Integration of 3D visualization with methods of designing of manufacturing processes

The doctoral dissertation is focused on the use of spatial layout model in the design and reorganization of industrial facilities. It is dedicated to find an efficient solution which will allow devising virtual models quickly and effectively. As changing a spatial layout requires technical knowledge and the process of reorganization is time-consuming, new methods which could enable shortening of planning time and cost reduction are in need nowadays. Consequently, the concept of creating a new method OLESTR has arisen. The method fills the gap of the lack of practical method concerning the reorganization of spatial layout. Due to the devised OLESTR method, accuracy and specificity of the solutions enable rapid digitalization of the industrial plant as well as design of photorealistic visualization and 3D animations.

The research of the solution for effective spatial planning displays the lack of tools and techniques regarding change as well as maintenance of the current enterprise design. In order to perform these tasks, the necessity of new and adequate work instruments as well as sufficient possibilities of operation in spatial exploitation is emphasised. As a result, the implementation of designing techniques and maintaining current enterprise design on each step of industrial plant development are a main focus of the dissertation. Furthermore, individual approach towards planning with regards to the intended use of the facility is crucial. The main objective of the doctoral dissertation is the development and analysis of the methods regarding spatial design and 3D visualization concerning current changes within industrial processes. The theoretical objective is focused on devising a method with regards to current spatial layout concerning included criteria and limitations. Furthermore, the practical objective is to verify devised method as well as to create a model in accordance with three-dimensional concept premisses regarding existing printing plant and to implement devised methods of layout and 3D visualization design.

Presented OLESTR method enables obtaining current condition of the placement of three-dimensional technological elementary objects in production hall. The research was conducted in existing printing plant in accordance with determined aims of the enterprise. It is significant to specify that synergy between technical planning and facility planning of an existing plant induces consideration of redesigning them as one integral system. Consequently, connection of phases of synergistic planning and phases of OLESTR method was one of the main tasks within the dissertation. It is essential to mention that OLESTR

method is based on synergistic planning phases concerning spatial requirements and project standards of the plant. One of the solutions within devised method is the design of libraries in virtual environment in accordance to the character of the plant. Another one includes the application of standardized and simplified graphic elements. The method of modeling is directed towards users in order to create three-dimensional technological elementary objects which are simplified real objects. This approach facilitates the design and conduction of changes. The dissertation presents the results of the research on OLESTR method with respect to spatial limitations in production hall of examined plant. After the identification of sources providing limitations during redesign process, spatial layout canvas with adequate layers was devised and a lot of limitations were determined for each layer. It can be stated that the layer of spatial layout canvas is gradation of limitation with regards to its complexity. As a result, canvas is a base defining the range and complexity of spatial limitations. Concerning OLESTR method every manufacturing operation includes the set of three-dimensional technological elementary objects with regards to criteria of the division for each layer of spatial layout canvas. Furthermore, relocation, installation and dismantlement of each three-dimensional technological elementary object was presented in the matrix form which allows devising algorithms within MathCAD regarding cost and the length of haul roads calculation in manufacturing processes.

With regards to declared objectives, it can be stated that layout redesigning with OLESTR method fulfils practical requirements. Moreover, the method described in the dissertation enables effective spatial layout design, manufacturing design bottlenecks removal and decreasing of traffic on haul roads.

The perspectives of further industrial plants development are based on the integration of 3D visualization and innovative design methods. One of such methods is OLESTR method, which is devised and described in the dissertation. Practical application of the method with regards to existing industrial plants is emphasised within the dissertation. Due to the visualization, three-dimensional display of a plant and design mistakes verification during redesign process is possible. These results enable the increase of design agility as well as influence decision-making process. Described OLESTR method is tightly connected to synergistic planning and emphasises practical approach towards planning. Moreover, further research can be conducted on OLESTR method focusing on new industrial plants planning or already existing ones concerning their extension and reorganization.