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USING SLP METHOD FOR EFFICIENT ESTABLISHMENT OF A PRODUCTIVE ENTERPRISE FOR RAILWAY INDUSTRY

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Abstract: The paper presents an application of the SLP (System Layout Planning) method for establishing, in an efficient manner, the layout of a productive enterprise. A case study is described in the paper, referring to a factory designated for manufacturing railway industry products, made of aluminum alloys and assembled by welding operations. The phases of the SLP method application are described in the paper, together with the presentation of one particular group of products given as example. The optimal solution of the productive system's layout is selected by analyzing three possible identified alternatives.

1. INTRODUCTION. PROBLEM STATEMENT

In the context of Production Systems Management, Plant Engineering appears as an outstanding area, in order to efficiently identify the technical, economic and human resources and means for the establishment of a new productive enterprise. In these conditions, the planning of the enterprise's layout is one of the main activities. For solving such an important issue as the above mentioned one, first of all a business justification is necessary and for this, it is important to analyze the industrial area where the project belongs.

The Spanish railway industry was chosen to be subjected to the study, because at the present time, in the context of European Union economy, the railway sector is experiencing in Spain an important renovation that comes bound up with the strong increase of the demand of transportation due to a couple of clearly identifiable phenomena:

- The phenomenon of the people from the big cities, changing their houses toward their metropolitan areas, and the necessity of traveling among them.
- The search for a viable alternative to the air transportation, for not very long distances.

Therefore, there have been clearly identified two different directions of growth in the Spanish railway sector: the proximities transportation and the high-speed transportation.

There has been noticed that administration actors which have the responsibility of offering public transportation services mostly chose to invest in a type of infrastructures that despite of being expensive and difficultly profitable, bring as a result a better interconnection among urban cores moderately distanced and between the center and the periphery of the big cities and, consequently, an improvement in the flows of people and goods that finish in determining the growth and enabling of the economic activities, mainly due to the great capacity of transportation, such as for passengers' volumes, very superior to that of the highways, to the competitive times of travel that can be obtained, and to their environmental smallest impact. Considering the new works and investments mainly in the high-speed railway transportation and in the urban and proximity transportation of the main metropolitan areas of Spain, the forecasts show that the demand volume of railway material and products will be very important in the next period, bringing serious difficulties of adaption for the big productive companies in the field.

In these conditions, the opportunity of developing a productive enterprise for manufacturing railway industry products, in the proximity of Valladolid, in Spain, seemed viable.

2. GENERAL PRESENTATION OF THE SLP METHOD

The SLP (System Layout Planning) method indicates the steps to follow in order to find the optimum plant distribution for the new productive enterprise to be analyzed. By applying the different phases from this method to the studied new factory, there will be established an optimal location of all the machines, equipment and of the rest of facilities in the factory layout.

The phases and steps, in which the method can be divided, are shown in the block-chart from Fig. 1:

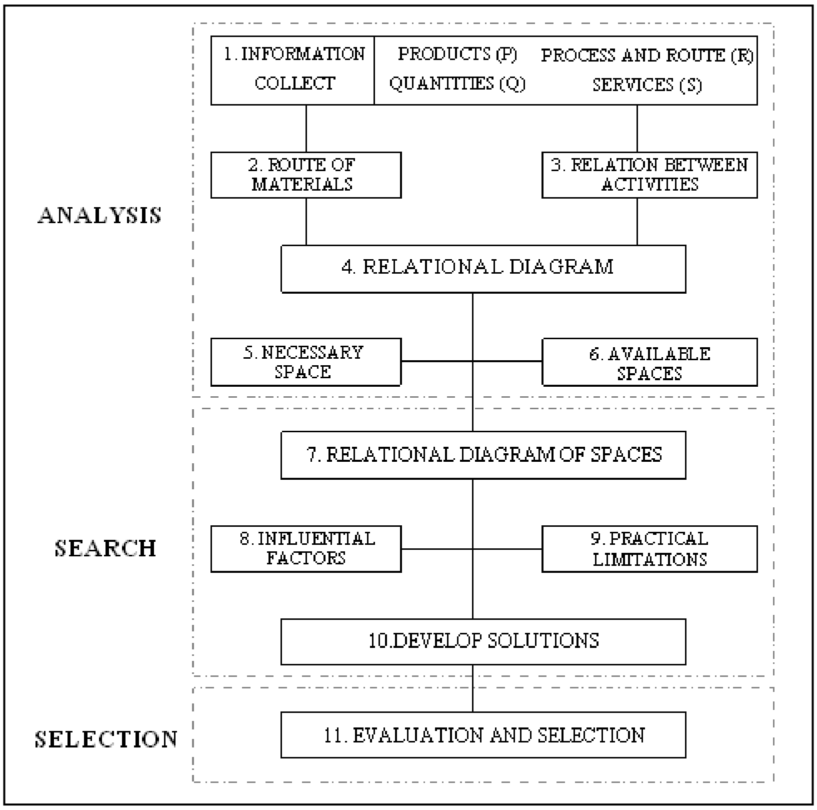

Fig. 1. Phases and steps to be followed in the SLP method

Accordingly to those shown in the block-chart from Fig.1, and by interpreting them, there can be concluded that the SLP method is based on six main stages, in which a series of procedures are followed and conventional symbols are used to identify, to evaluate and visualize the elements and the involved areas in the enterprise's layout planning:

1. Definition: In this stage, there must be defined what and how will be manufactured.
2. Analysis: In this stage there must be analyzed the different operations of the industrial manufacturing process and the different places of the functional areas of the factory.
3. Synthesis: In this stage, the analysis previously done must be visualized in various diagrams, and several alternative options have to be proposed.
4. Evaluation: In this stage, the different proposed alternative solutions are compared and evaluated.
5. Selection: In this stage, the most appropriate solution for each case is selected.
6. Implantation and pursuit: In this stage, the selected option is implanted and a pursuit of the same one is made.

3. DESCRIPTION OF A GROUP OF PRODUCTS TO BE MANUFACTURED

As it is known and is shown in Fig. 1, the first step in the design of a plant layout is to establish what product is intended to be manufactured and in what quantities. This approach is known with the name of Analysis P-Q (Product-Quantity).

When the range of manufactured products is very large, it is a good idea to form groups of similar products, not only to facilitate the treatment of the information and the formulation of forecasts, but also because the forecasts for one product can just be not very significant. A bigger or a smaller aggregation among the products must be function of their relative weight in the group, as much regarding the quantity as the value, so for the begining, there must be established relationships between the products, with some indication about their importance. After forecasts are proceeded, for certain period of time and for each group of products, those must be ordered accordingly to their importance and to the results of the developed forecasts. This ordination serves as base for a classification of the groups of products which will determine a different treatment in later stages of the SLP method.

The group of products that has been chosen as subject of the case study for the productive unit's layout planning is represented by the back headboard of a modern suburban train. The headboard is the assembly that represents the mechanical interface between the railway carriage's structure and the coupling elements. The coupling elements are the mechanical elements whose function is to provide the joint between railway carriages. For the coupling elements to be perfectly anchored to the carriage's structure, an intermediate structure, respectively the headboard, is needed, as it is shown in Fig. 2.

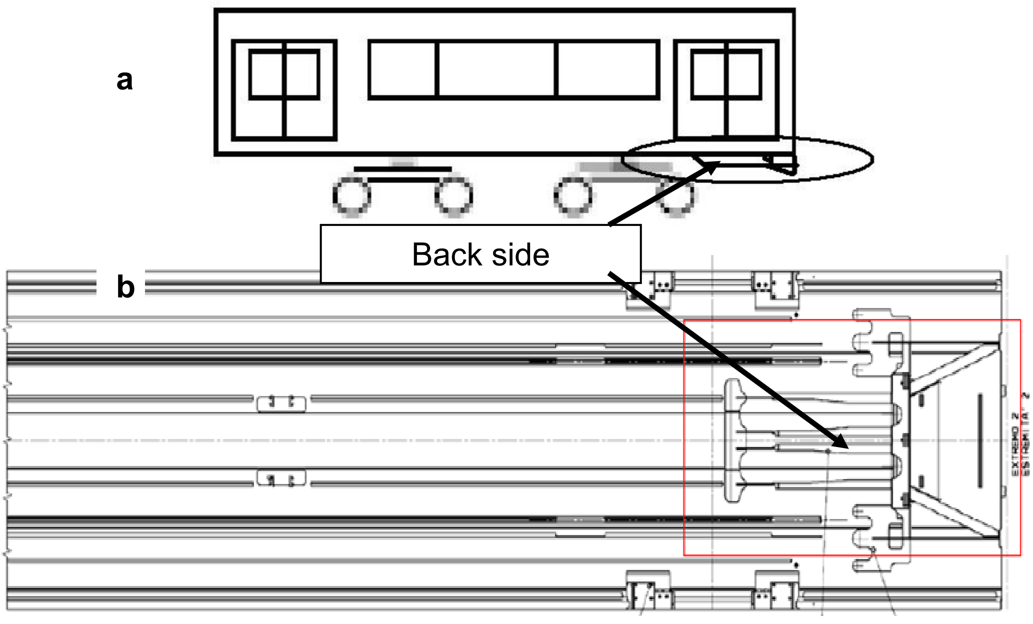

Fig. 2. Location of the product into a train: a ***– a side view;*** b ***– upward view***

As it can be seen from Fig. 2, the headboard occupies the whole extremity of the wing framework of the railway carriage. For a correct distribution of the mechanical efforts throughout the structure, the central part of the headboard is usually wider than the extreme ones. At the same time, this configuration allows a bigger central space that allows the anchorage of the coupling elements (Fig. 3).

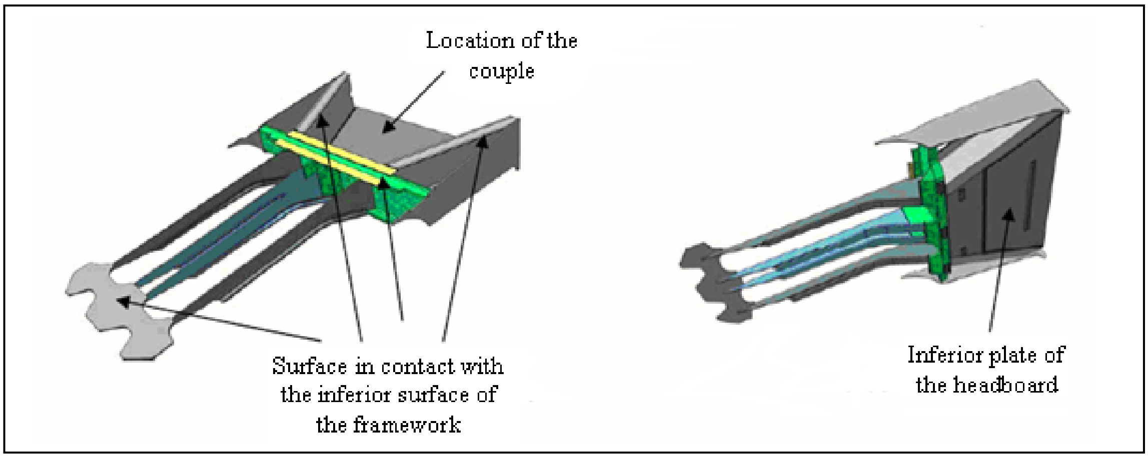

Fig. 3. The headboard subjected to the case study

Normally the coupling elements are anchored to the structure of the headboard by screwed fasteners. The headboard is joined to the rest of the carriage structure by welding, in the case of being from the same material. The shape of the headboard is designed to provide a bigger contact surface between the headboard and the carriage's wing, for maximizing the lengths of the weldments and in this way to guarantee a better joint between both structures. In some cases, the headboards are designed to carry out a function of collapsible structure, in order to absorb the energy generated in a crash, in the eventuality of an accident.

The back headboard, as well as the rest of the components that constitute the structure of a railway vehicle, is manufactured starting from plates of medium or big thickness, cut at stipulated dimensions and then joined by welding. In the case of aluminum structures, one of the big advantages is the possibility of using profiled bars extruded in cold conditions. The aluminum profiles give the possibility to build a structure more optimized in relation to the mechanical efforts the structure is subjected to.

In Fig. 4, the assembling scheme for the studied product is shown.

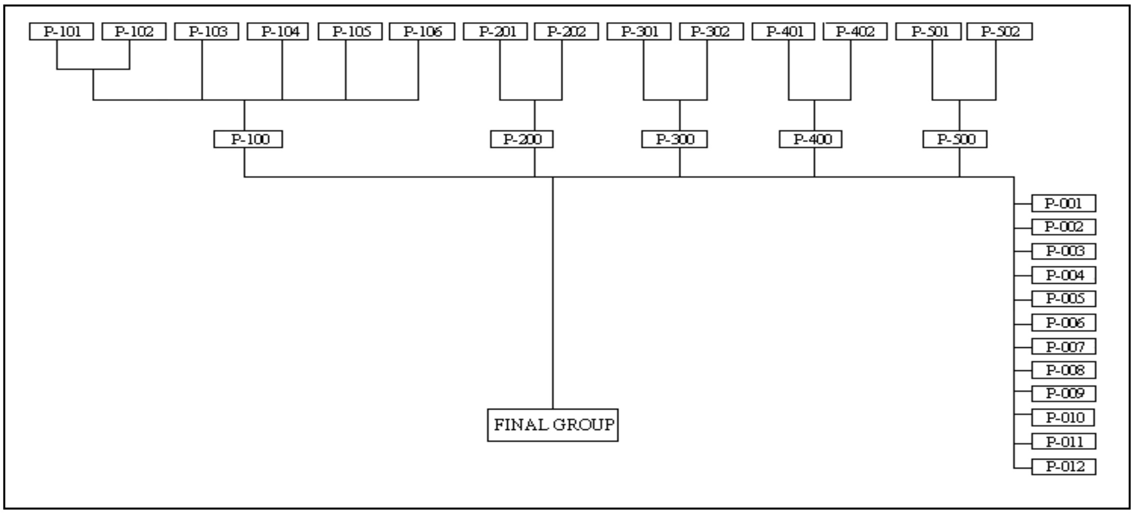

Fig. 4. The assembling scheme for the headboard subjected to the case study

In Fig. 5 and in Fig. 6, the location of the component parts in the studied assembly product is shown.

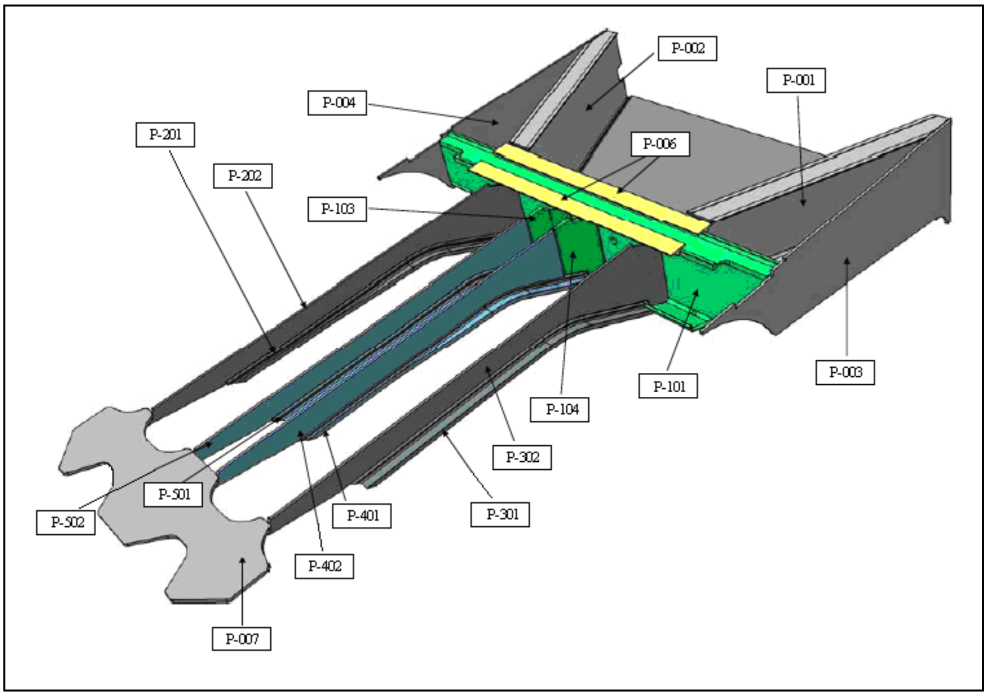

Fig. 5. The location of the parts in the headboard assembly – downward view

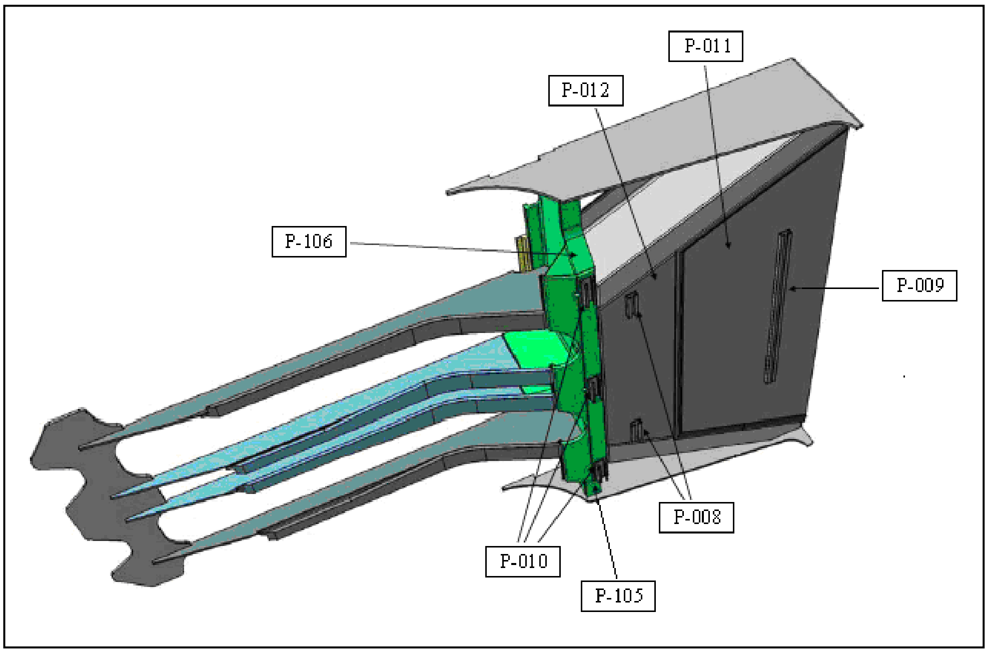

Fig. 6. The location of the parts in the headboard assembly – upward view

The reason that has directed the decision towards the design of a productive enterprise specialized in welding of big and medium aluminum structures has been represented by the increased impact and use that this material is having in diverse sectors of the industry, but with special emphasis in the European railway sectors. At the present time, about 80% of the orders that the administrations of the European railway sectors are launching, stipulate in the corresponding sheets of specifications the requirement that the structure must be manufactured in aluminum alloy. Lately, the aluminum has consolidated as a clear alternative to the steel in the production of boxes of railway vehicles. In the high-speed railway transportation segment, the aluminum is used in 100% of the cases. In tram and metropolitan transportation segments, the aluminum is located around 90%, while in regional and suburban train it descends around 60%. Anyway, also in the suburban trains, mainly when speaking of electric traction, the aluminum overcomes a lot over the steel in the orders of railway material during the last years.

4. SLP CASE STUDY. ALTERNATIVE SOLUTIONS' DEVELOPMENT, EVALUATION AND SELECTION

For the above presented group of products to be manufactured, the productive process workflow was established and for each operation, the equipment was chosen.

After that step was accomplished, the activities relations were analyzed, by identifying all the necessary activities and auxiliary resources and places, by building the activities relational table and the routes and activities relational diagram.

The space necessities were after that established. In Table 1, there are presented the areas in detail, for each equipment and activity, together with the total area that is needed to build the studied factory.

Table 1. Inventory of all areas necessary for the enterprise

Department / Place	Quantity	Dimension [m]	Area [m^2]	Total Area [m^2]
1. Band sawing machine	3	11,9 x 11,05	122,5	367,5
2. Machining centres	8	12,5 x 8	100	800
3. Folding machine	2	8 x 4	32	64
4. Welding of subgroup nerve-reinforcement	7	7 x 6,5	45,5	318,5
5. Welding of subgroup central part	6	7 x 6,5	45,5	273
6. Welding of final assembly	8	9,5 x 10	95	760
7. Cleaning pre-welding for subgroups	2	6 x 4	24	48
8. Retouch pre-welding for subgroups	2	6 x 4	24	48
9. Cleaning pre-welding for final assembly	2	6 x 4	24	48
10. Retouch for final assembly	1	6 x 4	24	24
11. Detail finish for subgroups	2	4 x 6	24	48
12. Detail finish for final assembly	1	7 x 8	56	56
13. Raw material warehouse	1	10 x 20	200	200
14. Warehouse of tools	1	10 x 10	100	100
15. Pre-machining safety stock	1	2 x 5,5	11	11
16. Pre-welding safety stock	1	2,5 x 4,4	11	11
17. Welded subgroups safety stock	1	3 x 10	30	30
18. Final product warehouse	1	10 x 10	100	100
19. Reception	1	10 x 3	30	30
20. Dressing room	1	5 x 12	60	60
21. Canteen	1	5 x 12	60	60
22. Medical services	1	6 x 11	66	66
23. Bathrooms	1	4 x 9	36	36
24. Offices	1	10 x 5	50	50
25. Metrology workshop	1	10 x 6	60	60
26. Material entrance	1	10 x 5	50	50
27. Exit final products	1	10 x 12	120	120
TOTAL	-	-	-	3839

Knowing the space necessities for each one of the involved activities, the total needed area must be compared to the available land surface. In the considered case there were known the dimensions of the available land surface which were: 50mx100m=5.000m^2, so there could be considered that there exist enough space for build the intended factory in the limits of considered location.

Accordingly to the routes and activities relational diagrams, previously obtained and mentioned above, there have been proposed different alternatives of layout organization for the intended new factory.

Three of such proposed alternative solutions are shown in Fig. 7, Fig. 8 and respectively Fig. 9.

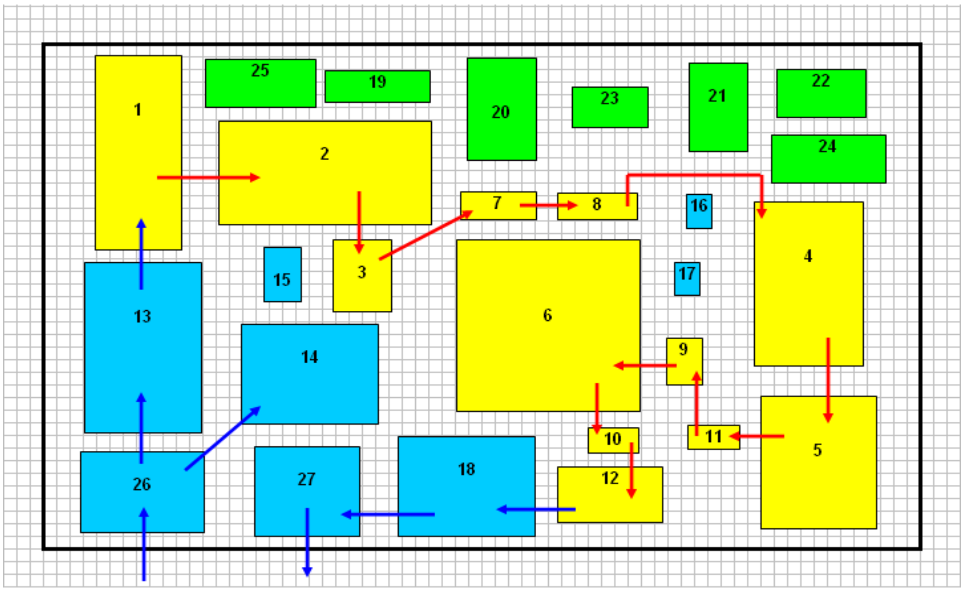

Fig. 7. First alternative solution for the factory layout

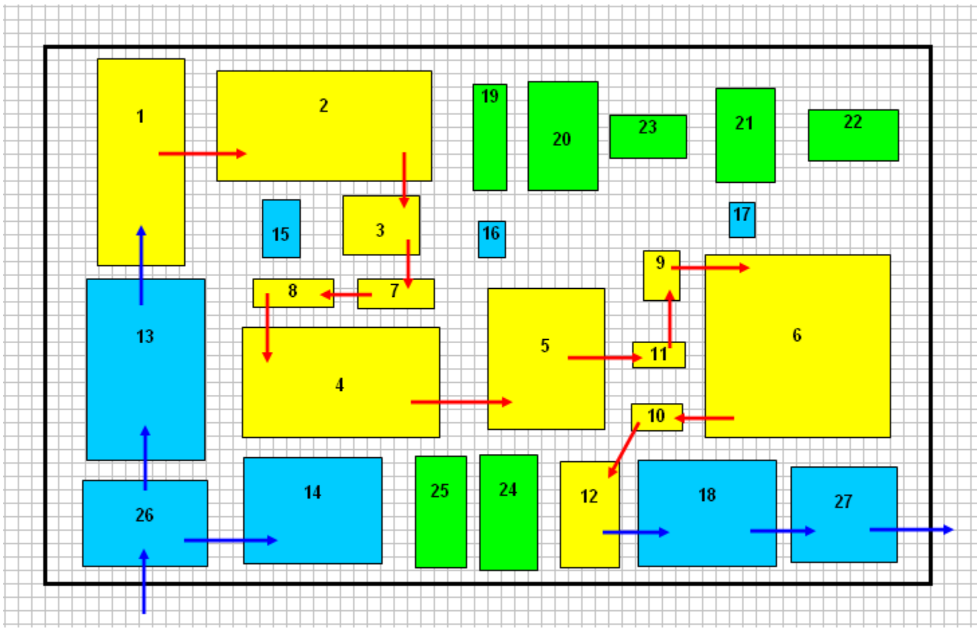

Fig. 8. Second alternative solution for the factory layout

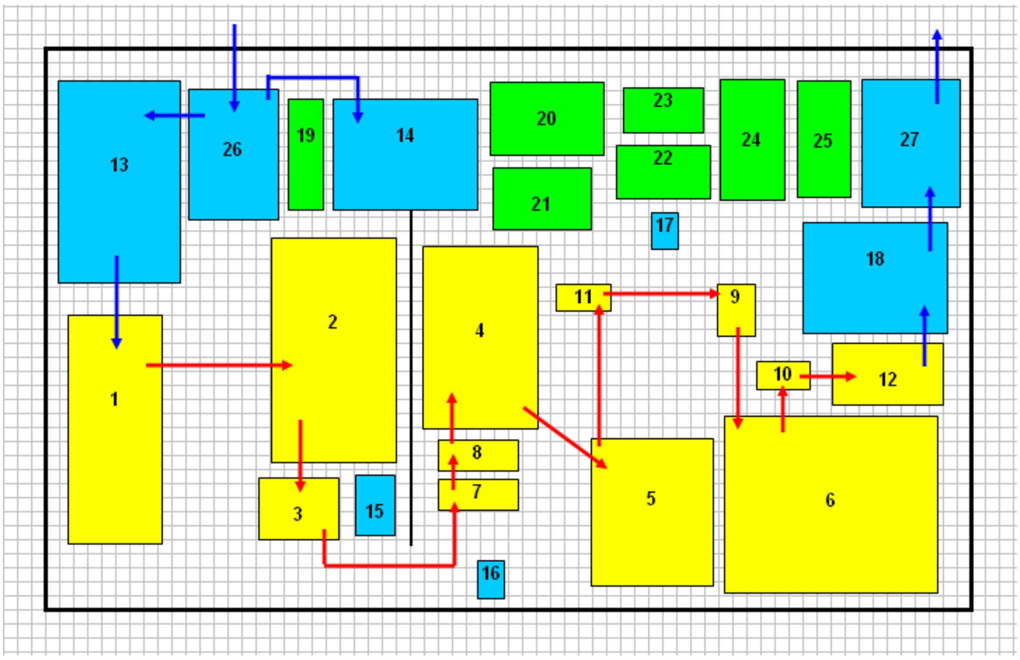

Fig. 9. Third alternative solution for the factory layout

There must be precised here that the numbered notations from Fig. 7, Fig. 8 and respectively Fig. 9 represent the activities, places and departments mentioned in Table 1, the used colours signifying the functional areas in the enterprise, respectively yellow for manufacturing, blue for logistics and green for auxiliary services.

In order to select the optimal alternative solution for the productive enterprise's layout, an evaluation for each of the alternatives, in relation with all the involved factors, was developed.

The main factors that have been considered to identify the optimal layout distribution, together with their weight values, are presented in Table 2.

Table 2. The considered factors and their weight

Factor	Weight
Growth easiness	2
Materials flow easiness	5
Optimum use of the space	6
Safety	4
Facility of control and supervision	3
Facility of instalations maintenance	2
Flexibility of the factory plan	2
Proximity of places with workers or machines shared	5
Working conditions	3

The weigth of each factor took value from 1 to 10 and has been assigned accordingly to the importance given to them, in correspondence to the agreement levels and the point awarded, as it can be seen in Table 3.

Table 3. Points awarded for agreement levels

Agreement Level	Points
Poor	0
Regular	1
Good	2
Excellent	3

In Table 4 there are presented the evaluation data for the three alternatives, considering the selected factors and their weigths.

Table 4. Evaluation and selection of the three proposed alternatives

Factor	Points / Alternative		
	1	**2**	**3**
Growth easiness	1	1	2
Materials flow easiness	1	2	3
Optimum use of the space	1	2	1
Safety	2	1	3
Facility of control and supervision	1	2	1
Facility of instalations maintenance	2	1	2
Flexibility of the factory plan	1	2	2
Proximity of places with workers or machines shared	2	1	2
Working conditions	1	2	3
Total Result	43	51	**67**

From the obtained evaluation data, there can be seen that the alternative with the best score is the alternative no. 3, so this alternative will represent the plant layout that must be used for the intended factory. Once that the best layout for the intended new productive enterprise was known, there have been put together all the parts of the enterprise accordingly to the needed number of them, as it is shown in Fig. 10.

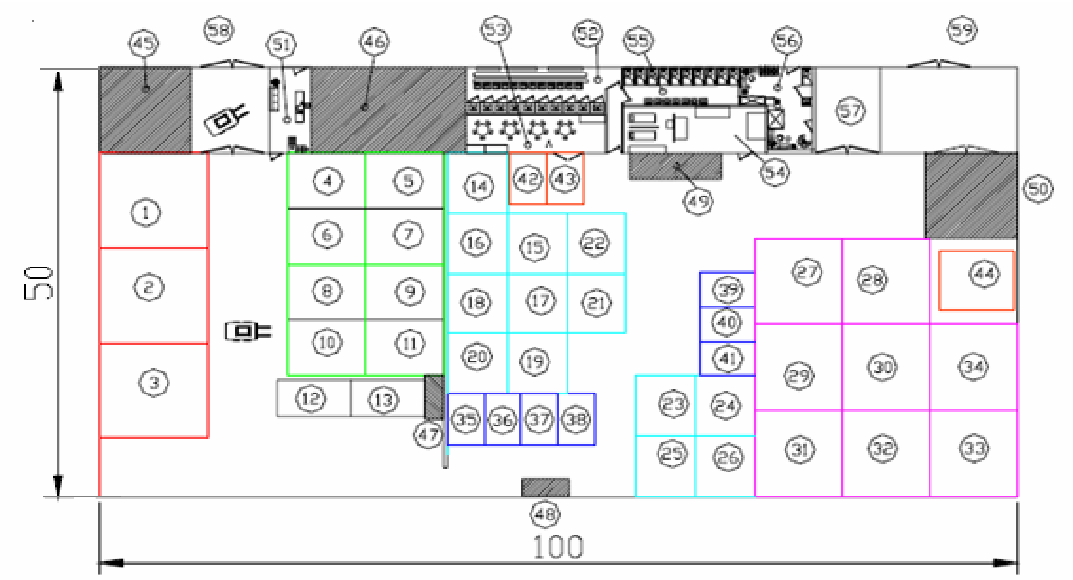

Fig. 10. Final solution for the factory layout

In Fig. 10, the numbered notations have the following meaning: 1÷3 - Band sawing machine; 4÷11 - Machining centres; 12, 13 - Folding machines; 14÷20 - Welding of subgroups rib-reinforcement; 20÷26 - Welding of subgroups central parts; 27÷34 - Welding of final assembly; 35, 38 - Cleaning pre-welding for subgroups; 36, 37 - Retouch pre-welding for subgroups; 39, 40 - Cleaning pre-welding for final assembly; 41 - Retouch for final assembly; 42, 43 - Detail finish for subgroups; 44 - Detail finish for final assembly; 45 - Raw material warehouse; 46 - Warehouse of tools; 47 - Buffer warehouse pre-machining; 48 - Buffer warehouse pre-welding; 49 - Buffer warehouse of welded subgroups; 50 - Final product warehouse; 51 - Reception; 52 - Dressing room for personel; 53 - Canteen; 54 - Medical services; 55 - Bathrooms; 56 - Offices; 57- Metrology workshop; 58 - Material entrance; 59 - Exit final products.

5. CONCLUSIONS

The paper presents an application of the SLP (System Layout Planning) method for establishing, in an efficient manner, the layout of a productive enterprise. A case study is described in the paper, referring to a factory designated for manufacturing railway industry products, made of aluminum alloys and assembled by welding operations.

The phases of the SLP method application are described in the paper, together with the presentation of one particular group of products given as example. The optimal solution of the productive system's layout is selected by analyzing three possible identified alternatives.

The presented case study refers to the Spanish railway industry, but with adequate adapting it can be extrapolated for developing a productive enterprise for the Romanian railway industry, as the Romanian railway infrastructure will may follow, in the near future, the renovation and development trends specific nowadays for the western countries in the European Union.

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