Simcenter Amesim Student Edition

Tutorial: Pressure Transducer

Introduction

This tutorial deals with a hydraulic transducer.
It explains how a piston rod connecting two pistons of different diameters can be used to reduce or amplify the pressure in a hydraulic system.
First we will define the equations describing the behavior of the hydraulic transducer.
Then we will use the Simcenter Amesim Student Edition, part of Simcenter™ portfolio, in order to validate easily and quickly the results.

→ Let's consider it with a practical example: a pressure transducer with a piston of Area A1 on one side and a piston of Area A2 at the other side.
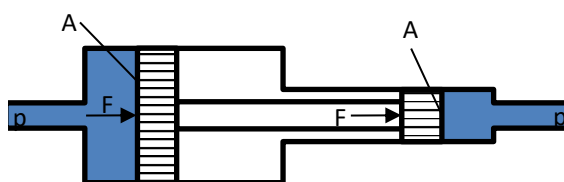

Figure 1: Pressure transducer

Let's answer to the following questions:

A pressure p_1 acts on the piston surface area A_1. The piston rod is transferring the resulting Force F_1 up onto the smaller piston with the surface area A_2.

   a) Can pressure p_2 be anticipated as greater, smaller or equal to p_1?
   b) What is the value of p_2?

Input data:
   - $A_1 = 100 \text{ cm}^2$
   - $A_2 = 10 \text{ cm}^2$
   - $p_1 = 6 \text{ bar}$

Theory and practical application

Considering that:

$$F_1 = F_2 \qquad (1)$$

And the mathematical relationship between the force and the pressure:

$$P = \frac{F}{A} \qquad (2)$$

We can write:

$$p_1 * A_1 = p_2 * A_2 \qquad (3)$$

Or:

$$p_2 = \frac{A_1}{A_2} * p_1 \qquad (4)$$

a) Can pressure p₂ be anticipated as greater, smaller or equal to p₁?

From this equation (4), we can deduce that **if A₁ > A₂, then p₂ > p₁**.

b) What is the value of p₂?

From (4), we can compute, taking into account the numerical data:

$$p_2 = \frac{A_1}{A_2} * p_1 = \frac{100}{10} * 6$$

Finally, **p₂ = 60 bar**

# Simulation, validation and practice with Simcenter Amesim Student Edition

1. Building the sketch

In sketch mode [SKETCH], the model of the system (Figure 2) can be built easily and fast, selecting the following components and connecting them together:

- **In the hydraulic library:**

Component	Icon	Comment
1 pressure source		Used to define P1
3 hydraulic restrictors		
2 pressure sensors		Used to compare pressure a t side 1 and side 2.
2 hydraulic actuators with single shaft		
1 hydraulic tank		
1 hydraulic zero flow source		
1 fluid definition icon		Used to define the hydraulics properties of the fluid
2 hydraulic 3 ports nodes		

- **In the mechanical library:**

Component	Icon	Comment
1 mass with 2 ports		

- **In the signal library:**

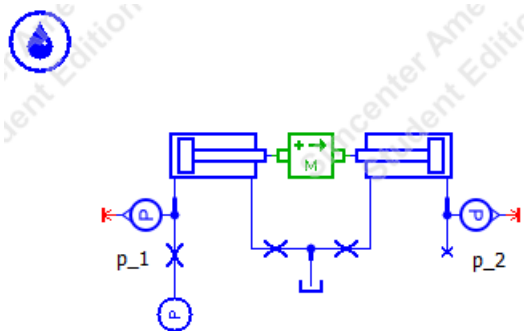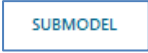| Component	Icon	Comment
2 signal sinks		

Figure 2: transducer model

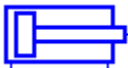*Trick*: You can easily rotate or flip your components on the sketch.
- Rotation: select the component and click with the mouse wheel (or use Ctrl + R)
- Flip: select the component and click with the mouse right button (or use Ctrl + M)

2. Selecting submodels

In this example, in submodel mode [SUBMODEL], submodels can be quickly selected using the "premier submodel" [Premier submodel].

3. Setting parameters

In parameter mode [PARAMETER], we will define the following values (default values are kept for other parameters):

Component	Icon	Parameters
pressure source		• number of stages = 1 • pressure at start of stage 1 = 6 bar • pressure at end of stage 1 = 6 bar
hydraulic actuators 1		• piston diameter = sqrt((4*100)/PI) cm • rod diameter = 0
hydraulic actuators 2		• piston diameter: sqrt((4*10)/PI) cm • rod diameter = 0 • #displacement of piston = 0.29 m

Trick: you can easily change the units in the parameter window. Just click on the unit of a parameter and select another one in the list of options.

4. Running the simulation and analyzing the results

In simulation mode [SIMULATION], we can run the simulation [▷ Run simulation]. Then, it is easy and fast to plot temporal results, just dragging and dropping any variable from the variable window to the sketch. For instance, you can plot the sensors pressure in order to get the value of p_1 and p_2 (Figure 3) and check the results evaluated before.
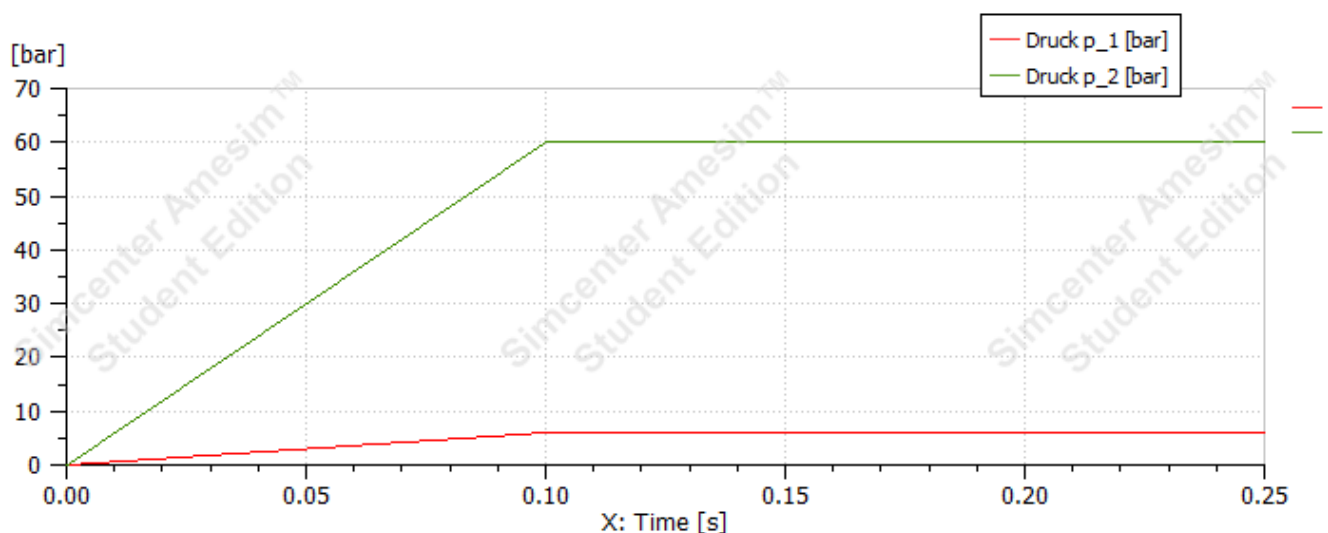
As we could expect, $p_2 = 60$ bar.

Figure 3: Simulation results

Conclusion

With this tutorial, we considered a pressure transducer.

We have explained the impact of the piston diameters on the amplification of the pressure. We have described the equations defining the behavior of the system and we applied them on a concrete case with numerical values.

Finally, we built a simple hydraulic model in Simcenter Amesim Student Edition that makes possible to validate our results.