



Recycling materials database as a Green Kaizen for sustainable development in the automotive industry

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ABSTRACT

Purpose: The article aims to present a proposal and discuss the Green Kaizen Model, which is focused on integrated development, ensuring cost reduction and fulfilling the requirements of all the organisation's interested parties.

Design/methodology/approach: The authors have prepared and presented the Green Kaizen Model in the study. Its effectiveness has been confirmed in the balanced development of the DPF production process.

Findings: The development of the model, based on the multiannual experience of the automotive-oriented organisation and its systemic application, has confirmed that its implementation brings measurable benefits in the range of limiting the environmental aspects.

Practical implications: The paper should be of special attention to engineers interested in applying Green Kaizen and recycling materials databases to develop processes.

Originality/value: The value of the presented paper is constituted by the Green Kaizen Model. The proposed model may create a complex tool for improving the costs and quality range processes and be dedicated to sustainable development.

Keywords: Sustainable development, Continuous improvement, Green Kaizen, DPF production

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INDUSTRIAL MANAGEMENT AND ORGANISATION

1. Introduction

The intensive development of enterprises functioning in the market forces the need to develop processes and functions and introduce innovative solutions continuously.

Nowadays, the importance of the enterprise is marked not only by its position in the market but also by the human resources taking advantage of their knowledge, experience and skills. The huge competition and rivalry in the market of production enterprises force the pursuit of the production

costs minimising as well as the continuous increase of effectiveness, which finally should ensure the production of the highest quality products with the simultaneous guarantee of the lowest price [1-3].

The problems that commonly appear in the production companies during the production process are connected with both the quality of the manufactured goods and the ones imported from the out-suppliers. They cause difficulties within the range of work, and also, they raise the production costs. In order to improve the production process and its effectiveness, the production enterprises apply various methods of production process development. It requires a systemic and planned approach, which first and basic stage is knowledge of the production process. The choice of the proper production development conception is the constituent of many factors, among others the character of the process, the sort and size of the production enterprise, and the complexity level of the production process [4-6].

One should, however, remember that the organisation directed exclusively to fulfil the requirements and expectations of the clients, connected with the delivery of product or service, is no longer the guarantee for the organisation to win the leader position in the competitive fight in the market. Nowadays, organisations must be oriented toward balanced development, and the so-far-applied management system has a new range – environmental management. It is also accompanied by applying the management tools exclusively to ensure the quality before [7-10].

2. Application of Kaizen in green approach

The production enterprises apply various conceptions for production development and, at the same time, continuously search for innovative solutions that reach beyond the ranges of the so-far-applied standards. One of the methods is Kaizen, which by acquiring the knowledge, allows for the solution of the existing problems, with the simultaneous and continuous development within the organisations being under the learning process. It is mainly the unstoppable efficiency improvement at eliminating mismanagement and wastefulness. The Kaizen method represents not only the way of thinking and management but also the proper communication style among all the participants of the production process within the enterprise. As a system of continuous development, the Kaizen method originates from Japan and in the lateral translation, it means: “slow, endless improvement of all the life’s aspects”. As the beginning of the “Japanese management style” and the Kaizen’s way of thinking, one has taken the 1980s. At that time, the Japanese

companies recorded huge economic success, which turned out to be a sort of ideal exemplar. Kaizen is a philosophy applied not only within the range of management but also in daily life in Japan. The term Kaizen represents the combination of the two Japanese words, where “kai” means “make” and “zen” means “well”, and the translation of the term introduces the changes and improvements. The Kaizen way of thinking aims at the process and the management, not at assessing the human’s work and the results they achieve. The crucial ways of solving problems in the Kaizen strategy are: cooperation and co-acting. Due to this, the obtained results are as crucial as obtaining them. Due to the Kaizen philosophy, all the workers should work together and aim for continuous improvement, which in turn influences the ability of proper communication among the workers within the organisation. The basic task of the management staff, who agree with the quality policy, tasks and procedures, is to keep continuous contact with the work team, create a friendly atmosphere in the workplace, and organise training and workshops to raise the workers’ qualifications. The basic conditions of the effective Kaizen philosophy implementation are continuous improvement of the existing conditions by human effort, communication, training and workshops, teamwork, and self-discipline in realising the planned aims [11-18].

The improvements are revised in two aspects. First represents the innovations that cover the actions revolutionising the existing systems and causing sudden and drastic status change. They do not undergo the standardisation process, so they have not taken any actions to maintain the changes at the particular level. As a result, there is an observable decrease in the work’s results after some time. The second aspect is Kaizen, which means small improvements done continuously and within the constantly developing time frames. Kaizen, therefore, fulfils the space between the innovations and the so-far-existing conditions. The leading thought of Kaizen is the unstoppable development of the quality of products, services, working conditions, and the relations among the co-workers. Implementation of the Kaizen method can be divided into seven stages. At the same time, the last stage of standardisation, enabling the realisation of the Japanese system – continuity- is the most important. The stages are identification of the improvement areas, analysis and selection of the key problems, identification of the reasons for development, planning of the remedial measures, implementation, comparison of the results and standardisation [14, 19-23].

The Kaizen techniques applied in the range of quality management seem to be the common tool nowadays. However, the search for improving solutions ensuring not

only the fulfilment of the clients' needs and minimising the production's cost but also the optimisation of the materials and energy consumption as well as the minimising the waste amount, all is the concept of the complex and integrated character. It represents the new tendency in the organisations and aims to build up their balanced identity. It is exactly the Lean thinking which should lead to the limitation of the production's cost and the reduction of the environmental influence. Integrating sustainability, social, economic and environmental aims should be the basis for building the organisation's strategy [24-26].

The works on the application of Lean thinking within the scope of environmental management allowed for formulation the basic rules of Lean and Green [27,28]:

- Lean can be applied both: in the improvement of productivity as well as the environmental improvement,
- Lean creates, within the production process, an operational and cultural environment that favours minimising the influence on the environment,
- Lean creates the financial conditions for introducing the environmental development,
- some regulatory friction can be encountered when applying Lean to environmentally sensitive processes,
- taking advantage of Lean within the organisation brings the outside benefits of refraining from the friendly approach of the environmental agencies,
- Kaizen is the technique recommended for obtaining the environmental benefits in Lean.

To confirm that the Lean tools can be used within the scope of minimising the environmental influence, the Environmental Protection Agency has issued a comparison of guidance for applying the Lean tools for the improvement of materials flow in the production process, also resulting in the limiting its environmental influence [27]. In the study, as "one of the main vehicles for change in Lean," Kaizen is pointed out. Within organisations where Kaizen is the base of continuous development, it is also natural to apply it to environmental development [29].

Organisations implementing Kaizen into activities connected with limiting the environmental aspects and influences build up their models of development by Kaizen. It is worth mentioning the following ones: Lean & Green Kaizen Model for Cell covering identification of development needs in these operational cells which – due to the material consumption – are of meaningful environmental character, estimation of the current cell's condition within its environmental influence and defining the aims of development, application of Kaizen workshop for defining the possibilities of limiting the waste amount and finally application. Lean & Green Kaizen Model for value stream

originates from the assumption that Lean means manufacturing what the client expects on time and with optimal costs and minimal waste. Environmental waste is not the value added to the processes; therefore, their elimination should be written in Lean thinking. Therefore, the Model for the value stream requires a detailed analysis of the environmental aspects and influences on the value stream, as to the requirements stated by ISO 14001 [26, 30-37].

3. Methodology

The aim of the study has been the development of the Green Kaizen Model and following its implementation and verification of its rightness within the automotive field enterprise. The analyses have been carried out in the context of the Lean & Green Kaizen Model for Cell and the Lean & Green Kaizen Model for value stream [26,30]. The model has been prepared based on the multiannual experience of the enterprise applying the Kaizen technique to develop quality. One has been applying the technique within the integrated range directed at balanced development for two years. The elements of the Green Kaizen Model, implemented in the development cycle, have been presented in Figure 1.

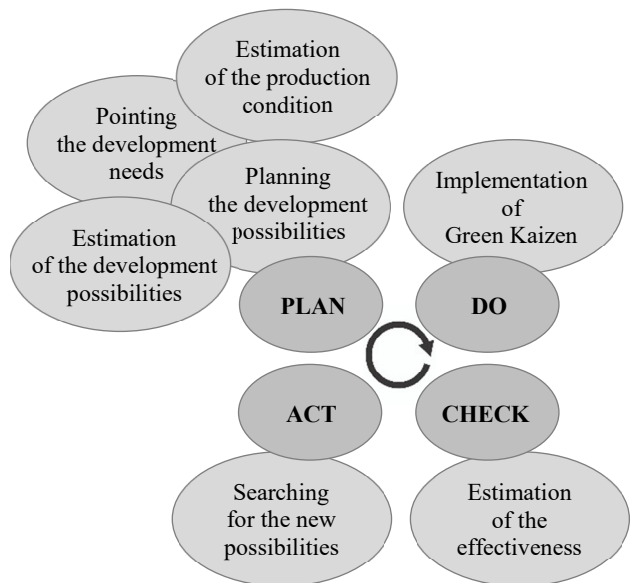


Fig. 1. Scheme of the Green Kaizen Model stages written in the continuous development cycle

The model covers the following sequential stages:

- pointing to the development needs within the production cell or the process. The need for development can refrain

not only from the clear resource usage, gas and particulate matter emission to the atmosphere, waste drop, emission and storage of the waste but also lack of control over these processes,

- estimation of the production cell or the process condition. Such an estimation covers the measurements of the environmental influence in resource usage, gas and particulate matter emission to the atmosphere, waste drop, emission and storage of the waste, and the organisation chooses the proper estimation methodology.

One should remember that those two stages might not be realised in such a sequence. Suppose the worker identifies the development need as closer to the development need. In that case, the report is intuitive, and its consequence fully estimates the reality of development necessity. However, when the organisation manages the environmental aspects and performs its estimation, the development needs results from the estimation in question. It refers to these production cells or processes where one has pointed out the meaningful environmental aspects. It is important if the estimation concerns the working place, production cell, operation, or whole process. It depends exclusively on the character of the realised production process. The organisation must accept, within its possibility, the homogenous methodology, including:

- estimation of the development possibilities (P). Propositions of development can be of the technical, technological or organisational character. However, independently of the way of the development, its plan does not go the estimation due to possibilities of minimising the environmental influence, finances, and the context of fulfilling the quality requirements. The realised risk estimation should cover not only the potential possibilities of Green Kaizen but also the potential threats,
- planning of the development possibilities (P). Implementation of Green Kaizen must be preceded by the prepared plan, taking into consideration the implementation algorithm, indispensable human and infrastructure resources, documentation and communication within the development process, as well as the supervision over the implementation,
- implementation of Green Kaizen by the accepted plan (D),
- estimation of effectiveness covering the environmental influence measurement and, in reality, being the repeated estimation of the current condition of the production cell or the process (C),
- searching for new possibilities of balanced development within the range of the analysed production cell or the process (A).

The Green Kaizen project has been realised in the production company specialising in the field of ceramic cartridge manufacture (DPF, Diesel Particulate Filter) for diesel catalytic convertors, which recycles the harmful elements of exhaust gases into the environmentally friendly and safe substances. Car manufacturers apply the ceramic component of the engine catalytic convertors in passenger cars and light commercial vehicles worldwide.

4. Results and discussion

The first stage in the production of DPF filters is the preparation of the proper mixture. Next, the mass is formed and pressed, creating the segments. After drying, the segments undergo sealing – meaning the particular canals are closed. After sealing and drying comes the firing process at a high temperature. After the firing process, the segments fulfilling the severe quality norms are passed to the next production stage.

During the next stage, special cement joins the segments into blocks. The dried blocks are passed to the mechanical processing section, where they are properly shaped. The shaped blocks are coated with a special cement to protect the side part of the filter, and next, they are dried again. In the final phase, the filters undergo the final inspection, covering numerous quality tests. After the positive quality control, filters are packed into special containers and directed to the receivers.

There are two types of waste in the extrusion process:

- cuttings; due to the specificity of the manufacturing process (Fig. 2a),
- non-compliant segments due to the classification of the segment as non-compliant with the specification (Fig. 2b).

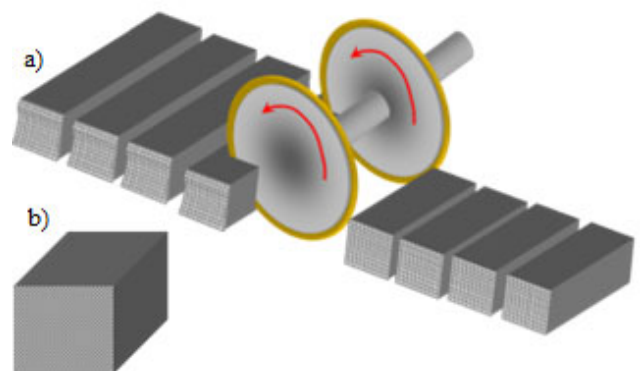


Fig. 2. Schemes of two kinds of the waste in the analysed process; a) cuttings, b) non-compliances

Within the range of developing the production process of DPF filters, one has devised the computer programme – recycling materials database (BSR), which aims to facilitate the production process by visualisation of the production waste circulation, type of the waste and the generated amount of waste. The implemented and functioning database is the example of the development the production process of DPF filters by and due to the Kaizen method. It is the IT programme that enables the optimal usage of the production materials, which can also be used to control the other materials used again in the production process.

The development project in the described production process has been realised in accordance with the proposed Green Kaizen Model. Identification of the development need has been described as control over the amount, and kind of the material obtained from the waste is difficult to realise and results in low effectiveness.

During the estimation of the current condition of the cell within its environmental influence as the important factor, one has pointed out the waste's generation and management. One has differentiated two sorts of waste: off-cuts – due to the specificity of the manufacturing process and the necessity of keeping the size tolerance and segments – inconsistent with the specification; for those two groups, one has carried out quality and quantity analyses.

To limit the waste amount, one has proposed devising a complete database of recycling materials to support the waste's management and circulation. One has assessed the project's risk, and its outcome has allowed its continuation.

All the indispensable tools ensuring the proper realisation of the project have been planned.

The project, in the form of the IT programme, enabling the optimal usage of the production materials in ceramic DPF filter production, has been implemented and estimated.

Application of the database allows for limiting the amounts of the set-ups of the mill, which in turn influences the production cost reduction and the effective usage of the warehouse space. The data included in the database enables the directed action; namely, the worker can define the amount and sort of the material being in the zone before the grinding process, as well as assess the amount of the material being on the resource buffer prepared for the next usage. It makes the fluent management of the warehouse zones and the materials before and after the grinding process possible. It is worth mentioning that the data concerning the amount of material undergoing the grinding process are the information for the department of waste generating and concerns the possible deviations.

To create the recycling materials database (RMD), one has taken advantage of the IT programme, which enables applications for computers and mobile devices. The programme in question boosts work efficiency and facilitates independence or teamwork. It is the integrated programming environment for creating independent and net applications, net services, and internet services. The input data represent the amount and sort of the material passed to grinding during the pressing process. In order to save the identification of the materials, one has to apply the label

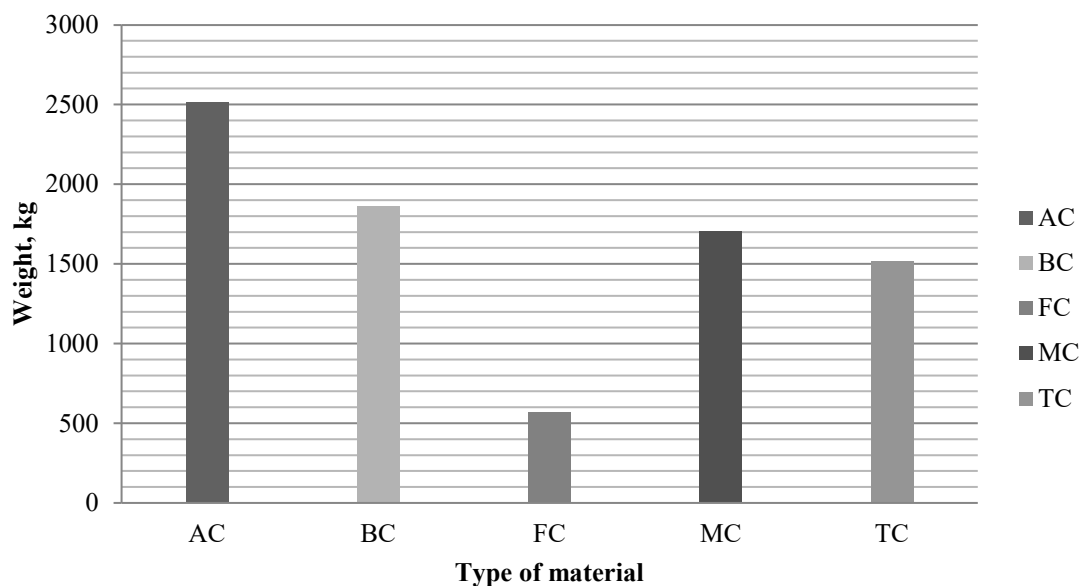


Fig. 3. Recycling in-put for the grinding process

containing the description and the bar code containing all the data concerning the production waste. So, the described materials go to the pointed buffer zones – by the sort of the product. RMD enables planning what material should be ground, marked by the information on the appropriate amount on the buffer in front of the mill and the information on the lack of the proper amount of the material after the grinding process. Before its next application, the ground material undergoes various laboratory tests to confirm if it will get the buffer zone or if it will be classified as waste. The precise planning, considering the amount of input to the mill as well as after the grinding process, allows for limiting the number of set-ups, which is time-consuming and influences the results of the company’s productivity.

Due to the important meaning of the production stages during which the recycling waste occurs, the database consists of the views allowing for the registration, identification and moving of the materials during the grinding process and using them for the next time in the production process. Placing the individual number for each batch of the material enables the identification of those materials in the next stages of processing the waste into the material fit for production. The crucial element is the registration of material’s weight, which allows for the analysis of waste generated in the particular stages of production, and it represents the information for the next stage of processing.

The charts are generated based on the data obtained from the recycling material’s database, representing the graph interpretation of the results. Figure 3 presents the chart of the

registered recycling material amounts, which passes to the grinding process by identifying the kind of material. Figure 4 presents additional information concerning the kind of recycling material (off-cuts and segments). Figure 5 shows the visualisation of the materials’ amount before and after the grinding process considering the maximum storage places. Tapes of materials used in the production have been replaced by symbols (AC, BC, FC, MC, TC).

The implemented and working recycling materials database brings measurable benefits for the enterprise by shortening the time of the mill’s set-up, which in turn influences the production cost reduction by almost 45%.

The information obtained from the database enables the more effective usage of the storage areas.

The developed database is an effective tool for the managerial team, allowing for the optimisation of the material circulation within the production process, which limits the waste amount and has a meaningful influence on environmental protection.

5. Conclusions

The production process is the base of each enterprise’s activity, and the production management understood as the processes, resources and information steering – has an important influence on the possibilities of obtaining the success of the particular company. To a high degree, continuous development in this field leads to the development and increase of the company’s competitiveness

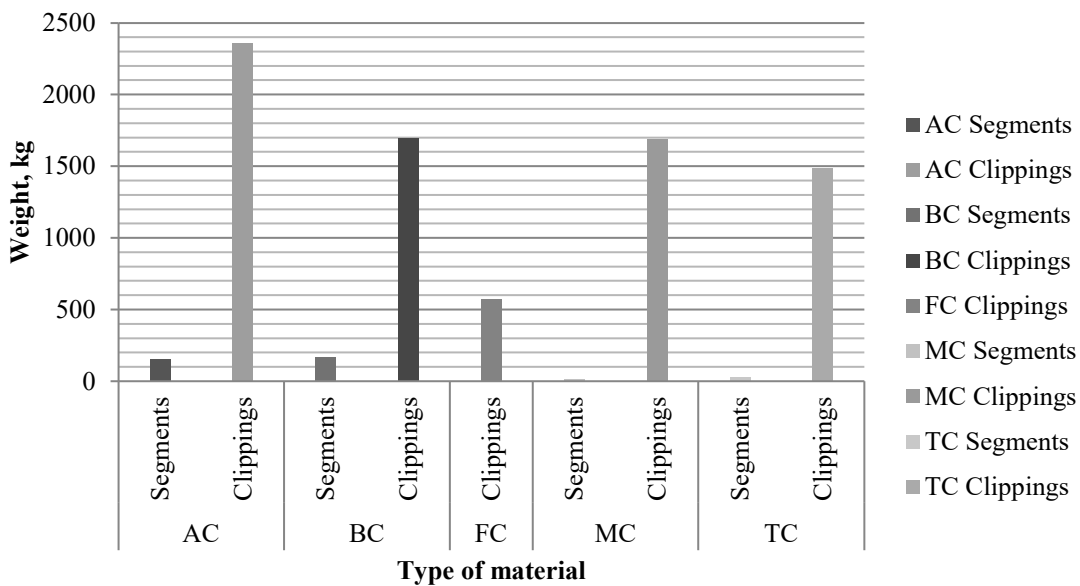


Fig. 4. Division due to the sort of recycling materials

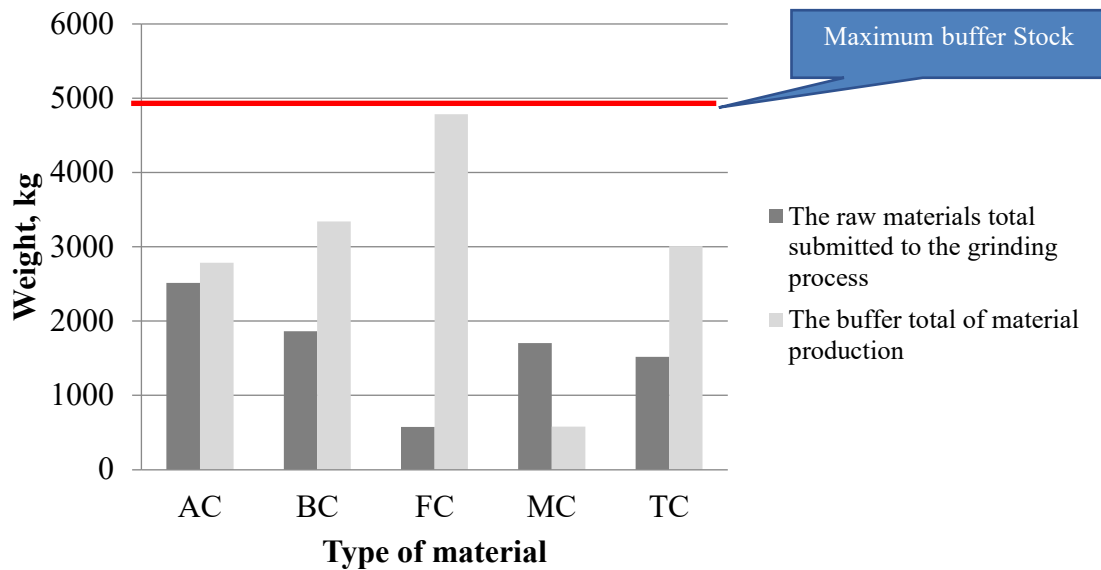


Fig. 5. Visualisation of the materials' amount before and after the grinding process

in the market. Properly implemented and functioning development brings measurable benefits for the enterprise, which refrain from reducing costs and increasing the processes' effectiveness. While developing the production process, one should eliminate wastefulness, which means all the actions and things negatively influence the costs of the particular organisation. So far, the application of the Lean management tools, among others, the Kaizen technique, for the development of the processes allowed for the wastefulness elimination only within the chosen aspects of the company's activities. Currently, companies more often want to fulfil the requirements of all interested parties by minimising the cost simultaneously. Therefore, they direct the development processes at the balanced development.

The analysis of the enterprise's experience within the automotive field, development of the Green Kaizen Model, and its verification allowed for formulating the conclusions confirming the significance of applying Green Kaizen in the balanced development of the processes.

The advantage of Green Kaizen is that it does not require any advanced technology. The most crucial is the human effort, engagement, and approach towards the facilities. Such a way of thinking allows one to obtain the set aims at every stage of the production process. The Kaizen system covers all the workers, which influences the improvement of the process, and as a consequence it aims at eliminating the loss. The idea based on Kaizen can be reported by each of the workers involved in the organisation's development –

which concerns the production workers and the executive ones.

The Kaizen system applied in the integrated range brings measurable benefits not only by eliminating the loss connected with over-stores, expectations, transportation, over-production and corrections but also by the optimisation of the material circulation during the production process, which in turn leads to the limitation of the waste amount as well as it has a meaningful impact on minimising the environmental influence.

The effectiveness of Green Kaizen implementation depends mainly on the workers' involvement in the works on planning and realisation of the project. However, the reliable, based on knowledge and experience, approach is also highly important when estimating the current condition of the production cell or the process and the realised project's risk assessment. As almost meaningless seems to be if the project concerns the production cell or the process.

The conclusions formulated on the ground of the survey are almost the same as the results of the analyses presented in the literature on the Kaizen application in the scope of environmental development. However, it has been confirmed that the Kaizen improvements, having the bottom-up character, are equated with the production cell or the process. The analysis of the stream value can only represent the methodology for estimating the current condition of the cell; however, it cannot be the starting point within the range of development needs identification.

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