ESTABLISHING CRITERIA FOR DESIGNING PRODUCTION SYSTEMS USING SELF-ORGANIZING NEURAL NETWORKS

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Abstract
Production systems required much information to be properly designed. Artificial neural networks seems to be perfect solution for analysis of such amount of data. However to gain useful output from artificial networks data have to be correctly prepared. This article shows a thinking-process of obtaining correct criteria for each step of systems designing process. Research goes through basics of knowledge management in production companies that gives further ideas for criteria prioritizing. Different criteria was dedicated to different management approach based of production unit complexity.

Keywords: PRODUCTION, SYSTEM, KNOWLEDGE MANAGEMENT, SELF-ORGANIZING NEURAL NETWORKS

1 INPUT FOR CRITERIA RESEARCH
The first step in identifying the ideal production system factors was to infer, as demonstrated by industry practitioners, the measurable factors affecting the efficiency of production system. To perform this, authors confronted the assembly modules grouping criteria with the optimization methods indicated by the practitioners [2]. Results of this research are presented in the Table no.1.

<table>
<thead>
<tr>
<th>Optimization methods</th>
<th>Assembly modules grouping criteria</th>
</tr>
</thead>
</table>
| 1. Operation sequencing | • operations time  
|                       | • production plan  
|                       | • production tact time  
|                       | • deepness of BOM levels  
|                       | • quantity of assembly parts |
| 2. Ergonomic optimization of workstation | • weight of assembly parts  
|                                         | • quantity of operators required  
|                                         | • quantity of assembly parts |
| 3. Ergonomic optimization of transport between workstations | • technology of transport between workstations  
|                                                            | • weight of assembly parts  
|                                                            | • production surface |
| 4. Distance between workstation and storage place optimisation | • technology of transport between workstations  
|                                                              | • storage surface |
| 5. Assembly connection analysis | • required production equipment  
|                                      | • effective machine time indicator |
| 6. Similarity of part shape and design | • shape of assembly parts |
| 7. Similarity of part dimensions | • dimensions of assembly parts |

During the research of using artificial intelligence for production systems designing process it was noticed that selected criteria for the network cannot be equal [research not published yet].

Preliminary attempt to create a production system optimized by artificial intelligence, on the basis of equal importance criteria, failed. This was due to the fact that the selected criteria were unambiguous for the Kohonen network. In addition, large discrepancies in the values of the input vector characteristics dominate the learning outcomes of those features that have the highest values, because they have a greater impact on the distance between each neuron during network learning process [7]. It is also noticed that creation of zero-by-one input vectors is more effective for the SOM Toolbox 2.0 than any other form. [8]. This research shows the fact that initial input vectors has to be pre-prepared and dedicated for production systems. Due to above authors decided to research a process of criteria evaluation and prioritizing. This research has a beginning in review of knowledge management in regards to operations management.

2 APPLICATION OF ENGINEERS KNOWLEDGE RESOURCES IN DESIGN OF PRODUCTION UNITS

Under conditions of contemporary competition of industrial enterprises, knowledge has become a significant factor of competitive advantage. It is not only the basis for creating innovation, but it is also an intrinsic part of making good decisions about managerial responsibility.

As noted by Mr. Nogalski and Niewiadomski [4], the state of the present economic reality no longer allows the hiring of only technically educated workers or only management educated workers. Times, when company access to the latest technology was a determinant of gaining competitive advantage, has passed. General availability of means of
production shifts the focus of competition on the ability to utilize company resources in an interdisciplinary manner primarily through knowledge management. The knowledge management aspect in industrial companies can be named as the possibility of the association of production engineering discipline with the management science.

2.1 Knowledge management in regards to operations management

To easily picture correlation between technical and management skills in production environment the authors present below diagram.

Figure 1. Graph of the dependence of knowledge demand on the scale of production company unit complexity.

Figure 1 shows a schematic distinction between the need for technical knowledge and organizational experience on the scale of level of complexity of production unit. By analyzing the above diagram, it should be noted that any type of knowledge at every level of design improvement is absolutely required.

Technical improvements cannot be made to a workplace without knowing the basic organizational structure of the workplace, nor can you manage changes throughout the corporation without the concept of, for example, new technology solutions used in the industry. As the level of company complexity is increasing, the demand for managerial knowledge increases, and the technical knowledge demand is decreasing. The risk of experience lack in various fields of knowledge is usually diversified through the creation of interdisciplinary project groups composed of people of varying levels and the nature of their knowledge and experience. Figure 1 shows the relationship between the use of knowledge in such groups depending on the level of the production unit.

It can also be stated that the graph of the use of technical knowledge also specifies the detail of the analyzed data, and the graph of managerial knowledge the scope of data that requires analysis. As the levels of the production unit increase, the level of knowledge strives for generalized values, but its scope widens considerably. The authors therefore found that the design of different levels of production units requires a variety of design assumptions and selection criteria.

2.2 Knowledge management in project management process

Effective knowledge management has a significant impact on each of the five generalized system design parameters [9], i.e.:

- project scope,
- quality,
- costs,
- duration of the project,
- resources.

Well-organized knowledge will serve to define the final boundaries of the project that is its scope. It can validate or undermine the project framework by showing unused areas that can maximize synergies effect that have a long-term impact on the outcome of the project. It can also be a source of high quality product or service at every stage of its design, and it has a clear impact on interpenetrating cost factors, time consuming tasks and the use of human and material resources.

As the authors note, all the described parameters of the project are mutually dependent, which is the basis for claiming that the change of each of these parameters at any stage of the project has an effect on its final form. It is therefore important to effectively use the accumulated knowledge at the stage of defining design assumptions and replenish his resource throughout the duration of the project.

A practical example of such behavior in production conditions is concurrent engineering.

3 CONCURRENT ENGINEERING AS AN ELEMENT OF KNOWLEDGE MANAGEMENT IN NON-AUTOMATED ASSEMBLY SYSTEMS DESIGNING

At present, companies dealing with the assembly process, based on mainly detachable connections, human, non-machine work, are trying to design their own assembly processes with the help of concurrent engineering (CE) methods. CE is defined as “a parallel approach to the product design and manufacturing processes related to it, in order to reduce the time needed to design and manufacture a product and then to use it effectively.” [10]

Concurrent engineering assumes continuous integration between each design process of the product and its manufacturing process, and thus it combines technical and organizational knowledge as unity.

The use of concurrent engineering principles in the light of adequate knowledge management expertise is now essential to managing the design of any production system, including assembly systems. This concept requires reference to the construction and technology of final products already at the stage of designing higher-level production units, where in recent years, the focus has mainly been on organizational aspects. According to the assumption based on the publication [4] it is stated that taking into account the technological processes of the designed units in the design management model will allow “greater possibilities of achieving the leading cost advantage and thus increase the profit margin gained from a given unit”. [4] To ensure the highest use of potential proportionality of such a system (according to the author, this is the level that determines the ratio between the use of managerial and technical knowledge) what also means to optimize the maximum use of production capacity, attention should be focused on human resources technical background and organizational skills in a concurrent manner.

Application of concurrent engineering principles will not only shorten the designing process time, but also improve the optimization effects. Figure 2 shows the options for choosing the optimization routes in the assembly plant. The core of the diagram is the vertically shaped elements, which are the means of adjusting the production capacity by both technical optimization and organizational improvement as parallel process.
It should also be noted that according to the Kaizen [5] philosophy, improvement of production systems is a continuous process, therefore the above diagram does not have a final operation. On the other hand, every local optimization phase ends with the implementation of optimization ideas, which is at the same time the beginning of “Determining new capacity” and further improvements.

Due to the above, the optimized component is usually the utilization of production capacities in the form of tools, machines and human resources. The most efficient use of this is when the assembly stations with the most varied production profiles are as balanced as possible, i.e. they have the same load factor at the set output, inventory level, reliability of machines and equipment, differentiation of the assortment produced and other operating conditions [F].

Inadequate use of company power is conditioned not only by the presence of “bottlenecks” but also by “wide areas of aspects” in the production capacity of assembly equipment. Removing in-plant disproportions is not just about improving bottlenecks, but also on the proper use of undersized parts of the system. In addition, technological progress is also important, which greatly affects the system as follows [6]:

- In a continuous process, the appropriate proportionality of the company's production capacity will be lost,
- is one of the two most important factors affecting capacity (alongside the process organization),
- Optimization of systems based on only one of the two factors of production (technical and organizational) balance maintenance causes continuous blurring at these proportions. Only the synergistic combination of the two criteria allows for continuous system development by maintaining its balance.

However, in the case of "strong" constraint in the production system (difficult to "break"), a tailored production planning system needs to be built [11], to maximize the utilization of the critical resource (and therefore going to achieve the maximum throughput of the system).

Alignment of capacity utilization can be managed in a variety of ways, but at different hierarchical levels. It depends mainly on the philosophy of the enterprise and their goals at operational, tactical and strategic levels. This is reflected in activities at the level that starts with a single position, through cells, lines, departments, factories, ending up with whole corporations. Therefore, the required knowledge and experience of designers, and the capital means of implementing process regulation will vary at different stages, and the uncontrollable difference will deepen. It is therefore very important to systematically balance technical and organizational knowledge as well as synergistic combination.

Using engineering knowledge in managing the design of production units requires the selection of design levels in the light of the use of differentiated knowledge at different stages of the process.
Considering the conclusions of the literary analysis presented in Chapter 1 "Using engineering knowledge in managing production unit design," the authors stated that selecting groups for assembly systems should refer to the degree of complexity of production units (0° - station, 1° - group of machines, 2° department, 3° division, etc.) [3]. It would be wrong to say that the criteria for grouping production units of all degrees are equivalent. It cannot be asserted that, for example, workstations analysis requires the same analyzing criteria as whole division. Such a mix of criteria would not reflect the logical form of research. All this comes from opinion that each management level needs different knowledge to be managed. This opinion is initiated on the information presented in section 2.2 of this article. Different production unit needs different management approach, especially in regards to time horizon, scope and details deepness analysis. Such correlation is presented on Figure 3.

As production units complexity and management levels correlation is known, there was a need to establish general algorithm of processing with designing production systems step by step. Below is presented the initial algorithm for such a process. It is the basis for the creating whole system includes designing stations, lines production cells, departments and divisions as production units.

![Figure 3](image-url)  
**FIGURE 3.** Relation between production units complexity and management levels, source: own study.

![Figure 4](image-url)  
**Figure 4.** Algorithm for assembly system design process, source: own study.
4.1 Establishing criteria for digital data representation for self-organizing neural networks on different management levels

Designing the assembly at strategic level is limited to production unit of level IV analysis. The decision-making process at this level is strongly linked to business decisions of the board of directors based on long-term analysis of competitive advantage. The purpose of such activities is to achieve a dominant role against the background of enterprises in the industry through long-term actions. There are many methods and tools for analyzing the proper shaping of strategic activities like BGC matrix, SWOT analysis, CCF method and other [1]. Designing assembly systems at tactical management refers to two levels of production units: department and division. In order to characterize the digital representation of neural network inputs, a data matrix should be created taking into account the differences between the characteristics of the finished products and their impact on the organization and management of the assembly system. For this purpose, three data groups representing different clustering categories were created according to Table 2.

Table 2. Optimisation methods and grouping criteria, source: own study.

<table>
<thead>
<tr>
<th>Feature/aspect</th>
<th>Organisational aspects</th>
<th>Technology aspects</th>
<th>Ergonomic and transport aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>produccion program</td>
<td>quantity of parts in final product</td>
<td>assembly connection technology</td>
<td>final product weight</td>
</tr>
<tr>
<td>quantity of BOM levels</td>
<td>expected tact time/customer needs</td>
<td>part with max. weight</td>
<td>weight ratio of parts within the product</td>
</tr>
<tr>
<td>influence</td>
<td>layout organization</td>
<td>demand for labor hours</td>
<td>equipment requirements</td>
</tr>
<tr>
<td>production units organization</td>
<td></td>
<td></td>
<td>ergonomic of transport between stations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>ergonomic of workstation</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>logistics of production (supplies of materials on the work stations)</td>
</tr>
</tbody>
</table>

In the next step we give priority to the individual aspects. Most often they are determined by the management of the company on the basis of the analysis made by the strategic management tools or the current and forecasted sales results of individual products. If priority order is not known, it is necessary to check all available combinations.

Designing individual workstations at operational level plays a special role in creating effective assembly systems. In this case, however, the use of self-organizing maps of Kohonen would be inadequate to the scale of the problem and the current scientific achievements and industrial experience.

Here you can use the following methods:

- MTM method - to analyze economics of operators elementary movement
- ABC + XYZ analysis to accommodate space for small mounting elements and staging locations,
- basic principles of ergonomic work at the assembly station,
- automation technology for work movements.

These methods will help to organize the work and the production space without interfering in existing production system.

5 CONCLUSION

For establishing correct criteria for designing production systems using self-organizing neural networks it was needed to separate production system for the different organizational level. Each level needs different management approach what creates different criteria. Criteria selection is based on the three management levels: strategic, tactical and operational and sequence of specific analyses on the each level.

6 REFERENCES

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