evaluations are, in both experiments, the following : (a) velocity of cylinder C1 (in cm/s); velocity of cylinder C2 (in cm/s); (c) power on the pump shaft (in kW). The three variables should be plotted as functions of time.