3.4.5: The Sequential Processes and the Bottleneck

The Sequential Processes and the Bottleneck

Any process that has several steps, one after another, is considered a **sequential process**. A good example of these processes is the manufacturing assembly line in which each workstation gets inputs from a previous workstation and give its outputs to the next workstation. It is safe to assume that each step has its own staff member, since this is exactly what happens in assembly lines. For this kind of process, it is crucial to have a balanced time across all steps. That is, there should not be any big difference between the amounts of time that different steps take to process one unit of product. For example, if step 1, 2 and 3 take 3, 10 and 5 minutes consecutively to process one unit of product, two main issues will happen during the production:

1) There will be a big pile of inventory sitting right before step 2, since step 1 is much faster than step 2, and the products that are already processed in step 1 will need to wait for step 2 to be done with its current unit at hand. As a result, this becomes an inventory holding issue, which is costly.

2) Step 3 will always need to wait for step 2 for an extra 5 minutes. This is due to the fact that step 3 finished its current product at hand in 5 minutes, but step 2 needs a total of 10 minutes to finish its work and feed it to step 3. This causes step 3 to be idle for a long time, which is also costly for the company. This is costly, because the company is already paying the staff who works in step 3 for the whole time, but they are not able to produce as many units as they should due to the very slow entry of the inputs coming from step 2.

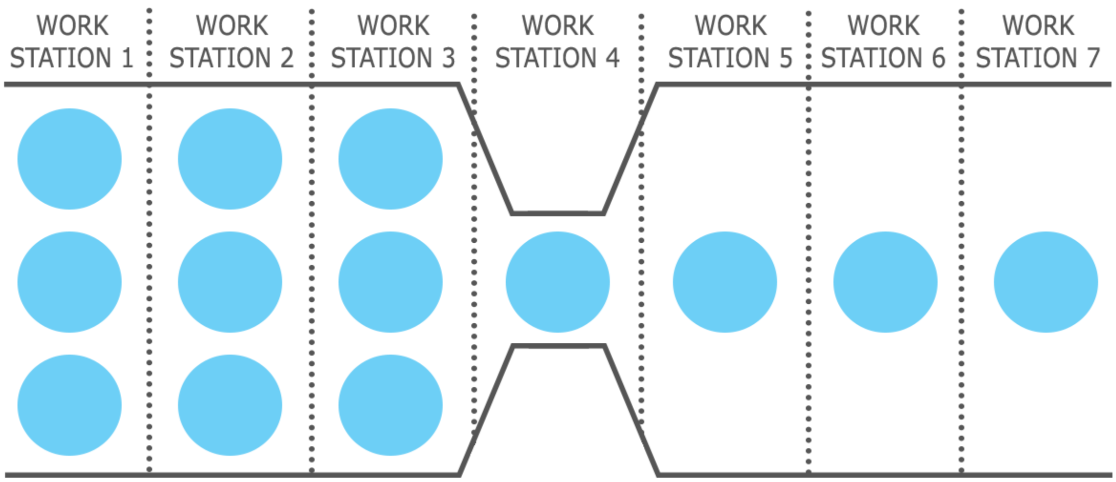

Figure 3.4.5.1: A diagram displaying the effects of a bottleneck.

The bottleneck is the slowest step in each process or the slowest process in a system. The capacity of the bottleneck defines the capacity of the whole process. In our example above, step 2 was the slowest, and as a result, the bottleneck. This means that the whole process (including all steps 1 to 3) will not be able to have an output any faster than one every 10 minutes. In the following, let’s see why this is happening:

In an 8-hour shift per day, we have 8 x 60 = 480 minutes

Assuming that step 1 has enough input to process during the day, the total output from step 1 will be 480 / 3 = 160 units per day. This is the capacity for step 1. In a similar way, the capacity for step 2 is 480 / 10 = 48, and the capacity for step 3 is 480 / 5 = 96 units.

This means that the input to step 2 will be 160 units to be processed. But as we see, step 2 will only be able to process a maximum of 48 units per day. That means that only 48 units get to step 3 for processing. Since step 3 has a capacity of 96 units per day, it will easily process those 48 units of inputs, and the output from step 3 will be 48 units. Because the step 3 is the last step of our process, this output of 48 units will automatically be the total output of the whole process per day.

The key observation here is that the capacity of step 2, which is the bottleneck, determined the capacity of the whole process. This concept is very important in practice. Often times, the companies that do not pay attention to the concept of bottleneck and its implications invest in parts of the process that are not bottleneck. This will keep the bottleneck unchanged and as a result, they will not see any improvement in the capacity of the whole process.

✔ Example 3.4.5.1

Caroline has a thriving business selling her tote bags through several popular websites. Her business volume has caused her to hire full-time employees. Her business has four main manufacturing operations: 1) cutting fabric (4 min), 2) stitching fabric (7 min), 3) adding zippers, toggles, and liner (10 min), and 4) inspecting, packing, and labeling (5 min).

Figure 3.4.5.2: Flow diagram depicting the time taken for each step of Caroline's manufacturing process.

Employees work 7 hours per day. Help Caroline to determine the following:

1. Based on her very high demand, is there a bottleneck and what stage is it? What is the capacity of the process per day?
2. Caroline's employee at step #2 has found a new machine that will enable him to do the stitching faster, at a rate of 5 min per bag instead of 7 min. The machine costs $3500. Would you suggest this is a good investment to help Caroline increase her output? Why or why not?
3. If there were another person to be added to the process, where should Caroline add him or her and what would be the new capacity?

Solution

3.4.5.1: Solution for Caroline's Totes example

Operation	Time	Daily Capacity
Step 1: Cutting fabric	4 min	420 / 4=105
Step 2: Stitching fabric	7 min	420 / 7=60
Step 3: Adding zippers, toggles, liners	10 min	420 / 10=42
Step 4: Inspecting, packing, labeling	5 min	420 / 5=84

(Based on 7×60 = 420 min per day)

1. The maximum output is 42 units, because that is what the bottleneck can do. The bottleneck is at stage #3, which is the slowest part of the process.
2. Caroline should NOT invest any funds into step #2. This may speed up the stitching, but the maximum output of the process will still be 42 units because step #3 has not changed.
3. If Caroline added another person, she should add it to step #3. (Install zippers/ toggles/ liner). Because that is where the bottleneck is. The capacity at stage three would now double to 84 units per day. The new capacity for the whole process would now be 60 units per day, as determined by Step 2 (Basic stitching) which is the new bottleneck of the process.