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THE OPTIMAL LOCATION LOGISTICS OF MANUFACTURING RESOURCES IN CASE OF FOUR PIECES MANUFACTURE OF AN INTAKE SYSTEM

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Abstract: *In this article the optimal location logistics of manufacturing resources is analyzed, for the manufacture of four parts: intake gallery, square flange, injector support and body of the component product intake system. After a preliminary analysis was found that the best method of location of the resources in this case is the links method. For its implementation will be completed the study stages: grouping of parts that are processed on workstations to be located; development of matrix location; the representation of theoretical location and adapting the theoretical location to real conditions of the workshop.*

Key words: *logistic industry, intake system, links method, optimal location, matrix location.*

1. INTRODUCTION IN LOGISTICS INDUSTRY

The industrial logistics consists in all models, processes and means of handling, storage, warehousing, intern transportation and management of blanks and other raw materials in an industry company, necessary to the production process. The simplified diagram of a logistics system is presented in Fig. 1 [5, 6, and 8].

S.L. – supply logistics;
D.L. – distribution logistics;
L.T. – others logistics;
L.I. – internal logistics;
S.P. – production system;
W.M. – materials warehouse;
W.Pf. – finished parts warehouse.

The internal logistics is the overall models, processes and means of handling, partial storage, partial warehouse, internal transportation within a manufacturing system [6].

The complementary functions of industrial logistics are [1, 6, and 10]:

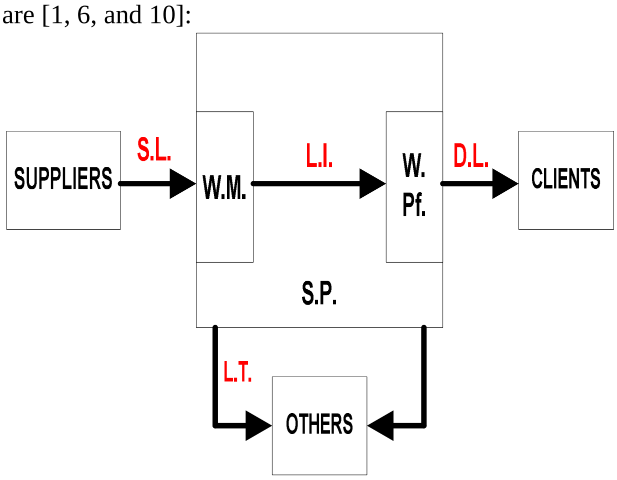

Fig. 1. Simplified diagram of a logistic system.

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1. Storage – is a partial function of manipulation only when it produces from a multitude of products accumulated in bunkers, or partially ordered in the store, included in handling subsystem. There are three types of storage:

- totally ordered – consists in temporary storage of geometrically defined products. The storage space is a store;
- partially ordered – storage and retention of geometrically defined products with orientation and positioning partially defined. The storage space is a deposit;
- disordered (bulk) – storage and retention of geometrically defined products with orientation and positioning partially undefined. The storage space is a bunker.

2. Change of quantities – refers to the variation number of products in material flows. In material flows, the number of handled products varies in time. The quantity variation is not a function of handling, but one of managing materials. There are four types of functions that characterize the change of quantity:

- ramification of separation, division type – sharing a set of handled products in components; it is an elementary function;
- ramification of reunion type – formation through reunion of a large crowd of components; it is an elementary function;
- dosage – divide a large crowd in small subsets (known). The particular case of the dosage is the delivery piece by piece;
- sort – separation and directing a set of products in known types.

3. Transport – the movement in space an changing the order of the manipulated object; it's done by certain elementary moves. The transport is not a component function of handling, but it are complements, sometimes inseparable. In terms of transport there are several types of movements: rotation, translation, change of direction, return, positioning, ordering, driving, and transport. Transport requires prior knowledge of initial and final position.

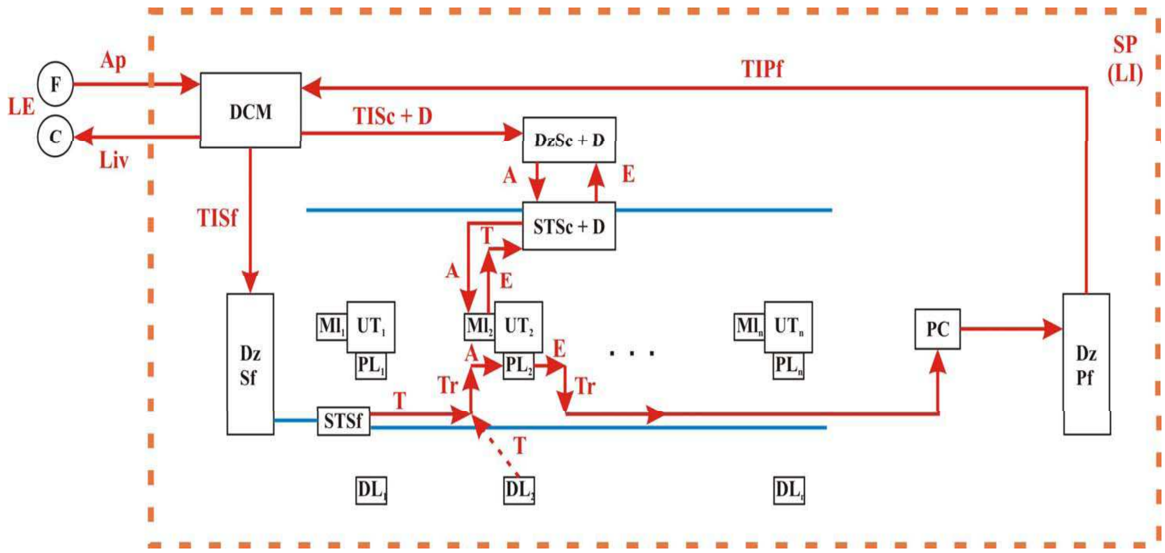

Fig. 2. Overall structure of an internal logistics system.

4. Retentions – consist in maintaining, in time, a previous state. Retention space ordered of the manipulated object can be: the long-term (storage) and the short-term (transient). Retention ordered of the manipulated object is done through: blocking material flow during long time and blocking transient components during short time.

Among the types of actions that fall into this category can be referred: accumulation (lock, parking, STOP), delivery (release, circulation START), fixation (temporary rising), release (sales in the process of the manipulated object).

5. Control – the main forms of control used in the manipulation of material flows are:

- testing, control, identification of: currently, mechanical space states, colour, position, orientation, number of corps;
- measurement – control – shape, size, weight, process parameters.

The control is a secondary basic function and spatial, complementary of handling.

The industrial logistics is specific to manipulated objects, so there is a logistics for manipulated objects, blank type (Sf) and finished parts(Pf), another for manipulated objects, tools type (Sc), another for manipulated objects, mechanisms type (D) and so on. In a production system, this kind of industrial logistics are distinctive and executed on no interacted trajectories. The overall structure of an internal logistics system is presented (more detailed) in Fig. 2 [6]. The external logistics is the link between internal logistics and suppliers, customers and others.

In Fig. 2 the abbreviations are as follows: F – suppliers; C – clients; DCM – central deposit of materials; DzSc + D – storage area of Sc and D; STSc + D – transport system of Sc and D; DzSf – storage area of Sf; DzPf – storage area of Pf; STSf – transport system of Sf; UTi – technological equipment; Mli – local working storage; PLi – workstation; DLi – local storage of Sf; PC – checkpoint; LE – external logistics; SP – production system; Ap – supply; Liv – delivery; TISc + D – internal transport of Sc; TISf – transport of Sf; A – alimentation; E – exhaust; T – transport; Tr – transfer; TIPf – internal transport of Pf.

2. FUNDAMENTAL MOVEMENTS IN INDUSTRIAL LOGISTICS [6, 7, 8, and 10]

During the technological operation, the movement of blanks (Sf) is not random, they are located and oriented in the production process. Bringing the blanks from random state to their final presentation, in the production process, is done through their handling. The handling is a specific concept of material flow, and in a general sense, is a movement in a given reference system of the manipulated object from a known spatial position in a definite position in space-time, followed or not by maintaining of a temporary location.

Handling an object is achieved by an indefinite sequence of elementary moves (translations – T and rotations – R), in global aspect, reducing at positioning and orientation.

Spatial position of an object is defined by the spatial place occupied by its own coordinate system origin (P1, P2), compared with the reference system O, and it is characterized by the origin coordinates of the own system compared to the reference axis system (a1, b1, c1 and a2, b2, c2).

Angular position of an object is defined by the angles (α, β, γ) of own axes system reference (p1x1, p1y1, p1z1) and reference axes system (Ox, Oy, Oz), more precisely between the versors that defining these axes.

Positioning represents the location of the origin of own system object, P1, in relation with the origin of reference system, and is characterized by the translations of the reference axes system (Δa, Δb, Δc). Orientation consists in own reference system rotating, compared to the reference system and is characterized by the angular variations ($\Delta\alpha$, $\Delta\beta$, $\Delta\gamma$).

The handling can be quantified. Positioning or orientation of an object can be completely determined by the three translations and three rotations. If all translations and rotations are not known, orientation or positioning is not determined.

The positioning degree of a handled object (HO) – DP – is defined by the number of known T for object origin P1, compared to the reference system origin O.

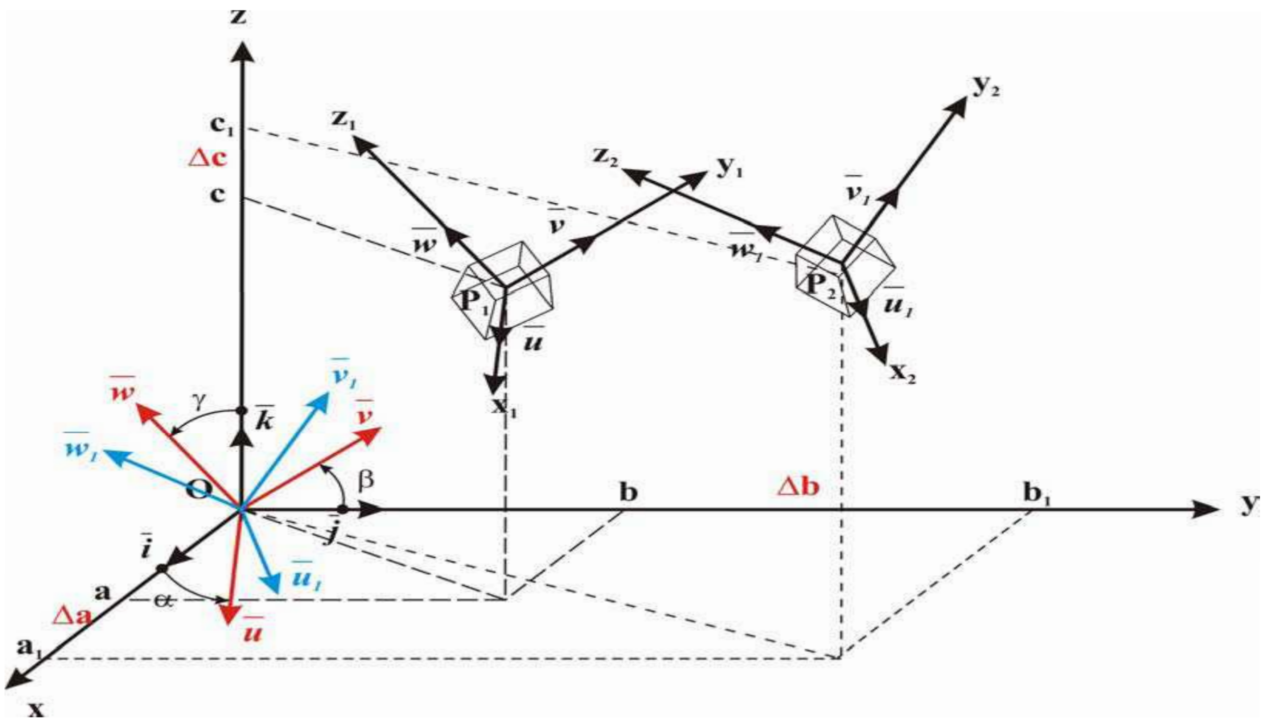

Fig. 3. Movement of an object in space.

Table 1

Values DP/DO and their meanings

Value DP/DO	**Significance**
DP=3	own reference system origin is in a known point, HO is precisely positioned
DP=2	positioning after a curve (a parameter is not known)
DP=1	positioning after a surface (two parameters are n known)
DP=0	object has a spatial position undetermined
DO=3	angular position, determined, after three axes
DO=2	angular position , partially determined on two axes
DO=1	angular position , partially determined on on axis
DO=0	angular position undetermined

Table 2

Logistics movements depending on DP and DO values

	DP	**DO**
Stocks, deposits	0	0
Transport	> 0	0
Handling	> 0	> 0

The orientation degree on a handled object – DO – is defined by the number of known R for object origin P1, compared to the origin O of the reference system.

In Table 1 [5] possible states of a handled object in space are presented. In industrial logistics, depending on values of the two degrees DP and DO, several rules were established (Table 2) [6, 7, 9, and 11].

3. LINKS METHOD

This method is part of constructive heuristic method categories. The method name has on the basis the concept of production link. Through production link s meant the couple of two machines that establish a relationship in the production process. Browsing a link in the production process in any direction (*i*–*j* or *j*–*i*) generates a relationship production [1, 2].

The initial data needed to apply this method are:

- the machines which will be located, identified by a number or a letter;
- flows of products that are made in those plants;
- number of groups (of manufacturing or transport) which moves between machines, for each product type.

The assumptions underlying the development of the method are:

- the location result is a theoretical one, which does not take into account any consideration of space;
- the machines are not characterized by a certain surface;
- the location is not predefined, machines will be positioned in a triangular network unbounded.

The method algorithm is [1, 3, 10]:

1) Establishing order of the location of units, following next steps:

- determining the number of links for each participating unit;
- it is established the traffic intensity for each unit, which reveal the number of lots that cross each unit;
- it is established placement order of the units depending on the traffic values intensities, previously determined for each unit;
- in case of two equal traffic intensity units, will had placement priority the unit which has more production links.

2) Theoretical preliminary location of the units. In this phase we determine the relative positions of units within the production system. The units will be placed successively, in previously established order, in the

nodes of a network with regular geometric shape (equilateral triangle). Placement of the units is done as follows:

- first three units are placed, with biggest traffic intensities, in the nodes of network centre;
- next placed unit will be the first unit of placement order list, placed after those located.

3) Finalization of the theoretical placement of units. This phase consists in the graphic representation of the trajectory of technology flows for each product. If the trajectories of technological flows do not comply previous conditions, the placement must be improved.

4) Adaptation of theoretical location to real conditions. After obtaining an agreeable solution, the relative positions of the units will be extrapolated at real dimensions space, considering the space restrictions.

4. CASE STUDY: OPTIMAL LOCATION OF THE MACHINES

The links method allows optimal placement of a polyvalent group of workstations. This method is to highlight two main aspects [4]:

- each piece flux within the group of workstations;
- the number of transport groups of each piece type.

In Fig. 4 are identified the production equipment necessary for the manufacturing of four components parts of the intake system.

The order processing surfaces of the four parts on processing machines is presented in Table 3.

The role of the intake system is to feed the cylinder with fuel and air needed for combustion and flue gas to evacuate. The intake gallery role is to evenly distribute the mixture air – fuel to the cylinders. Gallery consists of a maze of pipes of various diameters that are cast or joined together. The support serves to support the injector. The injector body contains the flow and return connections for fuel.

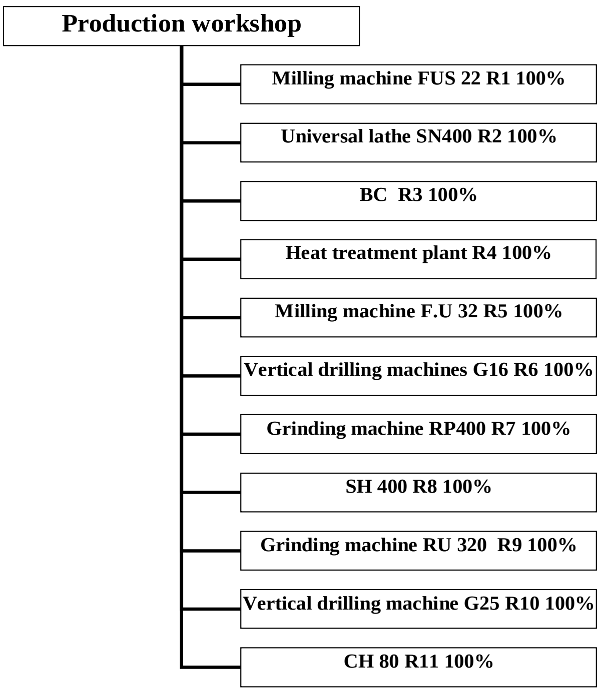

Fig. 4. Decomposition structure of resources.

Table 3

Summarizing table of the grouping products

Products	**Operation**									**No. of transport group**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	
Intake gallery	R1	R2	R1	R1	R3					**4**
Square flange	R4	R5	R6	R2	R2	R4	R5	R7	R3	**4**
Injector support	R5	R6	R8	R8	R6	R2	R4	R9	R3	**4**
Injector body	R2	R7	R5	R10	R11	R3				**2**

The development of matrix location has the following phases [2 and 3]:

- marking the drawing links;
- identification of the links and determination of the flux index;
- determining the number of links for every workstation.

The table links is plotted as a matrix whose rows and columns mean different workstations that are written in boxes corresponding to the secondary diagonal.

The other boxes of the matrix are called links. Also, near the matrix location (Table 4) near resources that are placed each flux density of them has been shown between brackets.

The placement order of the equipment is on a descending order of traffic intensities values previously determined.

Where the number of groups is the same, the placement order is established based on the number of links and production connections of the machines. List of placement order machines is the following: R5 – R2 – R6 – R4 – R3 – R7 – R1 – R8 – R9 – R10 – R11.

Representation of theoretical location (Fig. 5) is built through sequential location of resources in order of their priority placement, as follows: length of links to be according to their total flow indices; to avoid, if possible, the appearance of junction links in the network.

The control of theoretical location is done by representing the technological flows of each manufactured piece (Figs. 6–9).

This representation is made with arrows and allows verifying if each part goes through workstations according with technology designed.

Table 4

Matrix location

Work station	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**R10**	**R11**
R11			1							1	2(4)
R10					1					2(4)	
R9			1	1					2(8)		
R8						2		2(8)			
R7		1	1		2		4(16)				
R6		2			2	6(24)					
R5				2	7(24)						
R4		2		5(20)							
R3	1		4(20)								
R2	2	7(22)									
R1	3(12)										

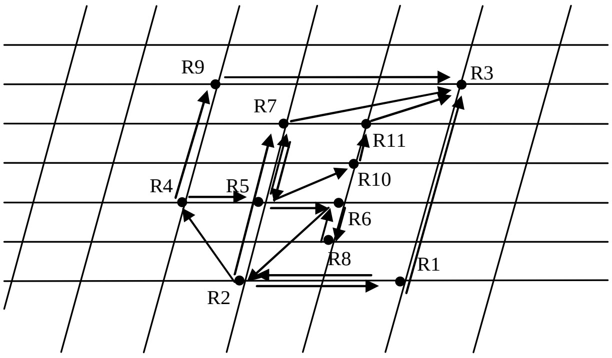

Fig. 5. Optimal placement of machines.

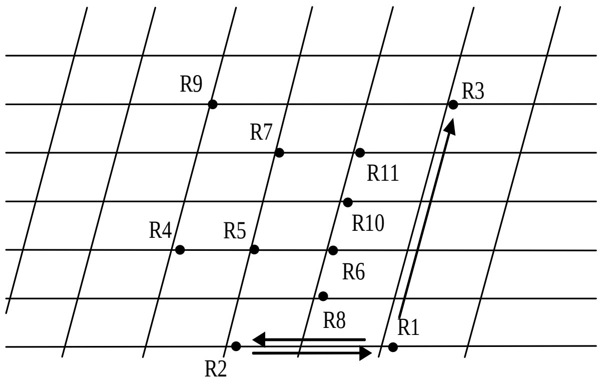

Fig. 6. Technological flux of first piece.

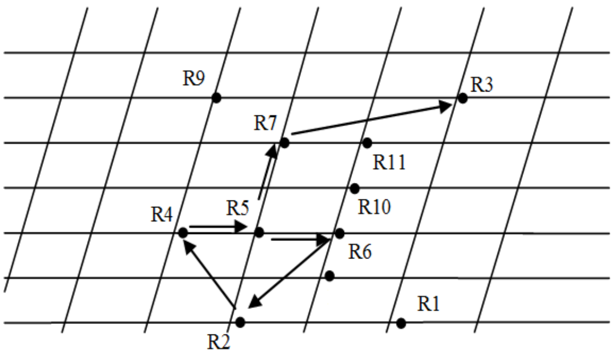

Fig. 7. Technological flux of second piece.

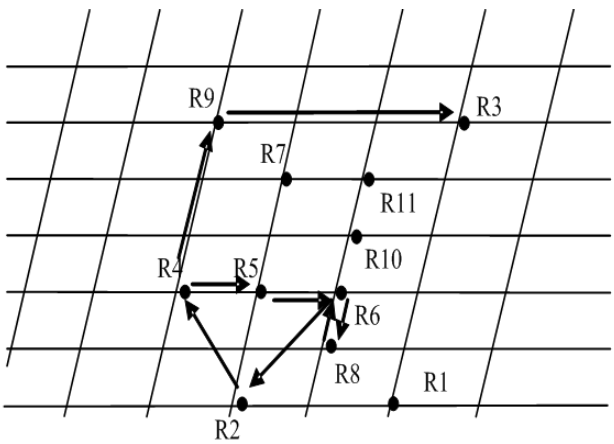

Fig. 8. Technological flux of third piece.

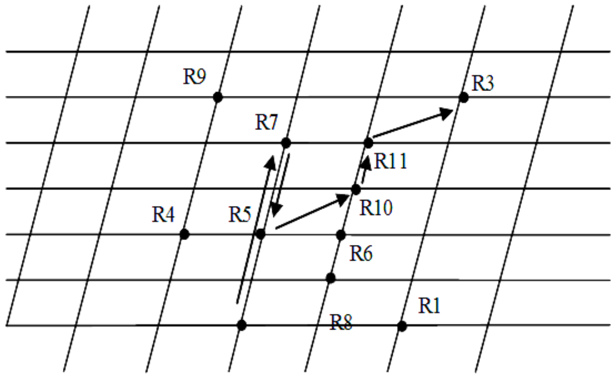

Fig. 9. Technological flux of fourth piece.

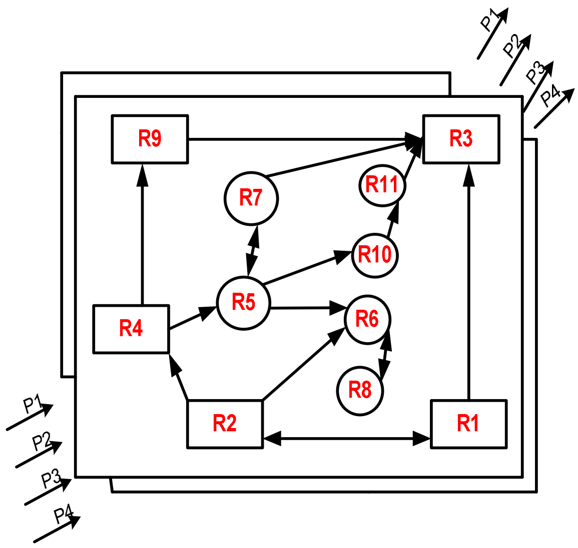

Fig. 10. Adaptation of theoretical location to real conditions.

In Fig. 10 the adaptation of theoretical location to real conditions of the workshop is represented. The found solution is a convenient one, but it should be adapted to real conditions on the space: shape and size of resources, shape and dimensions of the production system, rules and regulations for the location of resources.

It will take into account the areas necessary for resources, parts size and size of lots moved between resources (economic batch or economic transport batch). After determining the location of production resources within the production system, each job within it organized.

5. CONCLUSIONS

Modern logistics industry includes all activities related to product cycle, from getting raw materials, rescheduling acquisitions for production, transfer of documents and products between units of the same company, all production activities, transportation, transfer, intermediate storage in production assembly packaging processes, to service relationships with customers, management of distribution centres and warehouses, management of waste.

Logistics technique, important function of the industrial product life cycle, represents the ability to fulfil the mission for which it was designed, in terms of use and a specified duration of time.

Engineering of industrial logistics, in modern vision, made during the product creation, based on concurrent engineering concepts and computer-integrated manufacturing, ensures proper sizing and reliability of the product, using as an important tool, mathematical modelling, for the representation of failure processes, to establish logistics structures necessary for correct operation.

Engineering of integrated logistics, in the context of concurrent engineering, of the product life cycle and integration of computer manufacturing is crucial for achieving quality technical features and competitiveness.

The values resulting from logistics engineering addresses to the entire product life cycle from design and fabrication stages to operating stages. Evaluation of reliability and maintainability plays a very important role in the design stage of product, providing the possibility of iterations required for optimal solutions.

Logistics strategy should be an advantage for any Romanian company, in current conditions (for example, infrastructure difficulties in Romania and increases in combustible price).

In designing production units as in the elaboration of improving the organization of production units to determine the location of the theoretical schemes jobs several methods are currently used, such as links method, the method ranges fictitious, Cameron method, etc.

The links method is used for optimization the flux at implantation of a workshop or a factory. The links method is used in the production unit design and at elaboration of improvement studies of the production units organization, for determining a theoretical diagram location of workstations. This diagram is determined depending on the frequency links between workstations and volume of materials and products which need to be moved fromone workstation to another, so as to ensure a rational technological flux to minimize the volume of transport and avoid the cross paths.

In practice, the results obtained by the method links will be correlated with the concrete conditions existing in the production area, taking into account if additional requirements of workstations are necessary: natural lighting, approach of the ventilation systems etc.

Links method is used in the production of small and medium series for determining the sequence of different groups of jobs in relation to homogeneous technology in a production department, and also in the production of large series to determine the layout of jobs on a technological line.

The results obtained by the author in the case study presented can be easily put into practice as applied method resulted in an optimal placement of resources in the workshop.

This article can be useful for managers of enterprises who want to realize an optimal placement of machines in the production hall, using all available space.

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