

Environmental Management System as the part of the methodology for optimization of assembly workplaces.

V. Siskova, J. Dlabac

Abstract— The Optimization of assembly lines is a daily problem for all manufacturing companies. The most common optimization problem is the cost of the product being manufactured in the form of human labor. Activities related to the optimization of assembly workplace are not static, but can be managed through the "spontaneous". The article is focused not only on the evaluation of assembly lines in terms of productivity, but also the perspective on environmental aspects operators. This article described individual steps how the methodology could be created. There are described qualitative and quantitative research which were used and then was designed the methodology of optimization of assembly workplaces based on used procedures the integral methods

This article looked at designing methodology with respect of environmental aspects. Of course, the human factor plays the most important role in final methodology. In every phase there is considered human work and its responsibility. This article described the preparation phase, the phase of analysis, the phase of optimization and the improvement phase. Of course, in every phase it was recommended to use the methods of modern's industrial engineering as well as the methods for improving a managing environmental system. The methodology was design primarily for the assembly workplaces. Nevertheless, the methodology could be used for optimization of any sort manufacturing workplaces.

Keywords— Design of Manufacturing Systems, Environmental Management System, Ergonomic, Labor Productivity, Lean Manufacturing, Optimization.

I. INTRODUCTION

T ODAY'S global and hectic environment is primarily characteristic of rapidly changing conditions. Obscure prognosis of products market and various customer demands are changing day by day, more precisely hour by hour. Till the last moment it is not clear if the product is produced or not or if the customer receives more profitable offer from other suppliers. Growth or fall of requirements is not any exception

V. Šiskova is with the Faculty of Management and Economics, Thomas Bata University in Zlín, Mostní 5138, Zlín 760 01, the Czech Republic (corresponding author to provide phone: +420 737 959 389; veronica.siskova@centrum.cz).

J. Dlabac is with the Faculty of Management and Economics, Thomas Bata University in Zlín, Mostní 5138, Zlín 760 01, the Czech Republic (corresponding author to provide phone: +420 724 431 540; Jaroslav.Dlabac@e-api.cz). C. Author is with the Electrical Engineering Department, University of Colorado, Boulder, CO 80309 USA, on leave from the National Research Institute for Metals, Tsukuba, Japan (e-mail: author@nrim.go.jp).

in the present market. It is necessary to manage all market's demands at minimum costs. On the other hand, the customer asks about percentage of the price reduction, employees ask about higher salary every year. Energies rise even during the year. The company cannot fail its customers, competition is very hard.

Nevertheless, companies' effort should be aimed at satisfying customers' demands in faster, more effective, high quality way under lower costs than are offered by their competitors. Companies' survival is depending on their ability to manage all above mentioned. So the main mission of the enterprise improvement should be creating a competitive product. There are two very important disciplines that contribute to a successful product: design and ergonomics [2]. The human ability to execute his activity is affected by prevailing environmental elements in a workplace. So this fact has to be taken into consideration during any optimization.

According to Mr. A. Hedge, ergonomists even in the first half of 20 century were aware of this effect, when the ergonomics as a science that part is also analysis of a workplace making out from the environmental view, has become known. He also noticed that compromises could not be done between worker efficiency and his health. These two parts have to be in balance [9]. The objectives of Ergonomics are generally accepted as optimizing the human well-being and the overall system performance. Ergonomics are interested in preserving, protecting and improving the quality of life of humans, determined by their health, safety, well-being as socio-economic status. Simultaneously the discipline must respect the needs of industry and society, respectively by efficiency of production processes, the economy and the management of socioeconomic consequences [26]. The designer needs knowledge and experience from various branches to be able to design suitable production system accepting the relation man-machine. He must respect all important aspects of the workplace such as machine efficiency and information technology, capability and limits of human capital and other matters relating to the living environment, as well [13].

The goal of the workplace optimization is unambiguously to find from the point of workers the balance between efficiency and health, and from the point of the workplace we should bear in mind aspects relating to the living environment [3].

And just these aspects having relation to the environment and workers health are often underestimated or totally missed out [18].

Social development should be associated with rising human ability to make good use of the environment [34]. Development means the rising human responsibilities in well exploiting of his environment. Rational exploiting depends on economic, social and cultural properties [34], [35]. These free parts are included in The Strategy of Sustainable Development of the Czech Republic. Three pillars were established in 2002 by the World Summit on Sustainable Development in Johannesburg – social, economic and environmental.

After Oprita [20] the effect of human action and modern necessities (basically, technology and its needs) on nature, as same as on workplaces or production systems, lead to natural environmental degradation and continuous more raised changed to produce hazard.

II. PROBLEM FORMULATION

OPTIMIZATION AND ENVIRONMENTAL MANAGEMENT SYSTEM

A. *What is it optimization of assembly workplaces?*

Optimization can be generally characterized as a process of choice the best option from possible effects [19]. During the optimization process we firstly analyze existing state then design possibilities of new solutions and choice of the best possible variation. But what does optimization mean in connection with an assembly workplace? How to choose the best option?

The decisive criteria should certainly be parameter of efficiency, of productivity or of the effectiveness of workplace with keeping optimal conditions for work. In general conception efficiency means characteristic describing methods respectively process through that the surveyed object performs certain activity based on similarity with reference way of performing (process) this activity [28]. Synek mentions the definition of production facility efficiency as maximum productivity per a time unit during standardized quality and accurate keeping of technological process and quality of products [23].

And why should effort is just aimed at assembly workplace? Assembly lines are special flow-line production systems which have a great importance in the industrial production of high quantity standardized process. Recently, assembly lines even gained importance in low volume production of mass-customization. Due to high capital requirements when installing or redesigning a line, its configuration planning is of great relevance for practitioners. Accordingly, this attracted attention of plenty researchers, who tried to support real-world configuration planning by suited assembly line balancing problems [1].

The design of a job, or process, has an impact on human behaviour and thus on production performance. Incorrect job design may lead to absenteeism and turnover. Absenteeism causes fluctuations in production, and turnover may slow it down [7].

Many enterprises, especially from the automotive industry hold all key technologies in their mother companies and production activities of companies in the Eastern Europe are mainly based on assembling operations [29]. Constantin Kinský [25], a managing partner of the Prague office of Roland Berger Strategy Consultants confirms this trend and says: “The Central and Eastern Europe will not be managed as we know today, so as one region.” According to him, the reason is in different economic development of each country. While economy of Central Europe will be led by innovations in 2020, countries of East and South-East will still stay “factories” competing with BRIC countries (Brazil, Russia, India and China). Region will be more and more various. Therefore now corporations have divided Central and Eastern Europe into particular sub-regions. Three from five appealed managers are expecting that this trend will grow stronger during on-coming decade [25]. One question may arise in this connection: What trend will the Czech Republic follow within this progress? The Czech Republic lies geologically in the heart of Europe and due to purely Central-European position and its economy should be according to the Kinsky words [25] led by innovations. Probably it is very important for companies in the Czech Republic, with its not so high innovative potential, currently being somewhere on the edge, to concentrate on assembly operations and continually look for new potential for improvement [30].

B. *Characteristics of Environmental management System*

The Environmental Management System (EMS) is generally defined as a transparent process intervening into the whole organization strategy for the purpose of following regulations and implementation of environmental goals, policy, responsibility and organizing regular audits on workplaces [24]. It is purposeful impact on those products that can affect living environment. Implementing the system organizations binds to targeted protection of environment, to restricted production of living environment pollutants, to decline environmental risks effecting employees health and to train establishment in the sphere of human environment protection [11]. During the ends of 80s was published report, in which World Commission on Environment and Development (United Nations) have noted, that subsequent development of society, has to continue based on a new type of economic development. This development was called as “Sustainable development” [31]. Sustainable development has three dimensions – economic, social and environmental.

Sustainable development confirms EFFRA (European Factories of the Future Research Association). EFFRA mentioned Factory and Nature – gree/ sustainable:

- Lowest resource consumption / energy – lean, clean, green
- Closed loops for products / production and scares resources
- Sustainability in material, production processes / workers [4].

There are many ways of measuring liability but it is generally recognized that liability encompasses the easy in

which the system can be used. Its effectiveness in allowing the user to achieve his or her goals and its likeability are important [22], [32], [33].

Brozová and Flegl in their study mentioned two standards which are important for environmental management system. They concerned on new universal standards in quality were introduced in form of norms ISO 9001 [6] Quality management system (QMS) is more and more oriented on requirements of establishing ISO 9001 into the practice. Lee [15] pointed the usage of ISO to increase the knowledge application of the business.

On the other hand, environmental care also belongs among the important international problems of everyday production. Current experiences show all interesting people in the field of quality management system, that social and especially technological development had basically negative impact on the environment. In this context it is necessary reach sustainability of technological development. Environmental management system (EMS) became relevant since second half of 90s in connection with acceptance of new ISO norms 14001.

Organizations which take care about environment have opportunities to obtain competitive advantages due to the ISO 14001. EMS includes many parts. There are organizational structure, planning activities, responsibilities, practices, procedures and sources [27].

Till now processes have implemented EMS into the company's strategy was considerably limited [10]. But now quite a lot of enterprises active solve these problems and in practice there is a number of single instruments how to methodically implement EMS into companies. Implementation of EMS into the company supports it's positively approach to environment protection in fact.

Having decided to establish EMS the management has basically got two possibilities:

1. Implementing EMS in accordance with 14000 ISO Standards. ISO 14001 provides corporations with directives according to they can the EMS system implement [12]. Implement ISO norm of quality should lead towards to higher companies 'profit and competitiveness by optimizing proses with a particular focus on the customers [6].
2. Implementing EMS according to EMAS program.

Both systems are certified. The Eco-Management and Audit Scheme (EMAS) system is very similar to ISO 14001 as far as components and requirements [16], [21]. The main difference is in some requirements that are widely included in ISO 14000. EMAS requires some principles to be obliged whereas ISO 14000 only recommend or deal with them. These principles include:

1. Environmental review.
2. Publications and verification of environmental declarations.
3. Compliance with legislation.
4. Assessing of indirect environmental aspects.
5. Active staff participation on the process of continual

improvement.

6. Utilization of logo.
7. Registration [14].

In the last 15 years had quality management a significant growth. There are a few reasons for implementation EMS:

1. Huge competition on the market; prices of products are pressed down to the minimum and innovation must be everyday jobs of managers.
2. Customers expect more and more from companies (better services, quality, shorter time of delivery and so on) and expect low price for sure; there is a space for quality production [6].

C. Current situation in optimization and EMS

According to Brozová and Flégl [6] economic development in Czech Republic during the last two decades they say that development has been significant. Czech Republic adopted principles of western European countries in quality and environment. Czech Republic has increased a lot.

Actual optimization of assembly workplaces is based on the generally defined methodology to design manufacturing cells. This methodology (Fig. 1) is worked by Hales and Andersen [8]. It is based on the fact that life cycle of every cell's planned process goes through four phases:

- Orientation.
- The comprehensive plan for the cell.
- The detailed plans of the cells.
- Implementation [8].

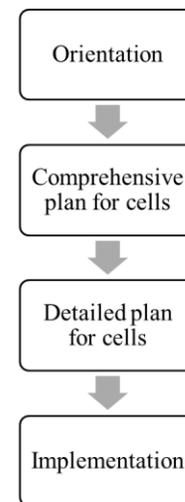


Fig. 1. Stages of designing manufacturing cells [according to [8].

In the designing the methodology with respects to environmental aspects is possibility to build on the basic steps of implementing an EMS. The introduction of EMS into business processes and uses appropriate indicators to assist the monitoring of business performance [5].

If the company wants to implement EMS, it must make the following steps. The steps are shown to simplify in Fig.2.

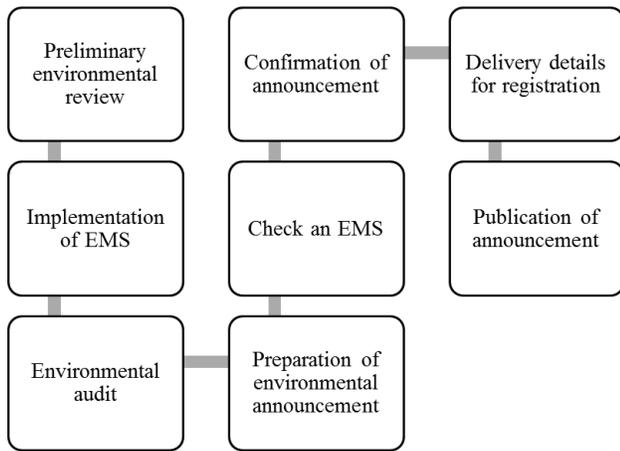


Fig. 2. Steps in implementation of EMS [according to [16]].

From Myskova et al study [17] tools used in the area of environmental aspects must be taken into account our methodology. They include monitoring and evaluating legislative, collection and analysis of data, gaining and broadening knowledge about the environment. Further tools could be used transfer of information meant for reducing environmental crisis and disasters, providing technical expertise, fulfilling sustainable development programs and other.

All points mentioned above should look at the human potential as one of the most important part in production system.

Both of these models functioned separately and must be linked from the point of environmental aspects together. These models had to be simplified and unified with methodology for assembly workplaces.

III. PROBLEM SOLUTION

The methodology was proposed on the basis of the results arising from a partial study. Partial study was divided into two steps: quantitative and qualitative research. In the partial study was identifying the actual state of Czech companies in the optimization of production lines and suitability relevance of the topic to deal with.

A. Quantitative research

Questionnaires were sent to 64 manufacturing enterprises all over the Czech Republic production companies [Fig. 3].

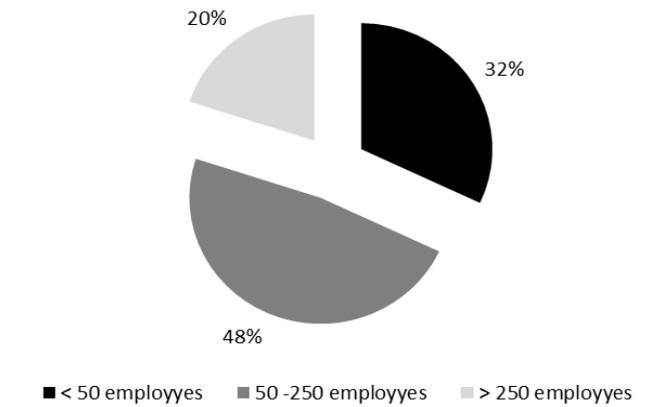


Fig. 3. Structure of companies from the point of number of employees [our research].

The results of the questionnaire were mainly based on the answers of people interested in the production company system (industrial engineering, production department and so on). Of course, the supervisors were asked to rate the importance of these steps in their problem-solving activities. We mentioned some of our important results from quantitative research.

1. Most of companies do not have any specialist as industrial engineering. Optimizing is the responsibility of people who should do other work. They do not care about the assembly line too much (Tab. 1).

Tab. 1. Responsibility for assembly line optimizing

Division	%	Number from 64
Production department	56	36
Technology	16	10
Industrial engineering	11	7
Other	17	11

2. In 1/5 of companies they have no methodology for how to optimize assembly lines. Some of them have never heard about the possibility or using any (Fig. 4).

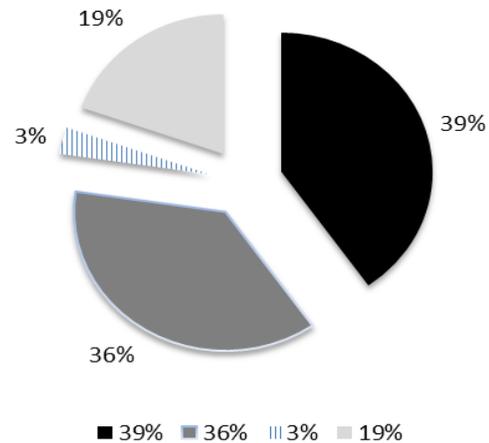


Fig. 4. Percentage of optimizing knowledge [our research]

- 25 per cent companies optimize assembly line on the base of internally methodology (elaborated procedure) which was create
 - 23 per cent companies optimize assembly line on base on historical experience
 - 3 per cent companies use the support of external companies (outsourcing)
 - 12 per cent companies don't use any purposefully and systematically methodology of optimization the assembly workplaces
3. Most companies use an ISO form of implementation of the EMS (Fig. 5).

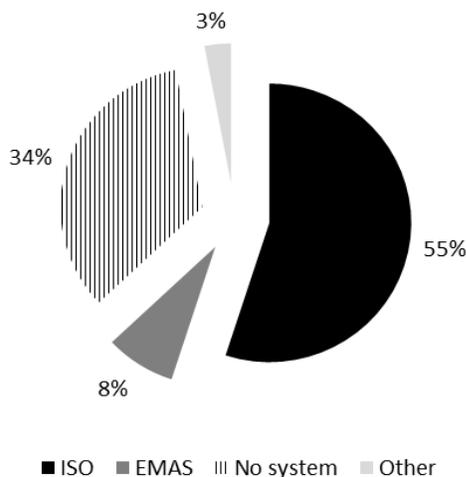


Fig. 5. EMS Implementation possibilities [our research]

- 55 per cent of companies used ISO standard for EMS implementation;
- 8 per cent of companies implemented EMS according to EMAS;
- In 34 per cent there is no standard for EMS evaluating;
- And 3 per cent of companies have other system EMS implementation.

After generally information from companies we prepared for structured interviews.

B. Qualitative research

The scope of this study was to find out if assembly workplaces and problems related to improving their effort and optimization are actual target for Czech companies. The partial study was implemented in 10 firms. Each of them was predetermined across the whole industry spectrum. Addressed companies confirmed that:

- Optimization of assembly workplaces is an actual problem for them.
- Companies' management would welcome generally valid methodology for optimizing assembly workplaces.

The qualitative research was based on structured discussions

performed in more than 30 companies representing big, middle and small firms. Interviews were conducted depending on the company size and its equity structure with persons being in positions as follows:

- Company director
- Plant director
- Production director
- Production unit director
- Assembly unit chief
- Industrial engineer (process engineer, specialist)

In their daily work, we could indicate frequent contact with their supervisors. We were in the most contact with working environmental professionals and enterprise safety and health workers. There seem to be a very limited contact between environmental professionals and workers in an assembly cells. This was also illustrated by the limited number of engineers working inside in the process. We recommended daily meetings with workers where professionals could introduce steps which we had designed.

Qualitative research brought out some facts which should be respected during suggesting generally valid methodology. There are some of them:

1. A large part of these companies is not interested in a development of assembly workplaces; the phase of optimizing is more actual for them.
2. During improvement and optimization of assembly workplaces, companies are mostly aimed to increase productivity.
3. There is no methodology for optimization in companies.
4. Most of assembly workplaces are not sufficiently flexible and universal.
5. People responsible for optimization are not process or industrial engineers mostly. There are people having little experience with methods of lean production.

We designed methodology after gaining all information together. In designing methodology we consider information from specialist in quantitative research more relevant. Nevertheless, we focus on generally information from qualitative research.

The following steps were designed for the assembly workplaces together with EMS's view.

I: Preparation	II: Analysis	III: Optimisation	IV: Improvement
<ul style="list-style-type: none"> • Definition of EP • Implementation of EMS policy • Responsible person and time schedule 	<ul style="list-style-type: none"> • Analysis of the EP's company • Analysis of problem 	<ul style="list-style-type: none"> • Designing of protective devices in the assembly workplaces • Implementation EP in to assembly workplaces • Internal audit 	<ul style="list-style-type: none"> • Review of function by leadership • The external communication • Review and registration

Fig. 6. Implementation of EMS and stages of designing manufacturing [our proposal].

C. Methodology of assembly workplaces optimizing

Generally, the methodology could be divided into 4 phases:

- Preparation;
- Analysis;
- Optimization;
- Improvement.

This optimization flowing in successive phases should be understood as never ending cycle or cycle that ends with a product lifecycle and assembly workplaces as well. The picture bellow shows schematic demonstration of general methodology. Each phase is briefly described in the following subchapters.

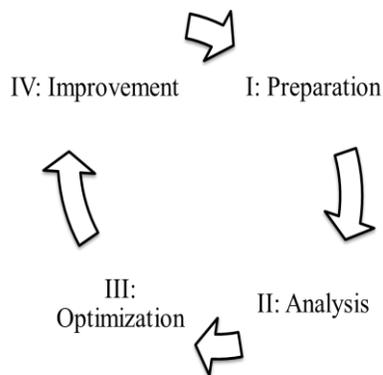


Fig. 7. The general procedure for optimizing the assembly workplaces (our proposal)

In the final step the methodology was verified in the real environment of the Czech companies and modified according to actual assessments.

D. I Phase: Preparation

First, preparation phase contained especially design procedure aimed at correct defining the project. All innovatory activities should be managed as projects and they should use standard implements of the project management. Basically it does not matter what implement or conception is used but it is necessary to ensure defined rules explicitly. A lot of companies included in concerns have to set for the project management a method DMAIC or they gently adjusted

conception issuing from this method. The DMAIC does not oppose suggested method in any way. On the contrary, it suitably completes it and it is acceptable to use it.

From the point of EMS, the EMS policy was implemented into the company strategy. Targets, responsible persons and time schedule of implementation for assembly workplace were set.

E. II Phase: Analysis

The second phase was aimed at analysis of existing state of assembly workplaces, eventually lines or units. It was always necessary to adapt the analysis to current needs and optimization goals that were defined during the first phase. The analysis should be focused on following problems:

- Analysis of material and information flow;
- Analysis of existing technological process;
- Analysis of activity of each workplaces;
- Analysis of workers activity;
- Analysis of logistics and supply line.

In connection with the EMS, it was necessary to present a plan with possible problems that could be arisen on workplaces and to describe possible solutions. All possible processes and procedures were taken into consideration within this phase.

Setting of education programs seemed to be the most important for staff and a plan for effective documents control.

F. III Phase: Optimization

This third key phase contained own optimization of assembly workplace. The optimization was certainly largely dependent on results from analysis of existing state of each workplace. In this phase we should be concentrated on searching for corrective actions for problems identified in the second phase. To propose general process was relatively doubtful. Nevertheless we could at least outline frame method. Optimization of assembly workplaces should be run in three steps:

- Proposing a layout conception.
- Detailed form of each workplace.
- Production start.

The objective was to propose and then choose assembly workplaces layout. In terms of EMS there were determined key activities for monitoring and measuring effectiveness of EMS implementation. Key activities are facilities maintenance and calibration and keeping records and documenting of possible problems.

G. IV Phase: Improvement

This final phase of improving was very closely connected to a start-up curve and it was aimed at identification of problems and their successive solution so that the effect defined by the curve would be achieved.

It was very important to set up systematic data collection and react to arising problems. The suitable instrument was the Shop floor management. The management's attention had to be drawn to continual keeping the EMS. The management

should review the system functioning irrespective of what were results from audits.

IV. CONCLUSION

Optimization is certainly not the only solution of problems which companies are dealing with. It can expressively contribute to higher effectiveness and flexibility of the whole production system with lower demands on production area, on lower manipulation and on lower production time. There is reduction of fixed costs and costs on a product as well. And flexibility and production costs will probably decide about winners and losers in the hard competitors struggle. We found out there are many factories which used an assembly workplaces in the Czech Republic. In our opinion, the share of the automotive industry will increase. The Czech Republic doesn't belong to the states which have the cheap labour force. Because of competitions between states which have much cheaper labor force, then the Czech Republic have, we have to improve assembly workplaces every day.

There are many documents connected with environmental protection in the Czech Republic. Companies 'individual priority goals were designed:

- Reduction of industrial impacts and risks;
- Protection of the environmental from negative impacts of human inattention;
- Impact of crisis situations.

In case that company decides to join this optimization with EMS implementing in their strategies they can profit from:

- The assembly workplaces can be more flexible and effectiveness.
- There can be simpler way how to solve problems with the law for companies.
- Companies can have possibilities to penetrate abroad and can break barriers in business.
- The companies can acquire confidential from their customers and other competition.
- The companies can decrease the influence of environmental harmful aspects.
- There can be way how to reduce of waste and decrease of costs.
- The main reason for optimization of assembly workplaces is lower injuries and diseases in the workplaces.

Managers generally agreed with opinion that the persons designing a product, implementing new technology and planning a process. The employees have a great influence on the working environment of their manufacturing the product or participating in the process. It is important to be interested in working environment aspects.

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Veronika Šišková graduated from Tomas Bata University in Zlín in the Czech Republic in 2010. She obtained his Master Degree in Enterprise Economy. She studied at Fachhochschule Nordwestschweiz in Switzerland. Currently she is a Ph.D. student at Tomas Bata University in Zlín. Her research included Ergonomics, ISO standard, Physical factors affecting human factors on the workplace.



Jaroslav Dlabač graduated from Tomas Bata University in Zlín in the Czech Republic. He obtained his Master Degree in Industrial Engineering. He works as senior consultant in consulting company. Currently he is a combined Ph.D. student at Tomas Bata University in Zlín. Her research included Lean Manufacturing, Optimization of workplaces. He has got many experiences from his lectors 'works, workshops, companies exercising and participation in project.