Automated Storage and Retrieval System

Worked out Problems:

Problem 1. Each aisle of a six-aisle Automated Storage/Retrieval System is to contain 50 storage compartments in the length direction and eight compartments in the vertical direction. All storage compartments will be the same size to accommodate standard size pallets of dimensions: x = 36 in and y = 48 in. The height of a unit load z = 30 in. Using the allowances a = 6 in, b = 8 in, and c = 10 in, determine: (a) how many unit loads can be stored in the AS/RS and (b) the width, length, and height of the AS/RS. The rack structure will be built 18 in above floor level.

Problem 2. Each aisle of a four-aisle AS/RS is to contain 60 storage compartments in the length direction and 12 compartments vertically. All storage compartments will be the same size to accommodate standard size pallet of dimensions: x = 42 in, and y = 48 in. The height of the unit load z = 36 in. Using the allowances, a = 6 in, b = 8 in, and c = 10 in, determine: (a) how many unit loads can be stored in the AS/RS, and (b) the width, length, and height of the AS/RS.

Problem 3. A unit load AS/RS is being designed to store 1000 pallet loads in a distribution centre located next to the factory. Pallet dimensions are: x = 1000 mm, y = 1200 mm, and the maximum height of a unit load = 1300 mm. The following is specified: (1) the AS/RS will consist of two aisles with one S/R machine per aisle, (2) length of the structure should be approximately five times its height, and (3) the rack structure will be built 500 mm above floor level. Using allowances a = 150 mm, b = 200 mm, and c = 250 mm, determine the width, length and height of the AS/RS rack structure.

Problem 4. The length of the storage aisle in an AS/RS 240 ft and its height = 60 ft. Suppose horizontal and vertical speed of the S/R machine are 300 ft/min and 60 ft/min, respectively. The S/R machine requires 18 sec to accomplish a pick-and-deposit operation. Find (a) the single command and dual command cycle time per aisle and (b) throughput for the aisle under the assumption that storage system utilization = 85% and the numbers of single command and dual command cycle are equal.

Problem 5. Consider the AS/RS is to contain 60 storage compartments in the length direction and 12 compartments vertically. The length of storage aisle = 280 ft and its height = 46 ft. Suppose horizontal and vertical speed of S/R machine are 200 ft/min and 75 ft/min respectively. The S/R machine requires 20 sec to accomplish a P&D operation. Find (a) the single command and dual command cycle time per aisle, and (b) throughput per aisle under the assumptions that storage system utilization = 90% and the number of single command and dual command cycle are equal.
Problem 6. A unit load AS/RS is being designed to store 1000 pallet loads in a distribution centre located next to the factory. Pallet dimensions are: \( x = 100\text{mm}, \ y = 1200\text{mm}, \) and the maximum height of a unit load = \( 1300\text{mm}. \) The following is specified: (1) The AS/RS will consist of two aisle with one S/R machine per aisle, (2) length of the structure should be approximately five times its height, and (3) the rack structure will be built 500 mm above floor level. Using allowance \( a = 150\text{mm}, \ b = 200\text{mm}, \) and \( c = 250\text{mm}, \) determine the width, length and height of the AS/RS rack structure.

Problem 7. An AS/RS is used for work-in-process storages in a manufacturing facility. The AS/SR has five aisles, each aisle being 120 ft long and 40 ft high. The horizontal and vertical speed of S/R machine is 400 ft/min and 500 ft/min, respectively. The S/R machine requires 21 sec to accomplish pick and deposit operation. The number of single commands cycle used is equal to dual commands cycles. If the requirement is that the AS/RS must have throughput rate of 200 S/R transactions /hr during periods of peak activity, will the AS/RS satisfy this requirement? If so, what is the utilization of the AS/RS during peak hours?

Problem 8. An automated storage/retrieval system installed in a warehouse has five aisles. The storage racks in each aisle are 30 ft high and 150 ft long. The S/R machine for each aisle travels at a horizontal speed of 350 ft/min and vertical speed of 60 ft/min. The pick-and-deposit time = 0.35 min. Assume that the number of single command cycles per hr is equal to the number of dual command cycle per hr and that the system operates at 75% utilization. Determine the throughput rate (load moved per hr) of the AS/RS.

Problem 9. A 10-aisle AS/RS is located in an integrated factory-warehouse facility. The storage racks in each aisle are 18 m high and 95 m long. The S/R machine for each aisle travels at a horizontal speed of 1.5 m/sec and a vertical speed of 0.5 m /sec. Pick-and-deposit = 20 sec. Assume that the number of the single command cycle per hr is equal to the number of dual command cycles per hr and that the system operates at 80% utilization. Determine the throughput rate (load moved/hr) of the AS/RS.

Problem 10. A unit load AS/RS for work-in-process storage in a factory must be designed to store 2000 pallet loads, with an allowance of no less than 20% additional storage compartments for peak period and flexibility. The unit load pallet dimensions are: depth \( (x) = 36\text{in}, \) width \( (y) = 48\text{in}. \) Maximum height of unit load = 42 in. It has been determined that the AS/RS will consist of four aisle with one S/R machine per aisle. The maximum height (interior) of the building permitted by local ordinance is 60 ft. so the AS/RS must fit within this height limitation. The rack level will be made 2ft above floor level. And the clearance between the rack structure and the ceiling of the building must be at least 18 in. determine the dimension (height, length, and width) of the rack structure.
Suggested Brief Answers:

Ans 1  Given data: Number of storage compartments = 50, x= 36in and y = 48in. The height of a unit load z = 30in, allowances a= 6in, b =8in, c=10in

(a) The storage capacity is given by
   Capacity per aisle = 2×50×8 =800 unit load
   Total capacity of AS/RS for 6 aisle = 6×800 =4800 unit loads.

(b) Dimension of storage rack structures.
   \[ W = 3 (x +a) = 3 (36+6) =126 \text{ in}. \]
   \[ L = n_y (y +b) = 50(48+8) =2800\text{in}. \]
   \[ H = n_z (z +c) = 8(30+10) =320\text{in} \]

Overall width of AS/RS = 6 ×126=756in.

Ans 2  (a) The storage capacity is given by
   Capacity per aisle = 2
   \[ \text{Capacity per aisle} = 2 n_y n_z = 2\times60\times12 = 1440 \text{ unit loads} \]
   With four aisles the total capacity is:
   \[ \text{AS/RS capacity} = 4(1440) = 5760 \text{ unit load} \]

(b) The dimension of the storage rack structure
   \[ W = 3 (x + a) = 3 (42+6) = 144 \text{ in} = 12\text{ft/aisle} \]
   Overall width of AS/RS = 4(12) = 48ft
   \[ L = n_y (y + b) = 60(48+8) = 3360 \text{ in} =280\text{ft} \]
   \[ H = n_z (z + c) = 12 (36+10) = 46\text{ft}. \]

Ans 3  Given data
   No of pallet loads = 1000 pallet loads
   Pallet dimension: x= 1000mm, y= 1200mm, Height of unit load h = 1300mm
   No of aisle =2, L = 5 H
   Allowances: a= 150 mm, b= 200 mm, c= 250mm
   Capacity of AS/RS =1000
   Capacity per aisle = 500
   \[ 2 n_y n_z = 500 , \quad n_y n_z = 250.................. \text{Esq. (1)} \]

Dimension are given as
   \[ W = 3(x + a) = 3 (1000 + 150) = 3450 \text{ mm} \]
   \[ L = n_y (y + b) = n_y (1200 + 200) \]
   \[ H = n_z (z + c) = n_z (1300+250) \]

According to question \[ L = 5 \text{ H} \]
   \[ n_z \times 1400 = 5 \times n_z \times 1550 \]

From Esq. (1)
   \[ 250 \times 1400 = n_z^8 \times 7750, \quad n_z = 7, \quad n_y = 38 \]
   Hence \[ H = n_z (z + c) = n_z (1300+250) = 10850 \text{ mm} \]
   \[ L = n_y (y + b) = n_y (1200 + 200) = 53200\text{mm} \]
Ans 4 Given data: \( L = 240 \text{ ft}, H = 60 \text{ ft}, V_y = 300 \text{ ft/min}, V_z = 60 \text{ ft/min}, T_{pd} = 18 \text{ sec}, U=0.85 \)

(a) The single and dual command cycle time per aisle

\[
T_{cs} = \max \left\{ \frac{L}{V_y}, \frac{H}{V_z} \right\} + 2 T_{pd}
\]

\[
= \max \left\{ \frac{240}{300}, \frac{60}{300} \right\} + 2 \times (18/60)
\]

\[
= 1 + 0.6 = 1.6 \text{ min}
\]

\[
T_{cd} = \max \left\{ \frac{1.5 L}{V_y}, \frac{1.5 H}{V_z} \right\} + 4 T_{pd}
\]

\[
= \max \left\{ \frac{1.5 \times 240}{300}, \frac{1.5 \times 60}{60} \right\} + 4 \times (18/60) = 2.4 \text{ min}
\]

According to problem statement, the number of single command cycle is equal to the number of dual command cycle. Thus

\[
R_{cs} = R_{cd} = 12.57 \text{ single command cycles/hr}
\]

\[
R_{cd} = 12.57 \text{ single command cycles/hr}
\]

System through put = the total number of S/R transactions per hour

\[
R = R_{cs} + 2 R_{cd} = 12.57 + 2 \times 12.57 = 37.71 \text{ transactions/hr}
\]

Ans 5 Given data \( L = 280 \text{ ft}, H = 46 \text{ ft} , V_y = 280 \text{ ft/min}, V_z = 75 \text{ ft/min}, T_{pd} = 20 \text{ sec}, U=0.90 \)

(a) The single and dual command cycle time per aisle

\[
T_{cs} = \max \left\{ \frac{L}{V_y}, \frac{H}{V_z} \right\} + 2 T_{pd}
\]

\[
= \max \left\{ \frac{280}{280}, \frac{46}{75} \right\} + 2 \times (20/60) = 2.066 \text{ min/cycle}
\]

\[
T_{cd} = \max \left\{ \frac{1.5 L}{V_y}, \frac{1.5 H}{V_z} \right\} + 4 T_{pd}
\]

\[
= \max \left\{ \frac{1.5 \times 280}{280}, \frac{1.5 \times 46}{75} \right\} + (4 \times 20)/60 = 2.4 \text{ min}
\]

We can establish the single command and dual command activity levels each hour as follows:

\[
R_{cs} T_{cs} + R_{cd} T_{cd} = 60 U
\]

\[
2.066 R_{cs} + 3.432 R_{cd} = 60 \times 0.90 = 54.0 \text{ min}
\]

According to problem statement, the number of single command cycle is equal to the number of dual command cycle. Thus

\[
R_{cs} = R_{cd} = 9.822 \text{ single command cycle/hr}
\]

\[
R_{cd} = 9.822 \text{ dual command cycle/hr}
\]

System through put = the total number of S/R transactions per hour
\[ R_t = R_{cp} + 2 \ R_{cd} = 9.822 + 2 \times 9.822 = 29.46 \text{ transactions/hr} \]

Ans 6  \( W = 3450\text{mm}, H = 10850\text{mm}, L = 53200\text{mm} \)
Ans 7  \( U = 37.9\% \)
Ans 8  \( 201.45 \text{ transaction/hr} \)
Ans 9  \( 317.53 \text{ transaction/hr} \)
Ans 10

The above mentioned problems are taken from the text books given below. I am thankful for the authors.

REFERENCES