Concepts of Hydraulics in simple words

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In this paper, we will explain the basic concepts of fluid mechanics (such as flow, pressure, pressure loss, C Factor, Internal pipe diameter...) by using some simple examples. Hydraulic calculations and system optimization will become easier if the designer fully understands each concept.

Assume that the blue circles in Figure "A" represent people present in the saloon. They should pass through the corridor and, when they arrive at the yard, lift and move the 20 kilogram weights.

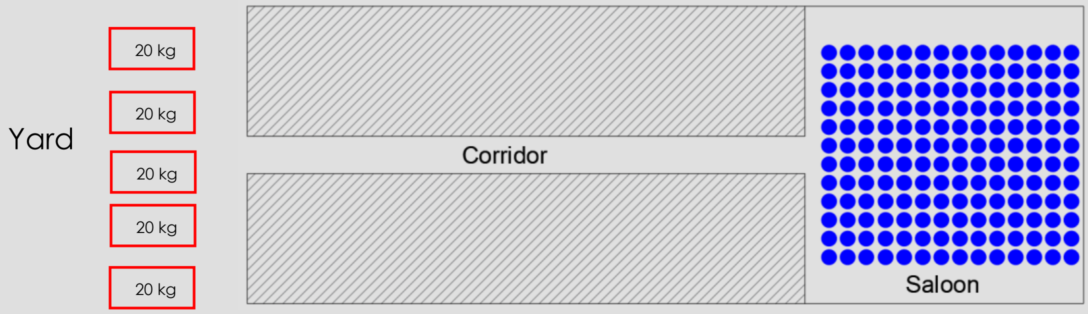

Figure "A"- Illustration of example

During their walks along the corridor, people lose energy from walking, colliding with one another, and contacting the walls, so they may not have enough energy to lift and move the weights.

This example focuses on how to reduce energy loss of people, so that when they arrive in the yard, they have enough energy to lift and move the weights.

Case 1) One of the solutions is changing the architectural layouts and relocating the saloon closer to the yard. As shown in Figure 1, shorter corridors will result in people walking fewer distances and losing less energy, and their contact with walls will be reduced as well.

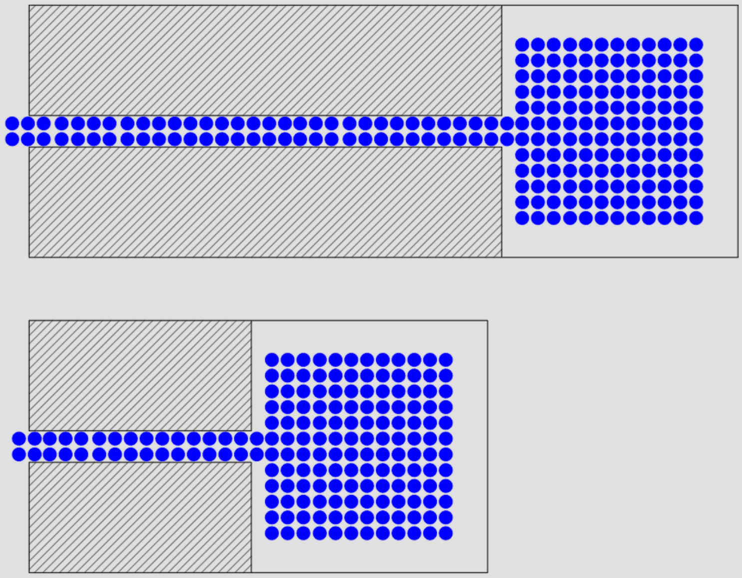

Figure 1- Effect of distance

Case 2) Another option would be to reduce the number of people passing through the corridor at the unit of time. Instead of two people entering the corridor per second, one person enters. The fewer people passing through the corridor, the less energy they will consume as they will have less contact with each other and the walls. (Figure 2.)

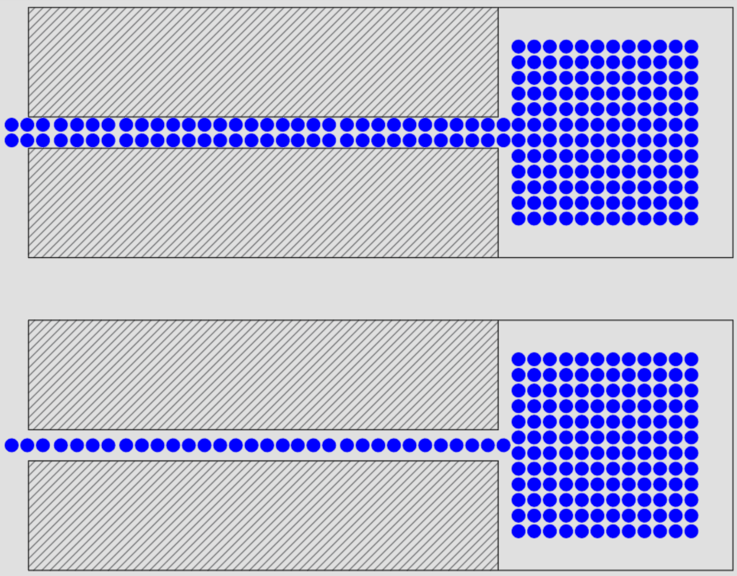

Figure 2- Less people passing through the corridor

Case 3) Increasing the width of the corridor is another option. By making the corridor wider, people will have less contact with each other and with the walls, so they will lose less energy. This case is shown in Figure 3.

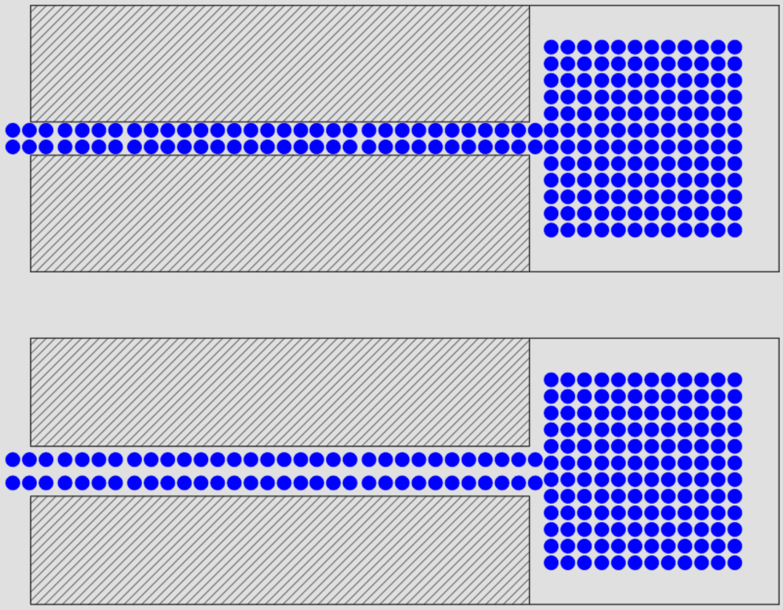

Figure 3- Effect of wider corridor

Case 4) By adding more corridors, people are able to choose less congested paths to reach the yard, reducing the contact between them and the walls. This case is shown in Figure 4.

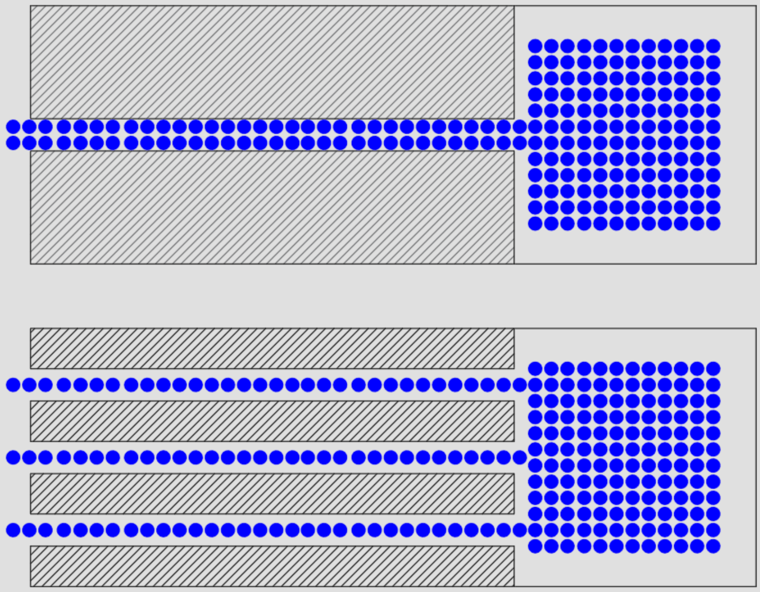

Figure 4- Effect of adding more corridors

Case 5) If we offer fresh fruit or energy drinks in the saloon, people will have more initial energy, so when they arrive at the yard, lifting the weights will be easier. In figure 6, Red circles represent people with higher initial energy.

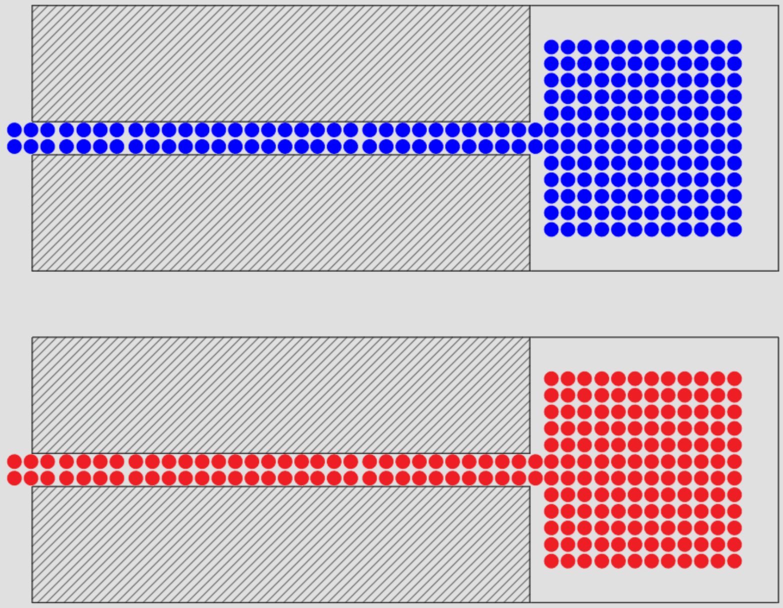

Figure 5- Effect of more initial energy

Case 6) Smoother corridor walls will cause people to lose less energy when they contact the walls. In Figure 6, the lower image shows rough walls that cause more energy loss when people contact them.

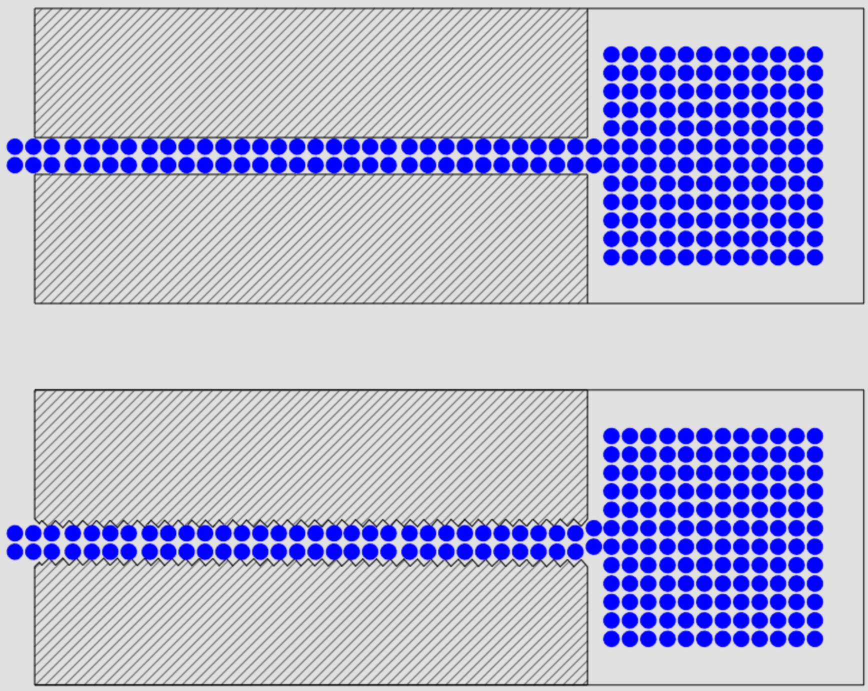

Figure 6- Effect of rough walls

Here, we match the above items with hydraulic concepts or water-based fire protection design concepts. Results are presented in the following table:

Items in the example	***Concepts in Hydraulics and Fire Protection Systems***
People	Fluid (water)
Saloon	Water Tank
Corridor	Pipe
Corridor width	Internal Diameter of Pipe
Weights in Yard	Fire
People reaching yard per unit of time	Flowrate
Energy of People	Pressure
Energy loss of People	Pressure Loss
Roughness of corridor's wall	C Factor

In a water-based fire protection system, the water stored in the tank (people in the saloon) should be transferred through a pipe network (via corridor), with enough flowrate (enough number of people), and enough pressure (enough energy) then discharges onto the fire (moving the weights). When water passes through the pipe, friction loss between water molecules which calls viscous friction (contacting people with each other) and friction between water and in pipe wall (contacting people with the walls of the corridor), cause pressure loss for water (cause people losing their energy). Water without enough flow rate and pressure (if the number of people is less or they don't have enough energy), we cannot control, suppress, or extinguish the fire. (People cannot lift and move all the weights).

In designing fire protection systems, the above-explained cases can be applied as follows:

Case 1) When a client asks the fire protection engineer where to locate the water tank on a large site, it's a good idea to place the tank and fire pumps in the center of the site (if the site is flat with no significant elevation changes). The distance between the water supply and the fire protection systems will be less if the water tank and fire pump are located in the middle of the site. Consequently, pressure loss will be lower.

Case 2) When the water-based fire protection systems require less water to control, suppress, or extinguish the fire, (For example, a sprinkler system that is designed for Light hazard in comparison with a system that is designed for Extra Hazard Group 2), water loses less pressure as it passes through the specific pipe size.

Case 3) As pipe size increases, pressure loss decreases.

Case 4) Sprinkler systems with looped or gridded piping configuration will have lower pressure losses than tree systems.

Case 5) Water at the outlet of fire protection systems (e.g., Sprinklers or Nozzles) has more pressure if fire pumps are used or water tanks are located at a higher elevation.

Case 6) Pipes with higher C Factor, such as CPVC and Copper, are smoother and resulting less friction and pressure loss.