

Methodology for Workplace Design at Food Production Process

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Abstract This paper aims to the methodology for workplace design at food production process. Based on implementation of industrial robot into the workplace and object specification is suitable to create an effective methodology for supporting attractive workplace design with emphasis to individual phases during solution process. Article also offers mathematical output, which can be generally applied to all workplaces with regards to food production process.

Keywords: palletization, production, methodology, process, food

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1. Introduction

Approach to an optimal methodology for design of workplace structure with industrial robot for palletization must be taken into account as a philosophy of understanding of the problem as its objective function. That can be characterized as performance capability of individual elements to change position and orientation of an object over time. A systematic approach includes phases from the perspective of the object for palletizing to its possible modifications as need for robotic manipulation through setting of various handling operations, choice of robot and peripherals, spatial distribution, decomposition handling process to programmable sections, fittings workplace conditions of operation, and operator safety to learning curve for staff to operate and maintain [1].

Use of industrial robots for palletizing is characterized by two areas. First is palletizing processes which require less capacity of the robots, but higher speed of their movements.

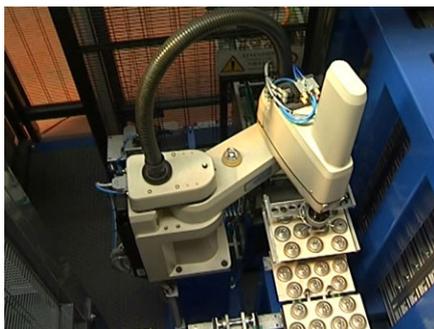


Figure 1. Configuration of industrial SCARA robot

This is particularly aimed to initial handling and palletizing operations i.e. consumer storage facilities to

transport of packaging respectively to a pre-molded or like relocations. Here can be applied configuration of industrial robot arm to move in a horizontal plane, SCARA type, see Figure 1 to Figure 5 kg capacity [2].

Configuration of industrial robots with arm in a vertical plane are used for palletizing of heavy objects such as transport pallet, see Figure 2.



Figure 2. Configuration of industrial robot for palletizing of heavy objects to transport pallet

Characteristic feature for proposal solutions of robotic workstations for palletizing food is use such size and kinematics of robot arm movements to contain the palletizing zone. Table 1 characterizes the extent of their performance.

Table 1. Characteristics of robotic workstations for palletizing

Characteristics	Value
Payload [kg]	5 - 140
DoF	4 - 5
Speed for linear movements [mm.s ⁻¹]	0.6 - 1
Speed for rotary movements [°.s ⁻¹]	90 - 140
Positioning accuracy [mm]	± 0,2 - 5
Number of programmed steps	1500
Performance of palletization [objects.h ⁻¹]	300 - 1440

2. Design Phase of Workplace

In applying design phase to palletizing workplace with industrial robot, we must realize that such workplace is an essential component of a broader handling-transport system. Problem for creation such workplaces to handling is essentially driven by the general methodology for design of automated and robotic systems for engineering technology with regard to specify handling operations of palletizing facility [3].

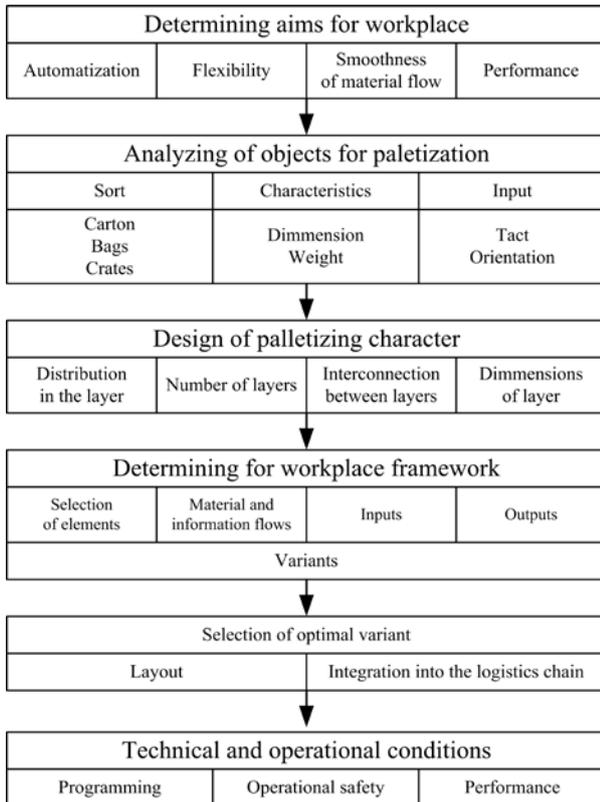


Figure 3. Etapy navrhovania paletizačného pracoviska s priemyselným robotom

Actually are currently being developed automated-based projection systems with compatible program modules based on creation of layouts, generation of control signals and programming of robot control language at robot to simulation and adaptation of data for actual workplace conditions. An effort to applying of design phases at workplace with a robot for palletizing is a one view to achieving optimal function so that on the one hand to avoid having to refill manual action and, second, that having too much untapped respectively under-utilized capacity.

The industrial robot is an essential component for deployment of palletizing workplaces with frequent changes of objects palletizing, their complex positioning and orientation, the irregular imposition and implementation respectively control of various other functions in workplace as an example is evaluation of damaged object and its disposal, orientation sensing, etc. [4].

Palletizing basis is a concentration of material in a single integrated unit called handling unit. Handling unit represents a packaged and unpackaged material stored in bulk or as a bundle on palette with which it can be handled as one coherent piece. It is determined by size ($L \times W \times H$)

weight and volume of stored material. Pallet load space is limited to 1 m^3 , above this threshold we are already talking about containers.

On basis of generalization at previous experience and knowledge for design and operation of robotic workstations for group packaging and palletizing as well as in other workplaces with robotic technology, it is possible to create phases of designing robotic workplace for palletizing with the following points:

- Setting of targets to be achieved by palletizing,
- Strategic decisions on transforming for manipulate-transport process,
- Analysis of object palletization and handling-transporting conditions process,
- Selection of elements workplace taking into account with regard to compatibility to its surroundings,
- Design of structure and spatial distribution of workplace elements,
- Determination of requirements for inputs,
- Providing of links to surroundings.

A determinant step in design phases for designing of robotic workplace for palletizing are unwinding from the proposed bond for palletizing and knowledge of basic types of structures with palletizing workplaces See Figure 3.

3. Methodology for Designing Workplace

In process of the methodology for designing workplace with palletizing robot is a mutually interconnected phases, where it is necessary to solve following aspects:

1. Method of attachment of object by palletizing grippers,
2. Determining the number of objects in the layer sequence, distribution and storage,
3. Determination of max. number of objects in the layer.

Method of attachment of object by palletizing grippers (1):

During applied method of attachment of object by palletizing grippers is the effort towards use of pallet storage areas to maximum extent possible. Advantage is usually where it is possible to make a regular pattern of a palletizing object.

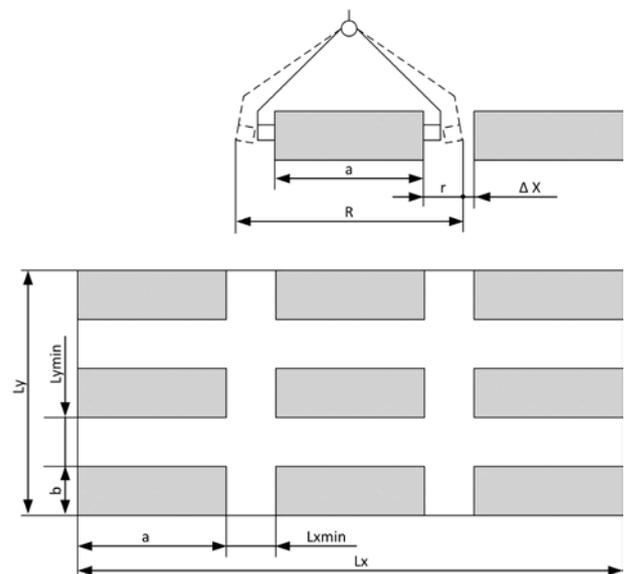


Figure 4. Proposal for distributing of the object and method of attachment by using claw gripper

For irregular pattern would increase demand for management activities, kinematics of gripper of an industrial robot, but on the other hand, in addition to achieving high utilization of pallet surface reaches the so-called interconnection facilities by cross-linking, thereby increasing the stability of transport [5].

Proposal for distributing of the object and method of attachment by using claw gripper is shown in Figure 4.

Determining the number of objects in the layer sequence, distribution and storage (2):

The calculation of distribution for quadratic objects on a pallet in X-axis we can calculate by equations:

$$M_x = \frac{L_x - a}{a + l_{x\min}} + 1 \quad (1)$$

Where

$$L_{x\min} = r + \Delta x = \frac{R}{2} - \frac{a}{2} + \Delta x \quad (2)$$

The calculation of distribution for quadratic objects on a pallet in Y-axis we can calculate by equations:

$$M_y = \frac{L_y - b}{b + l_{y\min}} + 1 \quad (3)$$

Where

$$l_{y\min} = \Delta y \quad (4)$$

Where:

M_x	Number of objects (direction X)
M_y	Number of objects (direction Y)
L_x	Length of pallet (direction X)
L_y	Length of pallet (direction Y)
$L_{x\min}$	Min. distance between objects (direction X)
$L_{y\min}$	Min. distance between objects (direction Y)
R	Max. opened gripper of released object
r	Distance of gripped surface from gripper shape during its opening
$\Delta x, \Delta y$	Accuracy for robot positioning

Determination of max. number of objects in the layer (3):

In this step, total maximum number of layers of objects based on the permissible load pallets and on this basis calculated allowable number of layers. In these calculations are based on the weight of objects palletizing and distribution of selected objects in the layer. The maximum number of objects in the layer depending on load pallets calculated as follows:

$$P_M = \frac{Q_p}{m_o} \quad (5)$$

Where:

P_M	Max. number of objects in layer
Q_p	Payload of pallet
m_o	Weight of object

Determination of number of layers:

$$v = \frac{P_M}{P_V} \quad (6)$$

Where:

V	Number of layers
P_M	Max. number of objects in layer
P_V	Number of objects at one layer

The number of layers can be rounded up, i.e. the last layer is not complete. The number of layers calculated according to the equation:

$$H_z = V \times C \quad (7)$$

Where:

H_z	Height of layer
V	Number of layers
C	Height of object for palletization

The follow-up is determination of max. number of layers as is a layer stability control and testing capacity and limit values set out from surrounding heights. During testing of layers according to above criteria arising from environment is a fact or a set number of objects or the height fits in terms of load transport system. Capacity transport system can be calculated on the basis of:

$$p_V = \frac{Q_V - m_p}{m_o} \quad (8)$$

Where:

p_V	Number of objects at one layer (regards to conveyor system)
Q_V	Payload of conveyor system
m_p	Weight of pallet

The final step to determination max. number of layers according to the above criteria resulting from temperature control is to state of capacity at the outlet conveyor respectively load at rack stackers or other equipment. With regard to this we fix the amount of cells in a warehouse respectively the height of the means of transport:

$$V_B = \frac{H_B}{C} \quad (9)$$

Where:

V_B	Number of layers (regards to height of cell storage system)
H_B	Height of cell storage system

The calculated values and determined requirements for number of objects in the layer and its amount is compared with the value P_m and V respectively H_z . In case some are smaller than in the p_m and after reference point for number of objects and allowing height of the layer is taken to be the smallest value. The stability control is generally based on the principle of the practice verified that the object is relatively small, several layers palletizing and we choose the cross-linking, if possible.

The exact calculation requires knowledge of many situations and parameters such as speed of traffic, acceleration, deceleration, material and coefficient of friction, vibration etc. In fact palletized layer is almost always fixed in order to protect what is sufficiently ensured the stability.

With manual disassembly of layers need to be designed layers in terms of compliance with ergonomic criteria such as easy accessibility to the building, easy to grip, i.e.

security that the layer does not fall apart during withdrawal of the object and so on.

4. Conclusion

Article offers a methodology for proposed structure of palletizing workplace with industrial robot according to the calculations of input characteristics of object for palletizing, palletizing design and arrangement of layers in the layer or number of layers and their linkages to the palletization objects.

The typical structures of palletizing workplaces with industrial robots are either with one or two palletizing places. The decisive criteria for the choice of the variants are particularly time aspect.

The main core of workplace is industrial robot whose function is to carry out handling operations due to a change of position respectively position and orientation i.e. take or object respectively objects more of homogeneous species or species-diverse from a place and move them to another location by a predetermined spatial mosaic with a specific sequence.

In determining the structure of the palletizing workplace with industrial robot should be given more scope and issues associated with determining type of structure palletizing of workplace, selection of elements of workplace with special attention to the selection of an industrial robot and shape of the workplace in terms of its

spatial arrangement of elements and determination of material and information bonding connections.

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