



## Production and Throughput

The automatic assembly machine, whether it is in-line or rotary, produces a complete assembly every time it indexes, regardless of the number of stations in the assembly process. Therefore, to compute the **production rate** of an automatic assembly machine, one needs to know only the indexing cycle time, the number of stations is immaterial.

**Throughput Time** is the time required to complete an assembly from start to finish. This time is dependent upon the number of stations and the indexing cycle time.



### **Example 1:**

An 8-station dial indexing automatic assembly machine is driven by a Geneva mechanism with a driver rotational speed of 30 rpm. Find the production and throughput time of the machine.

**Solution:** Every revolution of the driver constitutes one indexing of the assembly machine. Therefore the production rate is 30 units /min.

$$\text{Production time} = \frac{1}{\text{Production Rate}} = \frac{1}{30 \text{ units per min}} \times 60 = 2 \text{ sec/unit}$$



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**Throughput Time** = Production time x Number of Stations  
= 2 sec x 8 stations = 16 sec

This is only the ideal production rate without considering the machine malfunction.

### Example 2:

An 8-station rotary indexing assembly machine, driven by a Geneva mechanism, has an indexing time of 3 sec and a dwell time of 5 sec. Under ideal condition the machine produces a complete assembly in 8 sec, achieving a production rate of

$$\frac{1}{8} \times 60 \times 60 = 450 \text{ units per hour.}$$

Suppose, each station malfunctions once in every 100 cycles. One or more station malfunction will immediately jam the indexing machine requiring an operator to make adjustment to restart the machine. Suppose, the adjustment and restart time is 10 minutes.



### Solution:

If the chance of a station malfunction is 1 in 100 cycles, the chance that a given station will not malfunction in a given cycle is 99% or 0.99. But all 8 stations must operate without malfunction to produce a completed assembly successfully.

So, the probability of no-malfunction in a given cycle is the product of chances of no malfunction at each station during that cycle, or,  $0.99^8 = 0.9227$ .

Therefore, out of 10,000 machine cycles, 9227 assemblies will be produced without malfunction, with a cycle time of 8 sec/assembly. This will consume

$$9227 \times 8 = 73816 \text{ sec} = 20.5 \text{ hrs.}$$



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In the other  $(10,000 - 9227) = 773$  cycles, at least 1 station will malfunction, requiring 10 min to repair.

This will consume  $773 \times 10\text{min}/\text{breakdown} = 7730 \text{ min} = 128.83 \text{ hrs}$ .

Therefore, the total time to produce 9227 assemblies is  $20.5 + 128.83 = 149.33 \text{ hrs}$ .

The percent downtime is:  $\frac{128.83}{149.33} = 0.863 = 86.3\%$  of the total production time.

The production rate has been reduced from the total of 450 units/hr to:

$$\frac{9227 \text{ units}}{149.33 \text{ hr}} = 61.8 \text{ units / hr}$$



The efficiency of the assembly machine would be the ratio of the actual production rate to the real production rate, calculated as:

$$\text{Efficiency} = \frac{61.8 \text{ units / hr}}{450 \text{ units / hr}} = 0.137 = 13.7\%$$

That is a drop of 86.3% in efficiency of any one station malfunction rate.

## Component Quality:

The predominant cause of assembly station malfunction is some random variation in the components being assembled.



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Suppose, in the previous example, 90% of the assembly malfunctions were due to faulty components. Elimination of the component quality problem would reduce the station malfunction rate from 1 out of 100 cycles to say, 1 out of 10,000 cycles.

Let us refigure the production rate and % downtime.

Probability of no malfunction in a given typical cycle =  $0.999^8 = 0.9970$

That is in 10,000 machine cycles, 9970 assemblies will be produced with no malfunction with a cycle time of 8 sec/completed assembly.

This will consume,

$$9970 \times 8 \text{ sec} = 79,760 \text{ sec} = 22.16 \text{ hrs.}$$



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In other  $(10,000 - 9970) = 30$  cycles, at least 1 station will malfunction requiring a 10 min of repair time. This will consume

$$30 \times 10 \text{ min} = 300 \text{ min} = 5 \text{ hrs.}$$

Therefore, the total time required =  $22.16 + 5 = 27.16$  hrs.

$$\text{Percentage Downtime} = \frac{5 \text{ hrs}}{27.16 \text{ hrs}} = 18.4\% \text{ (from 86.3\%)}$$

$$\text{Production Rate} = \frac{9970 \text{ units}}{27.16 \text{ hrs}} = 367 \text{ units / hr}$$

$$\text{Production Efficiency} = \frac{367}{450} = 0.816 = 81.6\%$$