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ROLE OF WORKPLACE HANDLING PARAMETERS IN THE MATERIAL HANDLING EQUIPMENT SELECTION

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Abstract: *Usually, the handling characterisation of workplaces is not taken into consideration during the handling equipment selection process, so the handling solutions are not optimized and require additional modifications. If we could exactly define the handling parameters of workplaces and take them into account before the selection of the handling equipment, the result will be better suit. In this paper, the handling parameters of production workplaces and their effects to the handling solutions are presented. The focus is on the external handling process and the relation among workplace and handling equipment parameters, and an example is also presented.*

Key words: *Material handling, equipment selection, workplace parameters.*

Uloga parametara rukovanja radnim mestom u izboru opreme za rukovanje materijalom. *Obično se karakterizacija rukovanja radnih mesta ne uzima u obzir tokom procesa izbora opreme za rukovanje, tako da rešenja za rukovanje nisu optimizovana i zahtevaju dodatne modifikacije. Ako bismo mogli tačno da definišemo parametre rukovanja radnih mesta i da ih uzmemo u obzir pre izbora opreme za rukovanje, rezultat bi bio bolji. U ovom radu su prikazani parametri rukovanja proizvodnim radnim mestima i njihovi efekti na rešenja za rukovanje. Fokus je na procesu eksternog rukovanja i odnosu parametara radnog mesta i opreme za rukovanje, a prikazan je i primer.*

Key words: *Rukovanje materijalom, izbor opreme, parametri radnog mesta.*

1. INTRODUCTION

Material handling solution of a production process depends on the parameters of the related workplaces, however in many cases, the handling characterisation of the workplaces is not taken into consideration during the selection process of the applied handling equipment, only some conditions are defined (e. g. transfer points, gripping solution). Because of it, the workplace handling solutions are not optimized and require additional modifications.

If we could exactly define the handling parameters of the workplaces and take them into account before the selection of the material handling equipment, the result can be better suit without any corrections.

There are many publications in the international literature related to the building and analysis of production workplaces, but complex research on the handling characterization of the workplaces is not published so far. This paper presents the basics of a new material handling model, which enable to take the handling parameters of production workplaces into account with much more details than before. Of course, only those parameters are involved in the research, which have direct effects to the handling characterization of the workplaces.

2. WORKPLACE HANDLING – LITERATURE REVIEW

To determine the types and variations of handling solutions of workplaces used in the different industrial processes, the related literature in the Scopus database has been analysed. During the research, until April 2022, 2644 matches were found among research papers in the Scopus database related to the search: TITLE-ABS-KEY (workplace AND handling).

Most of the publications (almost 2000) deals with the human aspects (manual handling, health problems, etc.) of the workplace area and the operations, only 719 of them have relation to the equipment side (Fig. 1).

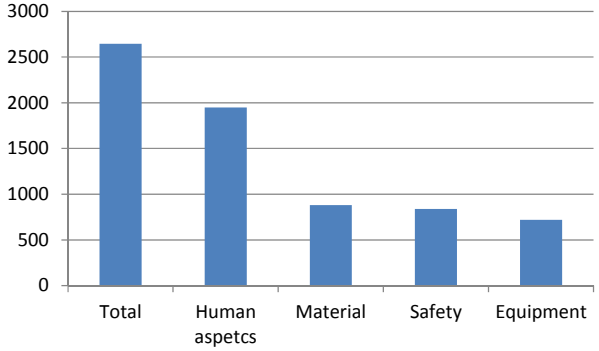


Fig. 1. Distribution of the topics of the related papers

Within the equipment category only 238 papers (34%) related to the engineering field, most of them are linked to other fields.

After reading the abstracts of the publications, only 47 papers (20%) were found which deal with the technical aspects of the equipment applied in workplaces (Fig. 2).

Near the half of the papers (44%) related to safety and health aspects, 17% presented the informatics hardware and software applied at the operation and planning of

workplaces, 9% deals with the manual handling and other human aspects and the remained 11% related to other fields (e. g. elements, material).

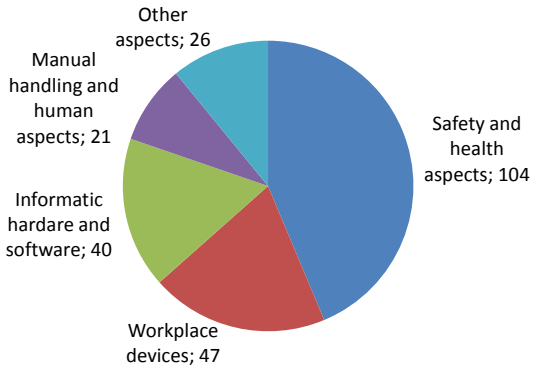


Fig. 2. Distribution of the papers deal with the engineering side of workplace handling

Among the publications, which related to the technical aspects of the workplace devices, the main topic is the internal material handling (53%), where 16 of 25 papers related to the robots (Fig. 3). Near the same number of the papers related to the technology (9) and the external handling (10) devices, only three of them presented general approaches.

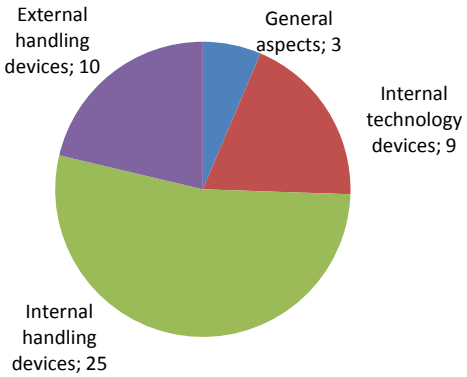


Fig. 3. Distribution of the papers deal with the technical aspects of workplace devices

This paper focuses only external material handling aspects of the workplaces, so only 13 publications will be analysed, which have relation to it.

Among the 3 papers, which presented general approaches, Holub et all [1] is dealing with the creation of production cells in virtual reality environment, Pukanic [2] focuses on an integrated approach involving the internal and external handling solutions at electronic assembling cells and Das et all [3] analyses the dispatching solutions of the tools and gauges to the workplaces. All of them contain some aspects of the external handling devices; however do not deal with the effects of the workplace parameters on the external handling solutions.

Among the 10 papers, which presented external handling solutions for workplaces, 4 publications [4, 5, 6, 7] deal with the handling of bulk materials, which are not fit to this research, because the unit handling is the main focus of the paper. Eck et all [8] presents outdoor handling equipment which is also out of the research. Also 4 publications [9, 10, 11, 12] deal with only one machine type and do not target to analyse the effects of the handling equipment specifications. The last paper [13] gives a general overview about the handling solutions of workplaces without any details.

Summarising the related literature research in the Scopus database, we can state that no one of the publications presented direct information about the effects of the workplace parameters to the external handling solutions.

3. WORKPLACE HANDLING PARAMETERS

Production workplace means an object where a given production operation is realized. There are many types of workplaces which can be different in physical, production, handling, or other aspects [14]. Parameters of the workplaces are

- geometrical parameters (size and shape of the area, vertical sizes, etc.),
- production process parameters (process-times, produced quantities, etc.),
- unit handling parameters (unit types, handled quantities, gripping possibility, etc.),
- unit moving parameters (directions, operations, complexity of the moving, etc.).

The scope of this paper is the external material handling, so mainly the effects of the geometrical and unit moving parameters will be presented, others are given during the research.

3.1. Geometrical parameters

In the aspect of the geometrical parameters, every workplace has a floor area, which contains the next parts (Fig. 4.):

- production area (place for machine or assembly table),
- operator area (place for the moving of the operator or the automatic operations),
- storage area (place for the stores for elements, products, materials, devices, wastes, etc.),
- loading area (place for the loading operations).

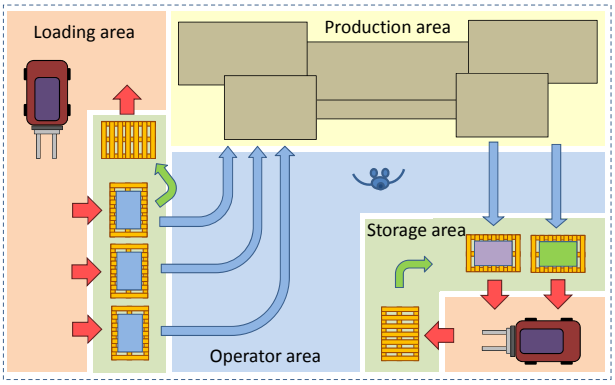
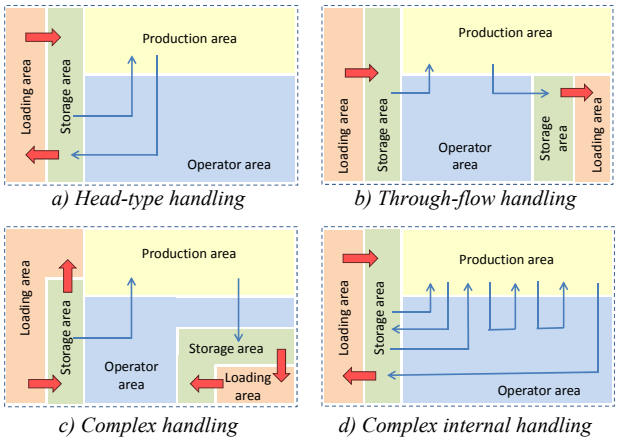


Fig 4. Parts of the workplace area

During the planning process of handling machines, the size and shape of the machine/production places and the operator areas are given, only the storage and loading areas can be modified. Of course, the number, size and location of the individual areas depend on the

characterisation of the production machine/place, the production process elements, the handling specifications and other aspects.

In the aspect of the handling process, different workplace variations can be described based on the external handling process (through-flow, head, complex) and also the internal handling process (one direction, complex). Some typical workplace area arrangement can be seen on Fig. 5.



a) Head-type handling *b) Through-flow handling*

c) Complex handling *d) Complex internal handling*

Fig. 5. Typical workplace area arrangement variations

Adding the vertical sizes to the workplaces area, we can define a prismatic volume which limits the handling movements and involve all related activities.

3.2. Unit moving at workplaces

There are large differences among the different production workplaces (e. g. forming, assembling), but the differences are important for this research if they significantly influence the material handling parameters.

Unit moving process of workplaces can be segmented into 5 different steps:

1. Entrance of the unit into the workplace.
2. Unit moving from the entrance point to the starting point of the production process.
3. Unit moving among the production activities.
4. Unit moving from the finishing point of the production process to the exit point.
5. Exit of the unit from the workplace.

In the aspect of the handling equipment the different steps can be realized individually or combined with others.

Based on the workplace area, presented in Fig. 4, a unit moving model can be formed. In most of the cases, the model does not contain the loading area because it belongs to the transport line. In the unit moving model used in the research (Fig. 6), the extern handling equipment connects to the workplace at the entrance and exit points in the storage areas.

There are 3 different solutions to combine the internal and external handling tasks:

- independent device for the external (entrance and exit) and internal handling,
- only external handling machine which also realizes the internal handling tasks (enter into the workplace),
- only internal handling machine which is able to realize the loading from/to a transport machine.

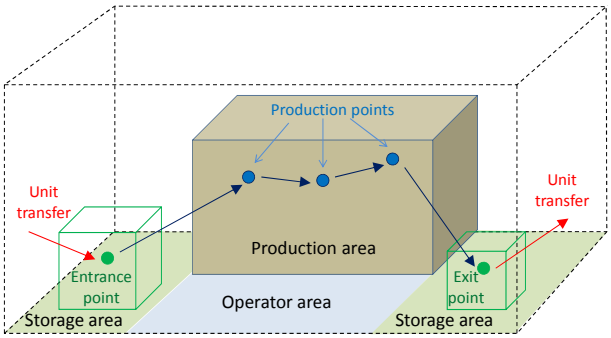


Fig. 6. Unit moving model of workplaces

The unit moving process is a chain of different handling operations where the linking points can be operation, storing, entrance and exit points.

Based on the workplace parameters, different model variations can be built:

a) one-point model (one handling equipment, one operation point, entrance, exit and operation point is the same, typical for large units),
b) two-point model with two sides (different internal and external handling machines, one operation point, entrance and operation point is the same, internal handling among the operation and exit points),
c) two-point model with one side (different internal and external handling machines, one operation point, entrance and exit point is the same, internal handling among the operation and entrance/exit points),
d) three-point model (different internal and external handling machines, one operation point, different entrance and exit points, internal handling among the operation and entrance/exit points),
e) general model (different internal and external handling machines, more than one operation points, different entrance and exit points, internal handling among the operation and entrance/exit points).

The external material handling of workplaces is easier task, because only the reaching of the transfer points and the gripping of the units can be realized.

The internal handling is much more complex, so beside the parameters of the linked points it requires additional information about the handling relations (distances, directions, obstacles, etc.).

4. EFFECTS OF WORKPLACE PARAMETERS TO THE MATERIAL HANDLING EQUIPMENT

During the planning of material handling, we are looking for suitable handling solutions for production or service processes. Usually, the equipment selection procedure is based on the handling relations among the different system objects.

Materials handling relation means a special connection between two objects (production or other objects), which contains any kind of handling activity.

Handling relations can be defined by the two linked objects and the handling parameters existing among them [15].

During the selection procedure the parameters of the handling relations determine the characterisations of the usable equipment [16], which can be physical parameters, technology process parameters, unit handling parameters and material handling process parameters (Fig. 7).

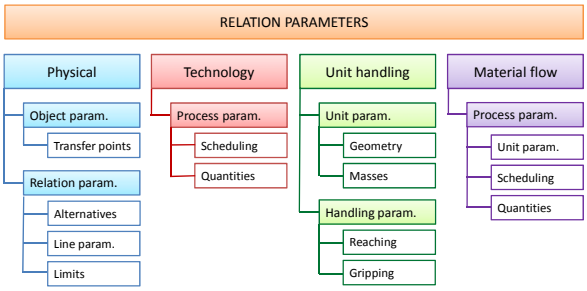


Fig. 7. Parameters of the handling relations

Based on Fig 7, we can select those relation parameters [17] which can directly link to the production workplaces:

- physical parameters of the objects,
- production process parameters,
- unit parameters,
- handling characterizations.

4.1. Influencing workplace parameters

The workplace parameters have different role in the external and internal handling processes.

The external handling solutions meet the workplaces only at the transfer (entrance, exit) points, so their parameters and the characterization of the units play important role in the selection procedure.

At the internal material handling methods, other operation points and the parameters of the production process also have effects to the selection of the handling machines. This situation is much more complex, but it is out of the scope of this paper, because the focus is only on the external handling machines.

The production process parameters are principally independent from the workplace structure, but in certain cases some workplace parameters can modify the production procedure (e. g. parallel operations). It is also true for the material handling process, because the final handling solution determines the process elements (transported units, scheduling of the transport, etc.), only some special parameter can be modified (e. g. pieces in the transported units).

Only the physical parameters and the environment of the production workplaces have direct effect to the external material handling equipment selection [18], which can be linked to the transfer points:

- geometric coordinates (x, y, z),
- unit parameters (size, shape, mass),
- handling parameters (gripping method, reaching direction, etc.),
- process parameters (scheduling, availability, etc.).

Based on the previously described aspects, only the effects of the geometrical and handling parameters will be analysed in the next chapter of the paper.

4.2. Effects of the workplace handling parameters

If we deal only with the external handling solutions, the parameters of the transfer points (see Fig. 6) and the units have to be taken into account at the equipment selection procedure. The location of the two transfer points can be

- different,
- the same and
- on operation points.

There is not any exact formula to describe the relation among the parameters of the transfer points and the handling equipment, but we can define a typical transfer environment for all handling machines, where their application is advantageous.

In this paper, the focus is on the workplaces which produce units [19], so the applicable material handling machines for the external handling process of workplaces are limited, the main types can be seen on Fig. 8.

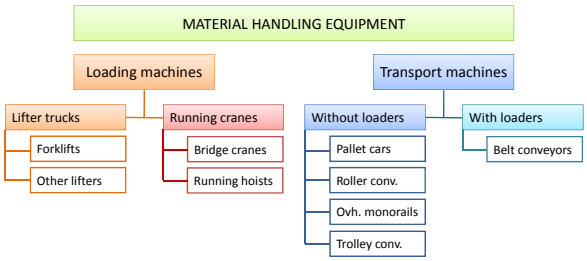


Fig. 8. Material handling equipment for unit handling

Loading machines can be used for the external handling of production workplaces, if they can also transport the units among the different objects. Only the lifting trucks and some types of running cranes can transport goods in short distances.

Lifter trucks can be able to reach any points of the workplaces (depend on their structure) if the suitable connection and access environment are built. Forklifts can easily reach all part of the transfer area, without any limitation, because of their front approaching direction, other types of lifter trucks require additional spaces for the side or upper reaching solutions (e. g. special grippers).

The application of bridge cranes also enables to reach any part of the workplace area; however the space above the operation points must be empty without any limitation. Running hoists can also be applied for the handling process of workplaces, but the transfer points must be located below one track line, and limitations also must be avoided.

The transport machines used for workplace handling can be separated into two main categories:

- handling without additional loading,
- using additional loading solutions.

Most of the transport machines can be applied for automatic uploading or unloading of the units without the application of any additional loading device. There

are 4 main handling machine types which belong to this group: pallet cars, roller conveyors, overhead monorails and trolley conveyors.

For some variations of pallet cars, special transfer connections can be applied, where the car can automatically leave or pick up the units (e. g. belt strips, roller strips). As roller conveyors consist of different modules, some of them can upload or unload the units to/from the transport roller line. Both machine types usually can handle the units only on the transport level, and the location of the transfer points must be predefined. Using of gravity rollers enables to reduce the transfer height till the floor, however it can increase the dynamical effects on the units.

In case of overhead transport (monorails and trolley conveyors), the transfer point is a stopped trolley, so its location must be along the transport line. Floor level trolley conveyors has the same situation, but they move on the floor level, so the height of the transfer points is limited.

Some transport machine type requires an additional loading device for uploading and unloading of the units at the workplaces. Most frequent used of them is the belt conveyor, where only the uploading requires additional device, the unloading is automatic at the end of a line section. Using of loading devices also enables the loading on any section of the belt.

The other, previously described transport machines (pallet cars, roller conveyors, overhead monorails and trolley conveyors) can also be assisted by a loader device, which can modify their handling parameters and wide their application possibilities.

Table 1 summarises the most important handling parameters of the unit handling machines.

Equipment type	Vertical area [m]	Handling deeps	TP location	Reaching direction
Lifter truck	0-4	no limit	anywhere	front, side
Bridge crane	0-4	no limit	anywhere	upside
Running hoist	0-4	given	along a line	upside
Pallet car	0,5-1,5	unit size	in one point	front
Roller conveyor	0,5-1,5	unit size	in one point	front
Overhead monorail	2-4	given	along a line	multi
Trolley conv. (floor level)	0-1	given	along a line	multi
Trolley conv. (overhead)	2-4	given	along a line	multi
Belt conv. (with loader)	0-2	unit size	along a line	front

Table 1. Material handling equipment parameters (with 4m height workplace area, TP -transfer point)

4.3. Example for the equipment selection

In this chapter, an example will be presented to demonstrate the effects of the geometrical parameters of the workplaces to the external handling equipment selection process.

In the example, an assembling workplace is examined, where the geometrical parameters are

- workplace area: 6x8m,
- workplace height: 4m,
- transfer location is at one side of the prismatic volume, its size: 8x4m.

The external transport line is located along the transfer side, outside for the floor level handling or inside the workplace for overhead handling.

In the example 4 different suitable handling zones were created, their locations and sizes, and the required transfer points can be seen on Fig. 9.

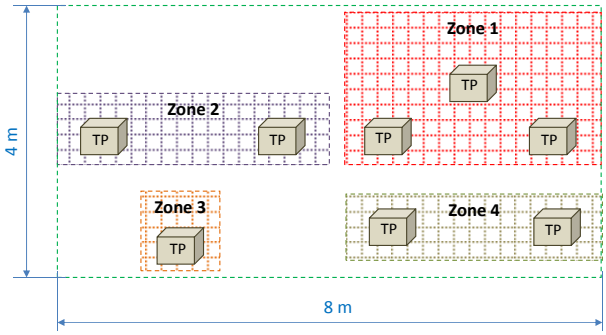


Fig. 9. Handling zones and transfer point (TP) locations

Physical parameters of the handling zones are involved into Table 2.

Zone	Horizontal location	Vertical location	Transfer points	Upside reaching
1.	4-8 m	2-4 m	3	yes
2.	0-4 m	2-3 m	2	no
3.	1-2 m	0-1,5 m	1	no
4.	4-8 m	0,5-1,5 m	2	no

Table 2. Parameters of the handling zones

For the selection of the handling equipment usable in the different zones, we can compare Table 1 and 2. The result of this simple selection process is the following:

- Zone 1: based on TP number and location, only lifter trucks or bridge cranes can be used.
- Zone 2: based on TP number, location and reaching direction, only lifter trucks, overhead monorails or overhead trolley conveyors can be used.
- Zone 3: based on TP location, reaching direction and narrow horizontal place only lifter trucks, pallet cars, roller conveyors or belt conveyors (with loader) can be used.
- Zone 4: based on TP number, location and reaching direction, only lifter trucks or belt conveyors (with loader) can be used.

Of course, this example is a simplified process only for demonstration, which gives a simple and cheap solution. The application of special devices and technical solutions can significantly modify the result, but this example is suitable to present the relation of the workplaces and the handling solutions.

5. CONCLUSIONS

Usually, the handling characterisation of the workplaces is not taken into consideration during the selection process of the applied handling equipment, so the workplace handling solutions are not optimized and require additional modifications, which can cause increased cost and production problems. If we could exactly define the handling parameters of the workplaces and take them into account before the selection of the material handling equipment, the result will be better suit without any corrections.

In this paper, the handling parameters of the production workplaces and their effects to the handling solutions have been presented. The focus was on the external handling process and the relation among the workplace and material handling equipment parameters. Also an example was examined to demonstrate the effects of the workplace parameters to the equipment selection procedure.

Of course, the result presented in this paper was only a small part of the research related to the role of the production workplaces in the equipment selection process.

Next steps will be the deeper analysis of the internal handling process and the connection possibilities of the internal and external handling equipment solutions.

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