Sheet 5

REVIEW QUESTIONS

1. Name three reasons why single-station manned cells are so widely used in industry.
2. What does the term *semi-automated station* mean?
3. What is a single-station automated cell?
4. What are the five enablers that are required for unattended operation of a single-model or batch-model automated production cell?
5. What are the additional three enablers that are required for unattended operation of a mixed-model automated production cell?
6. What is an automatic pallet changer?
7. What is a machining center?
8. What are some of the features on a NC machining center used to reduce nonproductive time in the work cycle?
9. What is a machine cluster?

PROBLEMS

Unattended Operation

1. A CNC machining center has a programmed cycle time = 25.0 min for a certain part. The time to unload the finished part and load a starting work unit = 5.0 min. (a) If loading and unloading are done directly onto the machine tool table and no automatic storage capacity exists at the machine, what are the cycle time and hourly production rate? (b) If the machine tool has an automatic pallet changer so that unloading and loading can be accomplished while the machine is cutting another part, and the repositioning time = 30 sec, what are the total cycle time and hourly production rate? (c) If the machine tool has an automatic pallet changer that interfaces with a parts storage unit whose capacity is 12 parts, and the repositioning time = 30 sec, what are the total cycle time and hourly production rate? Also, how long does it take to perform the loading and unloading of the 12 parts by the human worker, and what is the time the machine can operate unattended between parts changes?

Determining Workstation Requirements

2. A total of 7000 stampings must be produced in the press department during the next three days. Manually operated presses will be used to complete the job and the cycle time is 27 sec. Each press must be set up before production starts. Setup time for this job is 2.0 hr. How many presses and operators must be devoted to this production during the three days, if there are 7.5 hours of available time per day?
3. A stamping plant must be designed to supply an automotive engine plant with sheet metal stampings. The plant will operate one 8-hour shift for 250 days per year and must produce 15,000,000 good quality stampings annually. Batch size = 10,000 good stampings produced

per batch. Scrap rate = 5%. On average it takes 3.0 sec to produce each stamping when the presses are running. Before each batch, the press must be set up, and it takes 4 hr to accomplish each setup. Presses are 90% reliable during production and 100% reliable during setup. How many stamping presses will be required to accomplish the specified production?

4. A new forging plant must supply parts to the automotive industry. Because forging is a hot operation, the plant will operate 24 hr per day, five days per week, 50 weeks per year. Total output from the plant must be 10,000,000 forgings per year in batches of 1250 parts per batch. Anticipated scrap rate = 3%. Each forging cell will consist of a furnace to heat the parts, a forging press, and a trim press. Parts are placed in the furnace an hour prior to forging; they are then removed and forged and trimmed one at a time. On average the forging and trimming cycle takes 0.6 min to complete one part. Each time a new batch is started, the forging cell must be changed over, which consists of changing the forging and trimming dies for the next part style. It takes 2.0 hr on average to complete a changeover between batches. Each cell is considered to be 96% reliable during operation and 100% reliable during changeover. Determine the number of forging cells that will be required in the new plant.

5. A plastic injection molding plant will be built to produce 6 million molded parts per year. The plant will run three 8-hour shifts per day, five days per week, 50 weeks per year. For planning purposes, the average batch size = 6000 moldings, average changeover time between batches = 6 hrs, and average molding cycle time per part = 30 sec. Assume scrap rate = 2 percent, and average uptime proportion (reliability) per molding machine = 97 %, which applies to both run time and changeover time. How many molding machines are required in the new plant?

6. A plastic extrusion plant will be built to produce 30 million meters of plastic extrusions per year. The plant will run three 8-hour shifts per day, 360 days per year. For planning purposes, the average run length = 3000 meters of extruded plastic. The average changeover time between runs = 2.5 hr, and average extrusion speed = 15 m/min. Assume scrap rate = 1%, and average uptime proportion per extrusion machine = 95% during run time. Uptime proportion during changeover is assumed to be 100%. If each extrusion machine requires 500 sq. ft of floor space, and there is an allowance of 40% for aisles and office space, what is the total area of the extrusion plant?

7. Future production requirements in a machine shop call for several automatic bar machines to be acquired to produce three new parts (A, B, and C) that have been added to the shop's product line. Annual quantities and cycle times for the three parts are given in the table below. The machine shop operates one 8-hour shift for 250 days per year. The machines are expected to be 95% reliable, and the scrap rate is 3%. How many automatic bar machines will be required to meet the specified annual demand for the three new parts?

Part	Annual demand	Machining cycle time
A	25,000	5.0 min
B	40,000	7.0 min
C	50,000	10.0 min

8. A certain type of machine will be used to produce three products: A, B, and C. Sales forecasts for these products are: 52,000, 65,000, and 70,000 units per year, respectively.

Production rates for the three products are, respectively, 12, 15, and 10 pc/hr; and scrap rates are, respectively, 5%, 7%, and 9%. The plant will operate 50 weeks per year, 10 shifts per week, and 8 hr per shift. It is anticipated that production machines of this type will be down for repairs on average 10 percent of the time. How many machines will be required to meet demand?

9. An emergency situation has occurred in the milling department, because the ship carrying a certain quantity of a required part from an overseas supplier sank on Friday evening. A certain number of machines in the department must therefore be dedicated to the production of this part during the next week. A total of 1000 of these parts must be produced, and the production cycle time per part = 16.0 min. Each milling machine used for this emergency production job must first be set up, which takes 5.0 hr. A scrap rate of 2% can be expected. (a) If the production week consists of 10 shifts at 8.0 hr per shift, how many machines will be required? (b) It so happens that only two milling machines can be spared for this emergency job, due to other priority jobs in the department. To cope with the emergency situation, plant management has authorized a three-shift operation for six days next week. Can the 1000 replacement parts be completed within these constraints?

Machine Clusters

10. The CNC grinding section has a large number of machines devoted to grinding shafts for the automotive industry. The grinding machine cycle takes 3.6 min. At the end of this cycle an operator must be present to unload and load parts, which takes 40 sec. (a) Determine how many grinding machines the worker can service if it takes 20 sec to walk between the machines and no machine idle time is allowed. (b) How many seconds during the work cycle is the worker idle? (c) What is the hourly production rate of this machine cluster?

11. A worker is currently responsible for tending two machines in a machine cluster. The service time per machine is 0.35 min and the time to walk between machines is 0.15 min. The machine automatic cycle time is 1.90 min. If the worker's hourly rate = $12/hr and the hourly rate for each machine = $18/hr, determine (a) the current hourly rate for the cluster, and (b) the current cost per unit of product, given that two units are produced by each machine during each machine cycle. (c) What is the % idle time of the worker? (d) What is the optimum number of machines that should be used in the machine cluster, if minimum cost per unit of product is the decision criterion?

12. In a machine cluster, the appropriate number of production machines to assign to the worker is to be determined. Let n = the number of machines. Each production machine is identical and has an automatic processing time T_m = 4.0 min. The servicing time T_s = 12 sec for each machine. The full cycle time for each machine in the cell is $T_c = T_s + T_m$. The repositioning time for the worker is given by $T_r = 5 + 3n$, where T_r is in sec. T_r increases with n because the distance between machines increases with more machines. (a) Determine the maximum number of machines in the cell if no machine idle time is allowed. For your answer, compute (b) the cycle time and (c) the worker idle time expressed as a percent of the cycle time?

13. An industrial robot will service n production machines in a machine cluster. Each production machine is identical and has an automatic processing time T_m = 130 sec. The robot servicing and repositioning time for each machine is given by the equation $(T_s + T_r) = 15 + 4n$, where T_s is the servicing time (sec), T_r is the repositioning time (sec), and n =

number of machines that the robot services. ($T_s + T_r$) increases with n because more time is needed to reposition the robot arm as n increases. The full cycle time for each machine in the cell is $T_c = T_s + T_m$. (a) Determine the maximum number of machines in the cell such that machines are not kept waiting. For your answer, (b) what is the machine cycle time, and (c) what is the robot idle time expressed as a percent of the cycle time T_c?