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The Proposal of Structure for Workplaces with Palletizing Robot

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Abstract The article describes design of structure palletizing robot workplace. There is described a composition of work and criteria for selection of palletizing robot. End of the article are shown the typical structure of the palletizing workstations.

Keywords: *robot, workplace, palletization*

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1. Introduction

Approach to achieving an optimal structure of palletizing workplace is needed developed on the philosophy of understanding the problem as specific features characterizing the performance capability of the individual elements to change the position and orientation of an object in time.

System approach to design structures of palletizing workplace include all stages from the point of view of object palletizing based on its possible modifications to the need for robotic manipulation through determination of individual manipulation, selection of robot and peripherals, spatial distribution, decomposition manipulation process of programmable sections, installation elements for workplace conditions operation and safety of operator to teach workers to operate and maintain.

On the basis of generalization of experience and knowledge of design and operation of manipulation devices for group packaging and palletizing as well as robotized workplaces in other technologies can be methodical - process of designing robotic workplace for palletizing express the following points:

- Setting of goals to be achieved for palletizing robot,
- strategic decisions on transition in transport - manipulation process,
- analysis objects for palletizing and manipulation conditions - transportation process,
- palletizing pack proposal, taking into account the use of pallet surface contained pack for palletizing robot and restrictive conditions of environment,
- selection of elements for workplace regards to compatibility to environment,
- proposal of structure to spatial layout of elements,
- determination requirement on inputs,
- security relation on environment,
- determine the operating – security measures,

In design of palletizing pack is a solution for interrelated phases:

- Selecting of method to grasp object palletizing grippers
- Determining the number of objects in layers, their composition and sequence storage
- determining the total number of objects in a pack
- determining the number of layers and on basis of data to object palletizing, pallet, features of technological devices and restrictive criteria arising from bonds of surroundings.

In view of automatic palletization in the design pack palletizing apply the following principles:

- achievement a hard layered pack
- optimal use of the ground area pallets
- not exceeding the allowable filling height and the permissible load pallets
- compliance order storage must be designed to enable safe and easy disassembly pack

2. The Proposal of Structure for Workplaces with Palletizing Robot

The current industrial production moves from hand packaging to semi-automatic, respectively to complete process automation. They have been created palletizing equipment and industrial robots, to improve the speed and quality of the process palletizing. An important aspect in palletizing is safety, i.e. creating stable and collision-free transport costs. Palletizing piece of work consists of:

- input devices:
- palletizing objects
- pallets
- auxiliary materials such as prepositions and etc.
- palletizing robot
- supplement manipulation devices:

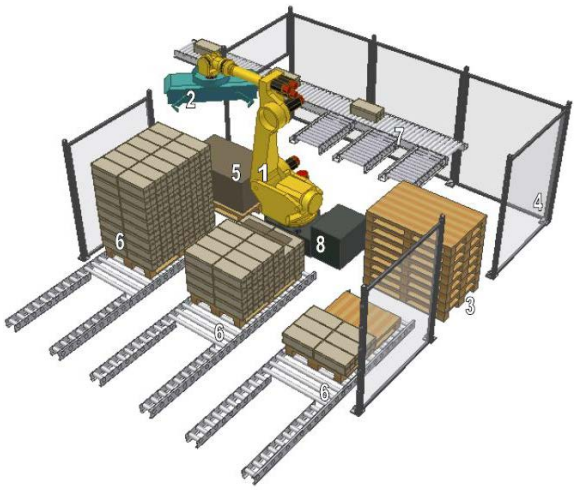
- manipulator with prepositions
- fixation devices
- output devices:
- full of devices
- stacks:
- pallets
- auxiliary material
- sensors:
- position of objects
- state of stacks
- presence of objects or pallets
- control system.

In determining of structure for palletizing workplace is needed wider scope in view of orientation to topic work given to question of relationship in the following areas of activity:

- determining type of structure for palletizing workplace
- selection of elements of workspace with special attention to the selection of the robot
- formation workplace in the view of its spatial arrangement of elements and determination of material and information connection binding

The technical core of robot, function of which is to carry out manipulation operations to the change of position or position and orientation i.e. take object respective more objects generically homogeneous or heterogeneous species in a given location and move them to another location by a predetermined spatial mosaic with a certain sequence to creation of integrated transport pack. The decisive selection criteria for palletizing robot are:

- shape, size and weight of the object palletizing
- dimension of palletizing stack
- space distribution of manipulation points
- available space
- method of distribution in layers
- required function of the robot.



1. angular robot,
2. gripper,
3. stack of empty pallets,
4. fences,
5. prepositions,
6. output of full pallets,
7. input objects palletization

Figure 1. Composition of palletizing robot workplace

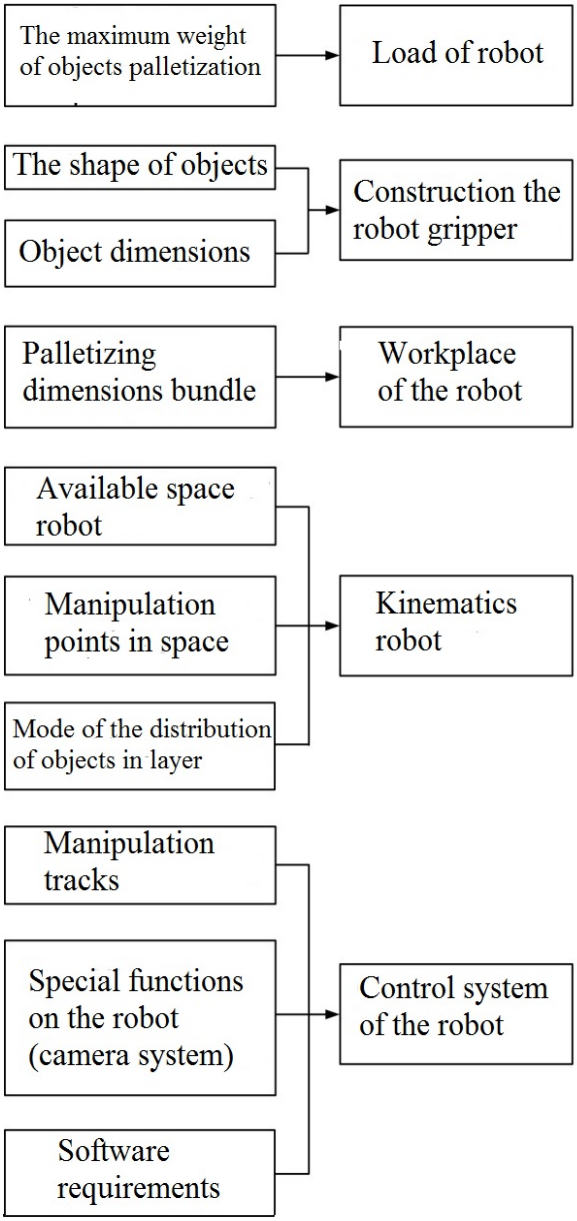


Figure 2. Decisive criteria for selection of palletizing robot

Palletizing function of transport system is to ensure that every object entering or leaving and the system is moved in the required amount in the desired position and orientation. The transport subsystem performs functions:

- supply of palletizing objects by the sampling location. These may enter chaotically arranged, partially oriented or oriented accurately. The first and second case requires to equip workplace either orientation devices by using known principles to achieve the desired orientation, e.g. the use CG position, mechanical barriers, etc., or equip the robot system for the analysis of 2D or scenes. 3D.
- supply of empty pallets to transport palletization zone. Additional features of this subsystem are positioning and fixation pallet palletizing zone. Part subsystem supply of empty pallets may also create supply of empty pallets so-called standby stack. Structure may be a solution as a stacker as a conveyor storage system.

- transfer - output full palletization pack. This subsystem provides full transfer pallets from palletization zone. It includes in many cases, the tool palette fixation on objects and ensuring protection from the weather, etc.

In practice, for the palletization of transport pallet (EURO) most often carried out first variant. Other variants are applicable on initial palletization, where typically a smaller "palette" as secondary consumer packages. For the second and third options it is sufficient to use manipulators respectively constituent units. The entire palletization layers are possible to divide between a variety of degrees of freedom and palletizer. If the palette has no degree of freedom from palletizer, is required for it to have two degrees of freedom. The palletization whole layer at a time, the is not requirement movement of pallet in a horizontal plane, so as second variant can be that, the pallet has one degree of freedom, the movement in the vertical direction, and in this case is required to be 1 or palletiser 2 degrees of freedom.

The typical structures of palletization workplaces with industrial robots are either with one or two palletizing places. The decisive criteria for choice of variants is time aspect. Time structure of the handling cycle palletization one pack consists of from this ingredient:

$$T = nt_p + t_v + \sum t_c \tag{1}$$

Where:
T - palletizing cycle time for one pack
t_p - time of manipulation cycle for palletization of one object
t_v – time of exchange from full pallet to empty pallet
t_c - waiting time of robot on object palletization
n - count of objects in palletization pack.

The time t_p constitutes an components of movements of the robot from initial position of object palletizing, its grip to transfer over pallet, storage and movement to starting position, in which it waits for the supply of next object. In fact, the time t_p taken as average of manipulation time for cycle of palletizing one object. Scattering times is because of different path of movement of robot and also due to complexity of orientation of objects in certain places palletizing. Time exchange of pallets t_v component consists of time required to transfer full pallets, time supply of empty pallets and positioning time respectively fixation in place of palletization.

Palletizing objects on robotic workplace comes with some stroke of t_T. From a practical point of view it should be considered at time of stroke as a clock with an average time. It shows that even when object leaves the technological process with a certain stroke, the other operations such as weighing, labeling, inspection, and subsequent removal of e.g. damaged object, group packaging, and stranded at belt and so, give out a deviation from this stroke. Workplace for palletizing of one point we decide if following conditions:

$$\text{A, } t_p \langle t_T \tag{2}$$

$$t_v \le t_p + t_c. \tag{3}$$

This means that cycle time for palletizing of one object is smaller than stroke of their arrival and robot must wait for the next object. However, exchange pallets must be carried out: in an overlapping time manipulation of palletizing cycle for one object and waiting time.

$$\text{B, } t_p = t_T \tag{4}$$

$$t_v \le t_p. \tag{5}$$

In this case is robot continuously performed by palletization e.g. $t_c = 0$ and exchange pallets must be made no later than at the time of one cycle manipulation palletizing. In these two cases, it is a condition that the input row is not created

C, in case of input it is possible to form a row, should apply :

$$t_p \langle t_T \tag{6}$$

and

$$t_v \rangle t_p + t_c \tag{7}$$

then must apply:

$$t_v \le n\left(t_T - t_p\right) = n.t_c. \tag{8}$$

During the exchange of pallets it is possible to form a row, but this is for palletizing volume destroyed.

$$\text{D, } t_T \langle t_p \tag{9}$$

In this case, during palletization on the input conveyor forms a row. However, such business must be able to stop arrival of objects of technological working for input conveyor after it is full. For working with two palletizing locations we decide if apply:

$$\text{A, } t_p = t_T \tag{10}$$

$$t_v \rangle t_p \text{ but at the same time } t_v \le n.t_p. \tag{11}$$

Time palletization is equal to stroke i.e. robot continuously palletized, but will not make exchange of pallets is carried out at one time palletizing cycle. However the time to exchange pallets must not exceed the cycle time for palletizing pack.

$$\text{B, } t_p \langle t_T \tag{12}$$

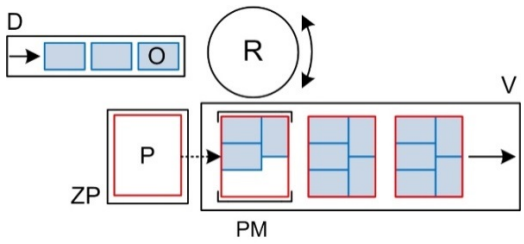
but

$$t_v \rangle t_p + t_c \tag{13}$$

then

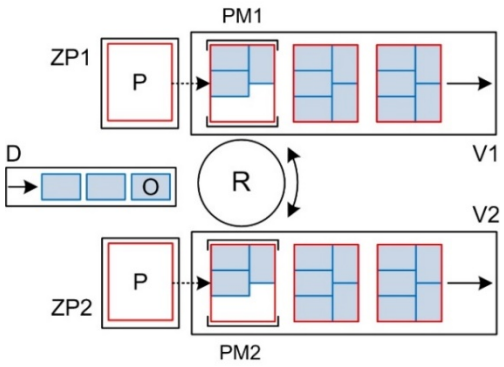
$$t_v \le n.t_p + \sum t_c. \tag{14}$$

Pallet exchange cannot be done in an overlapping time manipulation from palletizing cycle of one object and waiting time. However, this may not exchange with condition that it does not produce row palletizing exceed the cycle time of the all pack. Those recommendations have the character of the first decision and in many cases do not provide the final structure of the workplace. The choice of these variations in practice depends on many other factors like e.g. palletizing rhythm rotation of objects, length of delivery conveyor on which they can form, row and so on. The typical structure of palletizing robot workplaces are:



to ≅ tmc1
to – time input of object
tmc1 – manipulation cycle of storing one object
Legend:
D – input conveyor
O – palletizing object
R - robot
P – pallet (for storing of object of palletization)
ZP – stack of pallets
V – output conveyor full of pallets
PM – palletizing place

Figure 3. Structure workplace with one point of palletizing



Legend: It is not time for reserve to change palettes (i.e. ZP1 from stack moves the pallet PM1 and in the meantime it is possible to handle objects palletizing PM2). During the palletizing PM2 is realized by reloading pallets for PM1 in an overlapping time.

Figure 4. Structure workplace with two place of palletizing - palletizing one kind of object

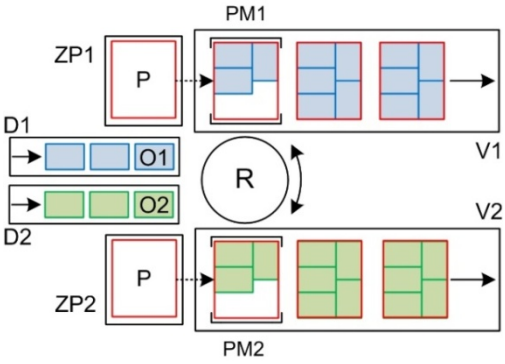


Figure 5. Structure workplace with two place of palletizing - palletizing of two different kinds of objects

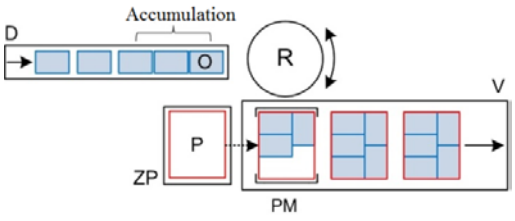


Figure 6. Structure workplace with accumulative conveyor - during pallet changes

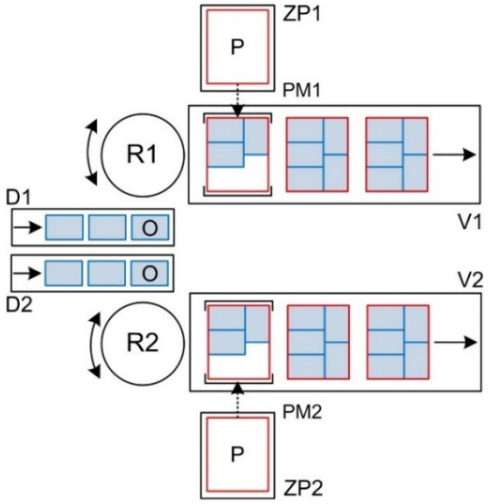


Figure 7. Structure workplace with two robots - one type of object

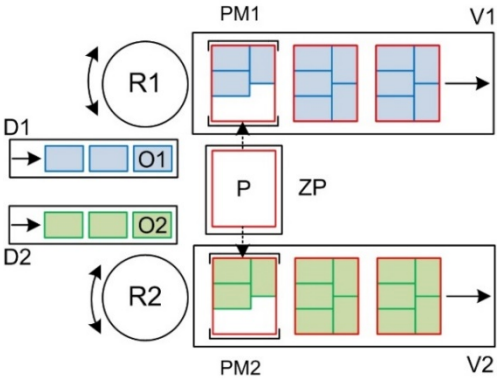


Figure 8. The structure workplace with two robots - more types of objects, a common stack of empty pallets

3. Conclusion

One of workplaces at department of robotics is also palletizing workplace. The structure of workplace corresponds to one palletizing work place. Center of workplace is Yamaha SCARA robot YK600X, which is an explanation to desired position by means of a camera system. All elements of workplace are controlled by a control system based on PLC. Manual control is provided by a touchscreen. This workstation will be used within the project RUSOS for training of teachers at secondary vocational schools.

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