Structural features of automated lean production planning system database

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Abstract. Necessity of creation of special automated systems based on lean manufacturing principles for efficient recourse usage and maximum customer-orientation was proved. Process of one of the planning system key elements such as structure of database creation is described. Importance of mixed development, includes technical task with description of subject area and problematics of solvable task and also variant of database structure, is explained. Provided initial and final structures of database after all stages of testing and adjustment with description of tables contents. Quantity of tables was increased from 9 to 25 in final version, this can be explained by the point that structure created only by planning specialist doesn’t include all specifics of process interpretation in automated system, and the fact is that iterative development is very important for such automation of processes. Provided research of methods that can increase speed of data processing was provided - specific type of key and algorithmic filling of data array by typical values.

1. Introduction

Automation of production planning process became a standard practice for industrial plants caused by permanent business competition and as a consequence change of management system. Main vector of development in this research field is creation of customer- oriented systems that are taking into account lean- manufacturing principles [1, 2].

In spite of high number of developed methods in field of production planning, it implementation in production process and practical application shows major difficulties. Especially this problem is particularly true for high- productivity plants that produce wide nomenclature of products count tens or sometimes even hundreds of variations. Such plants are very sensitive to influence of internal and external factors. In conditions of high volume production, issue of production plans optimization for the purpose of efficient plant resources utilization is especially acute. Optimization problem of production planning process in itself is complex and require involvement of management and skilled professionals almost of all plant departments.

At this time modern production planning methods implemented by different classes of IT systems classes. The best known are MRP and ERP [3, 4] systems and more modern CSRP, MES and APS. Depends on purposes of planning and functions that need to be automated, management chooses one or several systems for introduction. All of above mentioned systems implements operational planning.
This area of production planning is one of the most complex due to several factors such as specificity of products and production technologies, and also one of the best-investigated [5, 6]. Mentioned systems have some specific tools for plan creation such as “leveling”, but these tools number is very limited and also some of it does not really mean lean-tools. Also these systems related to pushing type of planning which is not comply with the principles of efficient lean-production.

Performed research of production planning process related with mid-term and long-term planning, which is more strategic process of any company. Considering specifics of instrument-making plant, automated planning system was developed by planning and IT-specialists.

Creation of production strategy that is taking into account forecasted demand, equipment and suppliers’ capacity and also human resources is the main task of production planning process and developed system. As a basis for plan creation used customer order and available working time for production, based on these key elements system is calculating takt time that will be used for the future production processes design.

Production planning process include several stages such as data gathering for plan creation, plan and it versions creation, assessment of plan and it versions by responsible specialists [7].

Each of listed stages needs to be automated for possible risks elimination [8] and reduction of planning process performance time.

Development of automated system within performed research include all steps from goal setting till testing of IT solution in actual use environment of instrument-making plant.

2. Database structure development
One of the main tasks during building of information system is development of database structure. Correctness of database structure selection is key indicator of automated system quality as database should include data that allows minimization of different risks impact.

Considering accumulated experience of development and introduction of different level and assignment IT-systems, it was concluded that creation of database could be implemented in following ways:

- Development of database in accordance with customer requirements;
- Iterative development of database which is quite complex and nontrivial task.

As a basis for system was chosen mixed development, includes technical task with description of subject area and problematics of solvable task and also variant of database structure.

Iterative approach in used variant of development was expressed in work on all system elements in line with PDCA cycle (figure 1).

![Figure 1. Iterative cycle of system development.](image-url)
Database scheme based on infological model. As a basis for database design, initial structure described by planning specialist was chosen (figure 2). Represented scheme was a part of customer requirements and an element of the technical task presented to IT-specialists. In addition to database structure, were presented algorithms for the implementation of each of the subprocesses of the planning process such as data collection, production plan construction and its evaluation.

![Initial database structure](image)

**Figure 2.** Initial database structure.

Initial database scheme (figure 2) was created within technical task and consist definitions and objects of subject area, which are well known for specialists involved in automated system development.

Structure of database initially included nine tables. Based on accepted algorithms and also in line with specificity of subject area during system design changes of initial database were done. Creation of database structure was done in several stages, consistently taking into account the nuances of the planning process and requirements of plan creation algorithms. Main tasks of database creation were to make it design less sparse and eliminate same type of data to increase normalization level.

After all stages of database testing, it structure was adjusted (figure 3).
Figure 3. Final structure of database.

As a result, optimal database that includes all necessary data and consists of 25 tables was created. Comparison of initial and final structures of database is presented in Table 1.

**Table 1. Content comparison of initial and final structures.**

| №  | Table name     | Content                                                                 |
|----|----------------|------------------------------------------------------------------------|
| 1  | days           | Day ID and status                                                      |
| 2  | stoppages      | Planned production stoppage name, time in seconds from the start of the day |
| 3  | OPRs           | Special requirements for OPR requested by shops for different days     |
| 4  | plan           | All planning criteria                                                 |
| 5  | state          | All possible day statuses                                             |
| 6  | products       | Product ID and it maximum capacity                                    |
| 7  | shifts         | Shift number, start and end of shift in seconds from beginning of the day, day ID |
| 8  | blockedDays    | Days blocked for production plan creation (first date, end date, when blocked these dates) |
| No. | Field                      | Description                                                                 |
|-----|---------------------------|------------------------------------------------------------------------------|
| 9   | maxProductByWorkshop      | Maximum production capacity for each product and each production shop with reason description |
| 10  | maxVTByWorkshop           | Maximum takt time capacity for each shop with reason description              |
| 11  | month                     | Quantity of calendar days in month                                            |
| 12  | order_                    | Names of all orders                                                           |
| 13  | period                    | Name of production period (if order requested not by months), date of start and end of period |
| 14  | planDays                  | Day ID and status, takt time and relation to subplan                           |
| 15  | planShifts                | Parameters of each shift of the day which has day ID, OPR, shift number, working time and planned stoppage time |
| 16  | planShiftsProducts        | Day ID, name of product planned for this day for each shift, production volume |
| 17  | productOrder              | Subplan ID, product ID, production volume                                     |
| 18  | productWorkshop           | List of shops involved in production of each product                           |
| 19  | role                      | User name, shop name and access permission                                     |
| 20  | standartDay               | Start and end of working shift of standard day, all days ID that are standard |
| 21  | standartOPRs              | OPR target for standard day, all days ID that are standard                    |
| 22  | subOrder                  | Data of one suborder such as month and year                                   |
| 23  | subPlan                   | Name of subplan and period name for each this plan is created                 |
| 24  | user                      | Login, password, role name, Name and Surname, time of last log in Shop name, restriction from each shop for minimum quantity of days with one takt time |
| 25  | shops                     | Shop name, restriction from each shop for minimum quantity of days with one takt time |

3. **Features of designed database**

Key element of production plan creation in automated system is working day and all related to it data (planned stoppages, quantity of shifts, special shops requirements and etc.). It is very important to select best day ID number, which allow to process request to database in the quickest way. For this purposes special research was done and statistical data of requests processing time was gathered. Research was conducted with database which includes two tables each ten millions of records. In first table key was performed as attribute with data type of DATETIME, in second table key had a data type INT, for keys capability of unambiguous interpretation, text format was brought to number view of YYYYMMDDhhmmss. Statistics of requests processing time shown in figure 4.
Based on research results, data type was chosen as INT. This type of key shown best time of processing. The more complicated the key selection mechanism, the greater gain in processing speed such keys provides. To disadvantages of such an approach can be linked algorithmic complication of dates interval generating. But in case of system under development the key criteria is speed of data processing and production plan creation.

Also one of the examples of database features is the mechanism of table “planDays” sparse reduction by algorithmic filling of data array by typical values. As a standard meanings assigned: Monday-Friday – working days, Saturday/ Sunday – weekend, also standard shift schedule for working days is set. For all days different from standard meanings, unique record in database table is created. Therefore, appliance of such a method allows to reduce quantity of record in table from 365 till 61 in average for one calendar year. Beside this, such method also simplifies highlighting of non-standard days.

4. Conclusion
Unique database structure was created. This database allows to perform production planning process in unified information environment, make centralized storage of large amount of information and receive necessary data in any time with access to Internet. During creation of database structure iterative approach was used due to specific requirement which were not included by planning specialist in initial description of database structure as obvious and also for providing of logical structure of database that is convenient for following technical support of automated system. Also in process of database structure creation additional research of methods that can increase speed of data processing was performed.

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