# Treatment design-engineering workflows in large enterprises*

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***Abstract*—The authors presented the analysis of design-engineering workflows in large design and manufacturing enterprise as well as developed a layered structure of similar enterprises' design workflows according to the IBP Rational Unified Process methodology. The problem of the coordination of design-engineering documentation was examined. The author's model of the Petri net modeling model flows of project works in coordination with design-engineering documentation is developed.**

***Keywords— workflows; business process; enterprise***

## I. INTRODUCTION

The company's activity is considered as a set of the processes directed to the collective purpose achievement. During these processes, the basic data will be transformed to the end result which quality depends on a set of factors:

• availability of modern production means, providing the maximum income from the enterprise's activity while minimizing expenses;

• use of professional software, as well as optimal compliance of its capabilities with the solved production tasks;

• organization and quality of production processes management and enterprise's resources (financial, technical, human);

• number and qualification of employees.

The first and last items are given serious attention, considering them not to be doubted factors. Most of scientists have already agreed with the importance of the second point. The importance of the third factor (organization and quality of production processes management), perhaps, is not so obvious yet.

One of the conditions for the enterprise's effective work is the effective interaction of all its departments, units and structures. Information flows, reflecting the essence of the production process, move along the chain. Due to a variety of reasons (organizational, technical, subjective), the speed and reliability of data transmission is not always satisfactory. Information can be distorted, delayed, not transmitted at all. All this does not have the best effect on the speed of the final result achievement and on its quality. The technology of workflow helps to remove these problems (at least in part). Workflow is based on the visual representation of flows in the form of connected diagrams with both textual and software components.

Over the past 20 years, many workflows management software systems have been developed. Most of them are focused on e-document flow (e.g., 1C [1], DocVision [2]). And only some organizations develop project management software (e.g., MS Project [3] or Pilot-Ace of ASCON [4], ELMA [5]). These systems have a number of problems in the workflow development, which will be discussed in more detail below.

Currently, the software solutions of most advanced manufacturers of data management systems have a workflow module: Simens PDM [6], Lotsia PDM [7]. The company ASCON also has such a module: LOTSMAN Workflow is one of the modules of the engineering data management system and the life cycle of the LOTSMAN: PLM product. It is intended for workflows modeling and workflow management automation.

However, most workflow processing systems have no effective methods for analyzing and controlling the structures of the diagrammatic workflows and semantic components associated with them. The semantic components can be presented as texts and program modules.

The paper has the following structure. Section 2 formulates the scientific and practical problem of research. Section 3 contains the level structure of the business processes organization. Section 4 presents the typical business process modeling approved by design-engineering documentation. Section 5 is devoted to the development of an automaton approach to the analysis and control of the structural features of diagrammatic workflows presented in ASCON (the visual language). Conclusions and further research directions are presented in conclusion.

## II. PROBLEM

Processing of design-engineering workflows of a large industrial enterprise requires the solution of the following tasks.

1. Analysis, systematization and development of normative diagrammatic workflows models.

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2. Analysis and control of properties of diagrammatic models, primarily topological ones.

3. Analysis of the business process integrity for such failures as hangs, loops and finitudes.

4. Workflow interpretation, including the implementation of workflow management systems based on the developed business process. If there is a lot of software for the development of the business process scheme, such as MS Project, etc., the implementation of workflow management systems is performed by most major PDM and ERP system developers independently of each other. This category of developers consists of document management system developers (1C, DocVision) and project management system developers (Pilot-Ace of the Ascon company).

The lack of modern tools for processing these workflows of effective methods and means to solve these problems determines the subject of research and its effectiveness.

## III. STRUCTURE OF FLOWS OF PROJECT WORKS IN LARGE DESIGN MANUFACTURING ENTERPRISE

Let's allocate the following coordinated workflows: The 6th main process of design and 3 processes of support. In Figure 1 the scheme of problems of a stream "Design-technology preparation of production" which is one of examples of standard workflow is developed.

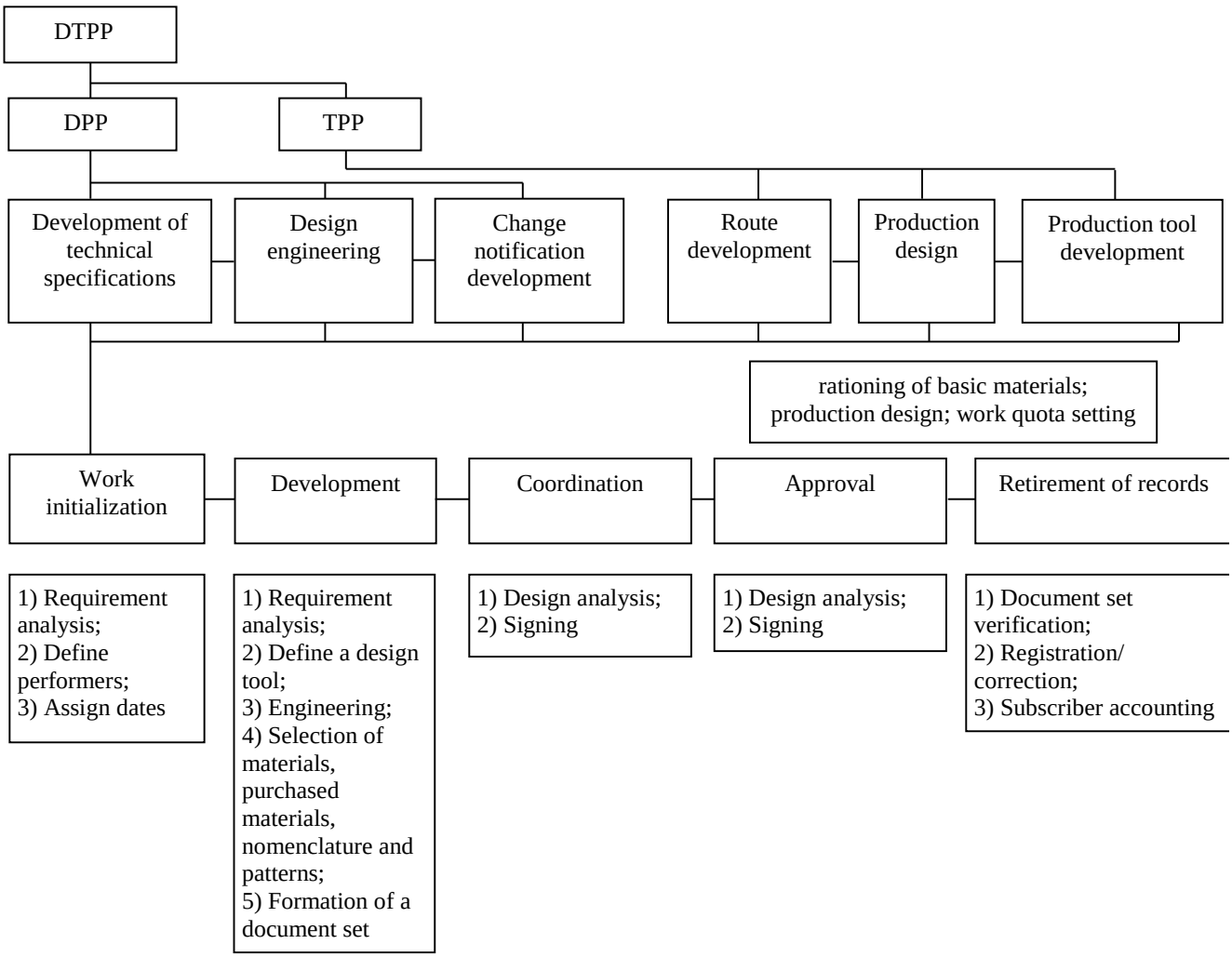


Fig. 1. Workflows "Design-technology preparation of production"

In the DTPP (Design-Technology Preparation of Production), DPP (Design Preparation of Production), TPP (Technology Preparation of Production), Development of technical specification, Design engineering, Change notification development, Route development, Production design, Production tool development are shown standard tasks.

For example, Development of technical specifications: Work initialization, Development, Coordination, Approval, Retirement of records. In turn "Work initialization" contains the following list of works: Requirement analysis, Definition of performers, Assign dates.

## IV. MODEL OF STANDARD BUSINESS PROCESS OF APPROVAL OF DESIGN-TECHNOLOGY DOCUMENTATION

The stage of coordination of design-technology documentation contains two levels: top (Figure 2) and lower (Figure 3). The top level represents laboratory coordination in respect of a correctness of the scheme (verification of electric circuits, nomenclatures, etc.). The lower level represents coordination of construct (technology of radio installation, etc.). The specified workflows are presented in the specialized language allowing to organize conditional and parallel performance of work. The topological correctness (especially in respect of remote "And", "OR" branching and their merges) is offered to be carried out by means of the author's device of RV-grammars [9-16], considered in section 5. Authors developed the coordination model on the basis of Petri's (Figure 4) network allowing to carry out the analysis "in general", and its specification to solve a problem of integrity of business process.

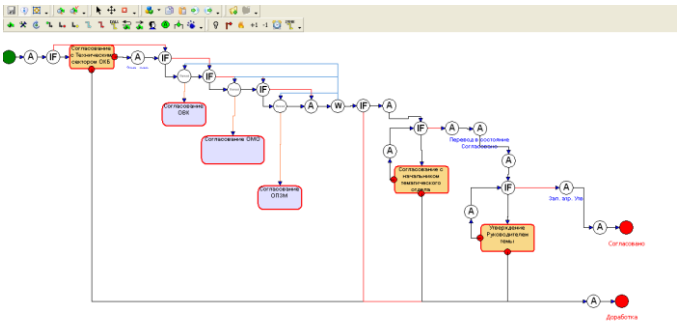

Fig. 2. Top level of approval

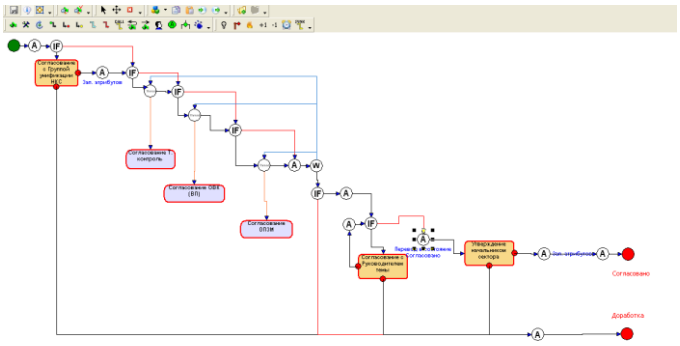

Fig. 3. Bottom level of approval

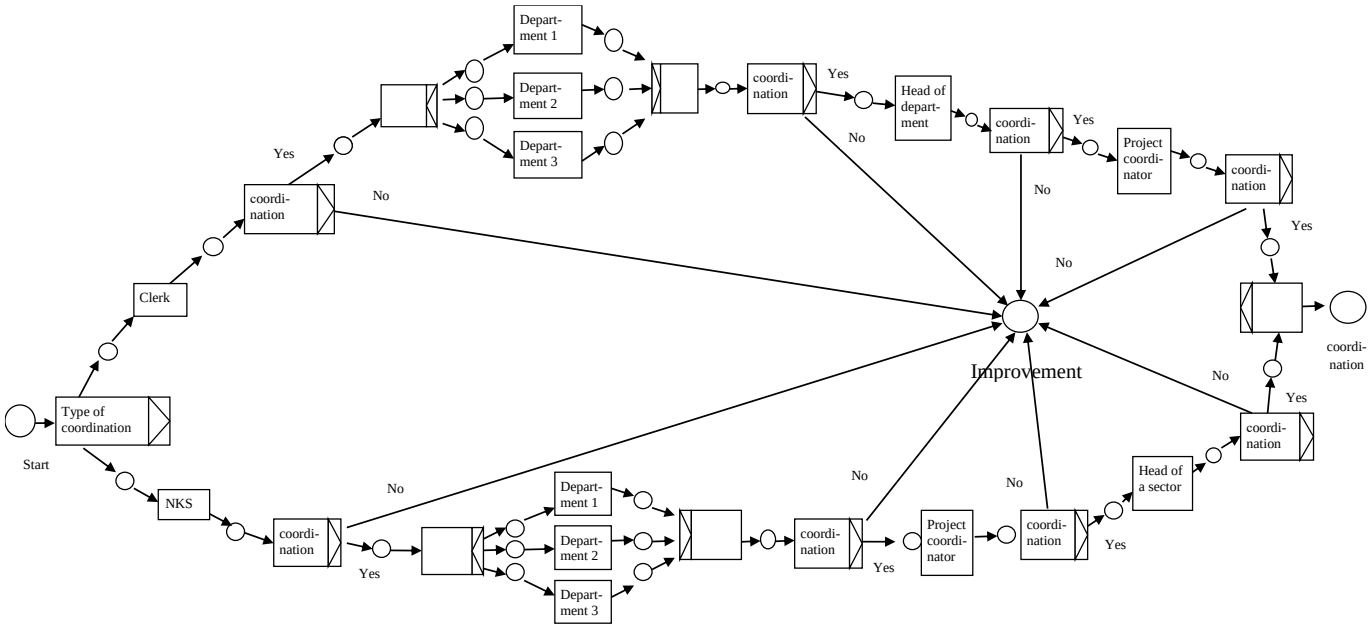


Fig. 4. Dynamic model of a stage of approval on the basis of a Petri net

## V. DEVELOPMENT OF THE METHOD FOR ANALYSING AND CONTROL OF DIAGRAMS OF WORKFLOWS

The specialized visual language allows to organize an enclosure of processes at the expense of several elements. The curtailed subprocess is developed for visualization of workflows in the form of diagrams in software products of ASCON. A creation of parallel workflows is supported in this language. Control of such workflows is possible by means of two elements "Events" and "Semaphore" which work together with the expectation element and additional type of communication of "Synchro action". There is "Phantom"

element which allows to connect parts of the diagram at the different levels of an enclosure. A number of graphic elements of language is shown in Table 1.

TABLE 1. ELEMENTS OF THE ASCON SPECIALIZED LANGUAGE

| Name | Graphical element | Description |
|---|---|---|
| Procedure |  | The curtailed subprocess which is possible for causing repeatedly. Has only one entering communication like “To pass into the procedure” |
| Task |  | The curtailed subprocess in which action is obligatory to performance by the user |
| Iteration |  | The curtailed subprocess which performance is required repeatedly |
| Call procedure |  | It is used together with “to pass into the procedure” and the procedure block |
| Create workflow |  | Create a new workflow |
| Intransitive |  | The operation which is carried out by the user |
| Script (Auto operation) |  | |
| Branching |  | Has only two proceeding communications. True and false respectively |
| Phantom |  | Allows to connect parts of the chart at the different levels of an enclosure. In fact, is communication |
| Event |  | It is used together with “Expectation”. Rub entering, one of them “Synchro action” notifying on performance of an event. |
| Semaphore |  | It is used together with "Expectation”. Rub entering, one of them “Synchro action” notifying on the beginning and completion of events. |
| Activate |  | Two proceeding branches, one of them “Synchro action” notifying “Event” on a successful completion of an event have |
| Waiting |  | Two proceeding branches, one of them “Synchro actrion” monitoring the status of performance of an event have. Passes a workflow only in case of a successful completion of an event |
| Increment |  | Two proceeding branches, one of them “Synchro action” notifying “Semaphore” on the beginning of execution of an event have |
| Decrement |  | Two proceeding branches, one of them “Synchro action” notifying “Semaphore” on completion of execution of an event have |

The developed automatic RV-grammar of language (Table 2) allows to carry out the analysis of topology of diagrams of the specified language and to reveal mistakes.

TABLE 2. ASCON LANGUAGE RV-GRAMMAR

| Start State | Quasiterm | End State | Operations with memory |
|---|---|---|---|
| r0 | A0 | r3 | o |
| r1 | return | r2 | $w_2(b^{4m})$ |
| r2 | vA | r1 | $w_1(s^{1m},t^{4m})$, CALL vA |
| | vIT | r1 | $w_1(s^{1m},t^{4m})$, CALL vIT |
| | Ak | r4 | o |
| | Akm | r5 | $w_1(1^{t(1)},i^{t(2)})/w_2(e^{t(1)})$ |
| | _Akm | r5 | $w_1(\mathrm{inc}(m^{t(1)}))/w_3(m^{t(1)}<k^{t(2)}\text{-}1)$ |
| | Akme | r4 | $w_1(\mathrm{inc}(m^{t(1)}))/w_3(m^{t(1)}=k^{t(2)}\text{-}1)$ |
| | CL | r6 | $w_1(t^{4m})$ |
| | TH | r6 | $w_1(1^{t(7)}, i^{t(8)}, t^{4m})$ |
| | SC | r3 | o |
| | SCm | r5 | $w_1(1^{t(3)},i^{t(4)})/w_2(e^{t(3)})$ |
| | _SCm | r5 | $w_1(\mathrm{inc}(m^{t(3)}))/w_3(m^{t(3)}<k^{t(4)}\text{-}1)$ |
| | SCme | r3 | $w_1(\mathrm{inc}(m^{t(3)}))/w_3(m^{t(3)}=k^{t(4)}\text{-}1)$ |
| | C | r7 | $w_1(t^{2m})$ |
| | EV | r3 | $w_1(0^{t(5)}, 0^{t(9)},0^{t(11)})/w_2(e^{t(5)})$ |
| | S | r3 | $w_1(0^{t(6)}, 0^{t(10)},0^{t(12)})/w_2(e^{t(6)})$ |
| | F | r11 | $w_1(t^{3m})$ |
| | W | r9 | $w_1(t^{3m})$ |
| | IN | r11 | $w_1(t^{3m})$ |
| | D | r12 | $w_1(t^{3m})$ |
| r3 | rel | r2 | o |
| r4 | no_label | r17 | * |
| r5 | labelC | r2 | $w_2(b^{2m})$ |
| r6 | prel | r13 | o |
| r7 | nrel | r2 | o |
| r8 | PHsp | r6 | o |
| r9 | arel | r14 | o |
| r10 | PHsa | r9 | o |
| r11 | airel | r15 | o |
| r12 | adrel | r16 | o |
| r13 | vPR | r1 | $w_1(s^{1m})$, CALL(vPR) |

| | | | |
|---|---|---|---|
| | PHep | r8 | o |
| r14 | THa | r2 | $w_1(inc(m^{t(7)}))/w_3(m^{t(7)}<k^{t(8)})$ |
| | PHea | r10 | o |
| | EVa | r2 | $w_1(1^{t(9)}), w_2(b^{3m})$ |
| | Sa | r2 | $w_1(1^{t(10)}), w_2(b^{3m})$ |
| r15 | EVa | r2 | $w_1(inc(m^{t(5)}), 1^{t(11)}), w_2(b^{3m})$ |
| | Sa | r2 | $w_1(inc(m^{t(6)}), 1^{t(12)}), w_2(b^{3m})$ |
| r16 | Sa | r2 | $w_1(dec(m^{t(6)}), 1^{t(12)}), w_2(b^{3m})$ |

## CONCLUSION AND FUTURE WORK

The authors analyzed the business processes of design-engineering preparation of a large design and manufacturing enterprise. We developed the author's scheme of typical project work streams as well as developed a workflow of the project process of the design-engineering documentation coordination. Topological analysis of the workflow scheme is proposed to be carried out using author's automaton RV-grammars. A model of the coordination project process based on Petri nets is developed. It has the properties of liveliness and safety and allows solving the problem of attainability. The future directions of the research work in this subject area is related to the development of mechanisms for the artifacts formation of the enterprise's intellectual knowledge base based on the analysis of workflow diagrammatic models using RV-grammars.

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