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Design Methods that Work

MODELLING AND SIMULATION OF AUTOMATED PRODUCTION LINE OF CEMENT TILE

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Abstract: *The paper presents a complex preparation of a modernization project of a production line. Methods of strategical planning and computer simulation were used for elaboration of the project of an loading – unloading appliance for Rotary module.*

1. INTRODUCTION

Reduction of production costs, improvement of quality of products and shortening the time of a production cycle enforce introducing new automated methods and means of technical preparation and realisation of production.
The mentioned above factors entail the necessity of introducing new, efficient materials and energy-saving technologies, modern methods of organisation, methods of computer aided design and utilisation of production systems. The basic feature of automation of processes and production systems is its flexibility. The flexible automated production systems enable widening the range of the products, without the necessity of replacing the stock of machinery. The contemporary realised automation of production processes is one of the basic directions of technical progress and qualitative development of production power. Automation of production enables solving many technological, economical and social problems [1,2,3,4,5] :

- shortening the time of a production cycle, decreasing reserves of work in process or their lack,
- improving the quality and lengthening the time of product durability,
- improving the work conditions, reducing or eliminating human work in a harmful for health zone.

2. AUTOMATION OF CEMENT TILES PRODUCTION

The production process of cement tiles consists of a various actions :

- technological,
- transportation (moving: materials, forms, semi-finished products and boxes),
- co-packing.

A general diagram of the process realisation is shown in figure 1. The quality requirements, necessity of lowering the costs, a considerable competition on the market force the producers to introduce automated production lines with higher productivity, above 15000 pieces/shift.

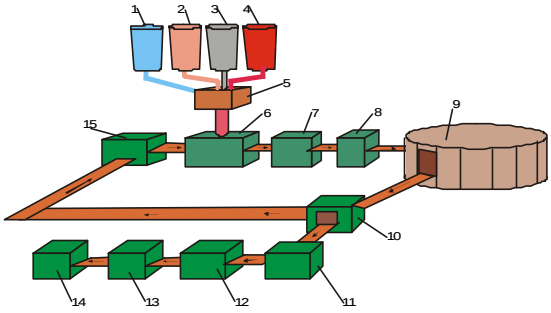

Figure 1. A general scheme of the production line

1 - water, 2 - sand, 3 - cement, 4 - pigment, 5 - concrete mixer centre, 6 - rolling, 7 - cutting, 8 - wet painting, 9 - drying and heating, 10 - tiles and moulds separating, 11 - dry painting, 12 - packing, 13 -palletization, 14 - storage, 15 - mould oiling.

The Institute of Automation and Organisation of Product Processes co-operates with Fortum – Pawe³ Adamowski firm, one of the main producer of cement tiles in the west of Poland. The firm, at first, used a tile production line which productivity amounted about 500 pieces/shift. Only some activities of the process were mechanised (figure 2).

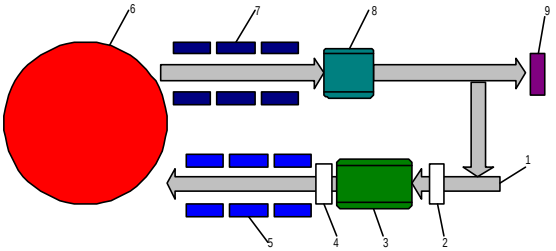

Figure 2. The initial conditions, a flow chart of the tile production process in the firm.

The development plan for the firm assumed increase in: products assortment, productivity above 25000 pieces/shift, improvement of the quality and the decrease of the production costs. The investment plans required involving a huge amount of financial means. Necessity of broader research co-operation arose. The research workers and the students of the university participated in the realisation of some of the tasks of the modernisation project.

3. THE RANGE OF TASKS AND THE RESEARCH METHODOLOGY

3.1. QFD method as strategy planning method in the firm.

In order to define the expectations and the rivals' achievements the QFD analysis was carried out. The firm has co-operated with some current and potential clients.

The study range included :

a) defining the clients' hypothetical demands and wishes,
b) weight of the clients' requirements,
c) technical features and measurable target values,
d) matrix of connections,
e) level of the achievement rate,
f) difficulties in technical realisation,
g) technical importance,
h) client's opinion about the actual product and about the rivals' products,
i) the analysis of competition by a potential client
j) mutual influence
k) sale points,
l) critical features.

The elaborated planning stages are presented in the form of a matrix of connections ("house of quality", figure 3). The carried out analysis confirmed the legitimacy of the investment and modernisation venture in Fortum firm.

3.2. Modelling and simulation of the tile production process.

Modernisation of the logistic-production system and the connected with it modification of functioning is connected with considerable risk. Modelling and simulation enable verification of the project assumptions before they will be put in practice. Two accessible packets of simulation software were used in this part of research: Witness(AT & T ISTEL Firm) and In Touch (Factory Suit Firm). Some of the results of the performed simulation research are quoted below.

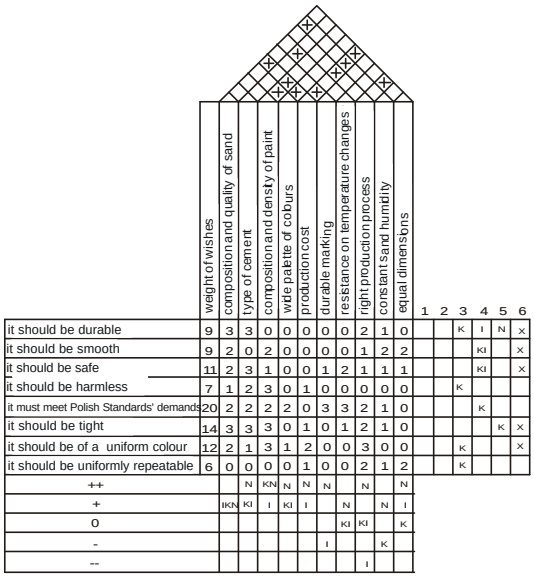

Figure3. Matrix of connections "house of quality"

3.3. Technical and organisational assumptions

Line productivity 39 pieces/min.
Single-shift work system.
ROTARY-type line, a drying module in a form of a turntable with stillage.
Loading wet tiles and unloading finished tiles is done simultaneously.

3.4. Preliminary project of the production line of cement tiles

The course of the production process is shown in figure 4 in a form of a flow chart. The Rotary line includes the following modules and appliances:

- a concrete mixer centre and a control station for monitoring the composition of concrete,
- an appliances for tile forming,
- a painting appliance,
- a piling machine,
- Rotary drying module,
- an unloading machine,
- an appliance for separating,
- a switch,
- moulds oiling,
- packing.

Figure 5 presents the scheme of the "double-Roman" tile production line.

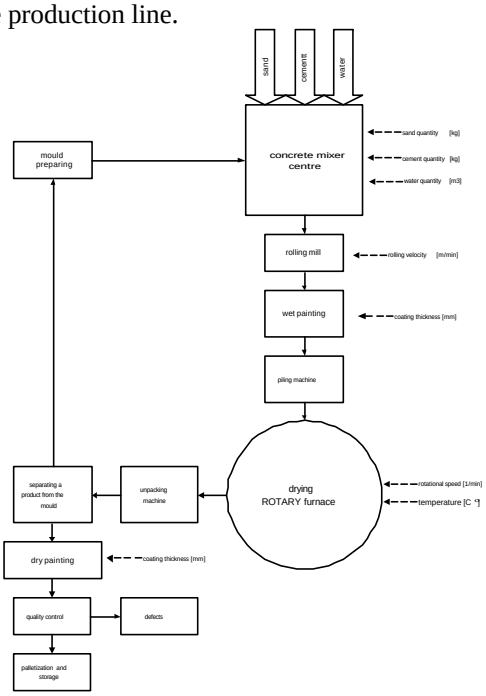

Figure 4. Flow chart of the tile production process

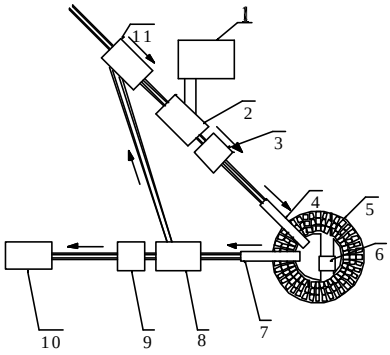

Figure 5. Scheme of ROTARY production line

1 - concrete mixer, 2 - rolling, 3 - wet painting, 4 - piling machine, 5 -Rotary furnace, 6 - heating element, 7 - unloading machine, 8 – tiles and moulds separating, 9 - dry painting, 10 - packing, palletization, 11 -mould oiling.

3.5. In Touch application

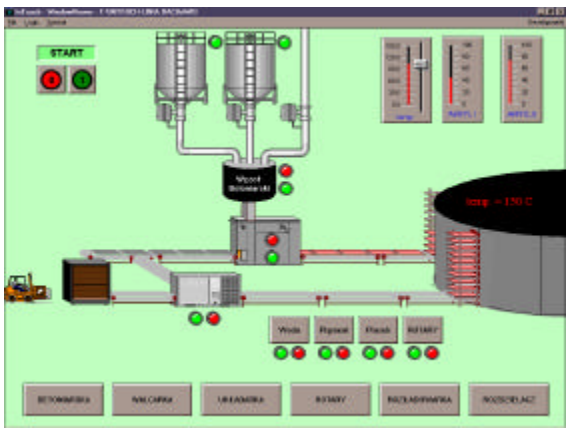

Figure 6. The main window of visualisation.

Program applications, shown below, have been prepared using In Touch program. Figure 6. presents an application window which visualise the work of the whole line and figure 7. visualise work of the piling machine module. The above applications were created with the use of the following: visard windows, basic icons for drawing, 'motion' with the use of the note editor window and the animation window.

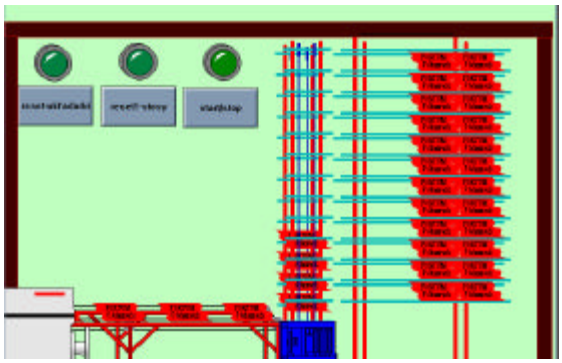

Figure 7. Visualisation window for piling machine.

4. Results

The results of the analyses, modelling and simulations have been used for preparing a detailed piling machine module, which is a part of a module of the loading-drying-unloading line. A kinematic-functional scheme of the piling machine is shown in figure 8.

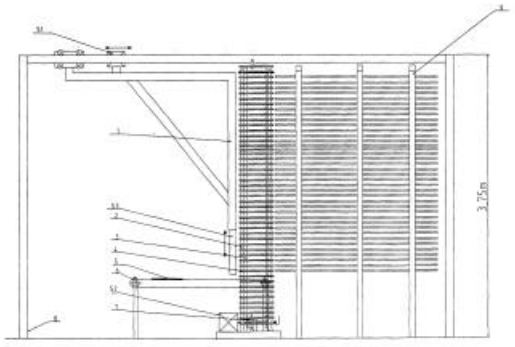

Figure 8. Scheme of the piling machine

Parameters of Rotary loading and unloading :
- conveyor belt velocity (39 pieces/min) : V = 0,273 m/s
- time for loading tiles into the piling machine: t_z = 1,54 s
- time for loading a pile of the piling machine (39 pieces): t = 39· 1,54 = 60,6 s
- time for loading one stillage (4 piles): T_z=4· 60,6= = 241,78 s
- time of moving the tiles from ROTARY to the piling machine: t_r = 6,16 s
- time of unloading the piling machine: t = 60,06 s
- time of unloading one stillage: T_r = 66,22 s

Pilling machine drive:
- stepper motor

(B201-92-1XXB18), power N=1,1 [kW]

5. SUMMARY

It has been proved, that applying ROTARY production line is the most benefitial solution for Fortum. Application of In Touch program has confirmed its usefulness for study and design of complex production systems on the example of the production process of cement tiles. The model and simulation research results have been applied in the project of loading and unloading appliance for Rotary module.

6. Bibliography

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