

TOPIC 5: PROCESS AND CAPACITY DESIGN

Solutions to Practice Problems

1. a. To solve the problem we first need to figure out which operation is the bottleneck of the entire production process. It can be shown that the lathe operation can produce 75 units/hour, the mill operation can produce 60 units/hour, and the grinder operation can produce 80 units/hour. Thus, the mill operation is the bottleneck and will determine the overall capacity of the production process. The overall daily capacity can be calculated as follows:

$$\text{Overall Daily Capacity} = (60 \text{ units/hour})(8 \text{ hours/day}) = 480 \text{ units/day}$$

- b. Now after the third mill has been added to the process, the capacity of the mill operation is increased to 90 units/hour. Thus, the bottleneck is “shifted” to the lathe operation. The new overall daily capacity becomes:

$$\text{New Overall Daily Capacity} = (75 \text{ units/hour})(8 \text{ hours/day}) = 600 \text{ units/day}$$

- c. To solve this problem, we first need to calculate the new production capacity of the lathe operation (in terms of *nondefective* units):

$$\text{New Lathe Operation Capacity} = (75 \text{ units/hour})(0.95) = 71.25 \text{ units/hour}$$

Therefore, the mill operation only has 71.25 units per hour to work on even it has the capacity to produce 90 units/hour. The capacity of the mill operation (in terms of *nondefective* units) actually becomes:

$$\text{New Lathe Operation Capacity} = (71.25 \text{ units/hour})(0.90) = 64.125 \text{ units/hour}$$

Similarly, the grinder operation’s capacity is also limited by the number of units the previous operation sends out. Thus, the new overall daily capacity should be calculated as follows:

$$\text{New Overall Daily Capacity} = (64.125 \text{ units/hour})(8 \text{ hours/day}) = 513 \text{ units/day.}$$

2. a. 15 minutes/100 loaves.
- b. $(100 \text{ loaves}/15 \text{ minutes})(60 \text{ minutes/hour})(8 \text{ hours/day}) = 3,200 \text{ loaves/day.}$
- c. Option (ii) is better. Option (i) improves the capacity of the bake operation. However, the bake operation is not the bottleneck of the entire manufacturing system (100 loaves/10 minutes); thus, option (i) would not help improve the overall capacity. If a new mixing machine with a capacity of 100 loaves/10 minutes is installed, the bottleneck is “shifted” to the pack operation (which has a capacity of 100 loaves/12 minutes).

New Overall Daily Capacity = (100 loaves/12 minutes)(60 minutes/hour)(8 hours/day)
= 4,000 loaves/day.

$$3. \quad C_{pk} = \min\left(\frac{160-140}{3 \times 20}, \frac{140-110}{3 \times 20}\right) = \min(0.333, 0.5) = 0.333 \Rightarrow \text{The process is not capable.}$$

$$4. \quad C_{pk} = \min\left(\frac{75-70}{3 \times 10}, \frac{70-50}{3 \times 10}\right) = \min(0.167, 0.667) = 0.167 \Rightarrow \text{The process is not capable.}$$

$$5. \quad Z_{up} = \frac{USL - \mu}{\sigma} = \frac{2.8 - 2.6}{0.12} = 1.67 \quad P(>USL) = 1 - \Phi(1.67) = 1 - 0.9525 = 0.0475$$

$$Z_{down} = \frac{LSL - \mu}{\sigma} = \frac{2.55 - 2.6}{0.12} = -0.42 \quad P(<LSL) = \Phi(-0.42) = 0.3372$$

$$\begin{aligned} \text{Expected Monthly Fixing Cost} &= 20,000[\$10.00(.0475) + \$3.00(.3372)] \\ &= 20,000[\$0.475 + \$1.0116] \\ &= 20,000(\$1.4866) \\ &= \mathbf{\$29,732} \end{aligned}$$

$$6. \quad Z_{up} = \frac{USL - \mu}{\sigma} = \frac{12.15 - 12}{0.06} = 2.5 \quad P(>USL) = 1 - \Phi(2.5) = 1 - 0.9938 = 0.0062$$

$$Z_{down} = \frac{LSL - \mu}{\sigma} = \frac{11.8 - 12}{0.06} = -3.33 \quad P(<LSL) = \Phi(-3.33) = 0.0005$$

$$\begin{aligned} \text{Expecting fixing costs per day} &= 250[\$3.00(.0062) + \$5.00(.0005)] \\ &= 250[\$0.0186 + \$0.0025] \\ &= 250(\$0.0211) \\ &= \mathbf{\$ 5.28 /day} \end{aligned}$$