Methodology of multi-objective optimization of assembly lines

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***Abstract*— Paper summarizes my research work and its results during my postgraduate studies within the topic of multi-objective assembly line optimization. Visions and goals for the future research are mentioned in the last part of the paper.**

***Keywords*— assembly lines, decision making, modeling, objectives, optimization**

I. INTRODUCTION

Assembly lines are the most common way of production process realization nowadays. In comparison to the former production methods, there is minimum or no human intervention into production process, possibility of production process optimization etc. These factors can result in building cost and time-efficient systems for product realization.

In most cases, main criterion for optimizing assembly lines production is profit optimization. But many other criteria can be defined to make this problem more complex and focused also on the other aspects of production process:

- maximization of reliability and safety,
- maximization of efficiency resp. minimizing overload,
- minimization of manual interventions,
- minimization of environmental affects,
- minimization of initial investments,
- minimization of production time. [1]

Main motivation in my research is definition of the complex methodology in the field of multi-objective assembly lines' optimization for solving tasks in various areas, like assembly lines' modeling by using simulation models ,configuration of assembly lines and scheduling the orders by using multi-objective decision-making methods, and last but not least, optimizing of production process realized by multi-objective optimization methods. Methods and models used in solving assembly line balancing tasks can be found in [2] and [3].

II. PREVIOUS TASKS AND ACHIEVED RESULTS IN THE RESEARCH FIELD

At the first place, theoretical background of multi-objective optimization had to be studied, in order to be applied in the research. Summary of these methods and their application in MATLAB simulating system is the subject of [1] and [4]. Afterwards, application for solving multi-objective optimization problems for 2 optimized factors was created in MATLAB. Detail description of this application is published in [5]. All these research papers were supported by projects Vega, KEGA and USP Technicom.

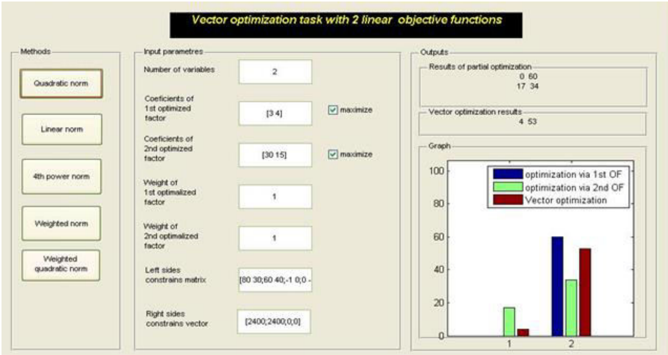

Fig. 1 Application for solving multi-objective optimization tasks

Possible usage of this application (shown in Fig. 1) in optimizing the production plan (maximizing profit and maximizing amount of saved time) and also in economical sphere (maximizing profit and minimizing the riskiness of investment at the same time) is the main subject of [6]. This research work was the part of realization of the project USP Technicom mentioned above.

My work was also focused on designing and creating the information system for assembly line model situated in DCAI laboratory. This system was created mainly to manage tasks dealing with users and order management. Information system was also interconnected with RDBS Oracle, which was used as data acquisition system providing users with data from real production. Details of this task were published in [7] as results of the contribution to projects KEGA and USP Technicom.

III. TASKS AND RESULTS SOLVED IN LAST YEAR

Both tasks closely described in this chapter are the part of work of our group within DCAI. Other activities of our group are the main topic of the paper [8].

A. Stateflow model of assembly line

In order to find proper results for multi-objective assembly line optimization, creating a model of this assembly line is the necessary step. Purpose of building simulation model is to simulate the production processes in details and also to find most of mistakes from assembly line design phase. Simulation model of Flexible Assembly Company (laboratory model of assembly line placed in DCAI) was designed in MATLAB simulating system using Simulink blocks.

Main part of this model (Fig. 2) was realized with Stateflow diagrams, which are included in the Simulink library. This model is properly divided into blocks, which represents particular posts of assembly line. Production is realized simultaneously in every post, but particular posts are exclusive (there can be only one active state in the moment within the post). Outputs of this model are: execution times of particular posts, final execution time for each product and the status of warehouse.

Simulation results are published into the Excel spreadsheet as well as on the screen. Outputs of the model can be used as data source for building the mathematical model of assembly line, which would be resolved by using multi-objective optimization methods in further research process.

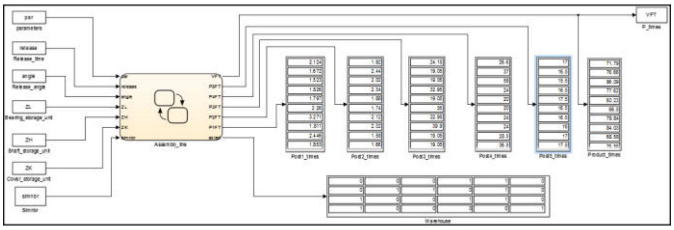

Fig. 2 Stateflow assembly line model

Model can be used also in resolving assembly line configuration task, e.g. how another workstation placed in particular post will affect the final execution time, the idle times etc. Results from the model can be the source for multi-objective decision-making task used for optimal assembly line configuration. Model and real assembly line is detailly described in [9], where Stateflow model of every post is placed, as well as comparison of real and created simulation model. This paper was made in contribution within participating on projects USP Technicom and by grant KEGA.

B. Solution for multi-objective decision making task

Another part of the research activities was focused on solving multi-objective decision making task dealing with finding optimal configuration of assembly line, where 7 possible configurations (Fig. 3) were compared according to 4 criteria: profitability (weight 0,69), minimization of idle times (0,08), environmental effects (0,06) and value of investment (0,17).

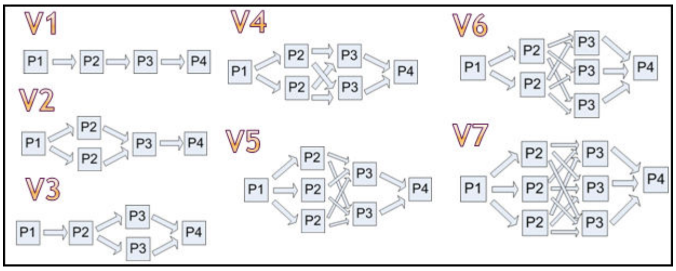

Fig. 3 Possible alternatives of assembly line configuration

Multi-objective decision-making methods were applied to find optimal solution: ELECTRE III, TOPSIS, AGREPREF. Results were raised from application designed and realized in MATLAB simulating system. Descending order of all configurations counted by all methods is displayed in TABLE 1. From the results is clear that the best configuration according to selected criteria is the configuration with 3 parallel workstations in post 2 and with 3 workstations in post 3.

TABLE 1 Order of alternatives sorted by multi-objective decision making methods

ELECTRE III	TOPSIS	AGREPREF
V7	V7	V7
V5	V5	V5
V4	V6	V6
V2	V4	V4
V6	V2	V2
V1	V1	V3
V3	V3	V1

Detail description of whole task is the part of my dissertation prospectus - [10].

IV. FUTURE RESEARCH STEPS

My future research will be focused on definition of complex methodology for multi-objective assembly line optimization. Correctness of this methodology will be tested on laboratory assembly line models within DCAI, solving mainly tasks dealing with optimal configuration, production plan and orders' schedule. In this case it is inevitable to complete partial tasks like models of other assembly lines etc. In terms of proper definition of assembly line mathematical model, queuing system theory will be applied.

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