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INTRODUCTION AND ADAPTATION OF METHODS FOR SUSTAINABLE PRODUCT DEVELOPMENT IN SMALL AND MIDDLE-SIZED ENTERPRISES – RESULTS AND EXPERIENCES

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Abstract

In the last years a new environment strategy was developed by the European commission, which is called „Integrated Product Policy“ or IPP. Within this political process the Bavarian State Ministry for State Development and Environment started to support IPP pilot projects in order to facilitate and speed up the conversion of the theoretical IPP concept into practical applications. One of the special focuses was on small and middle-size enterprises. SME have a limited availability of personnel and financial resources for environmental issues as well as a lack of know-how compared to larger enterprises. They need a more pragmatic methodology to utilize their potentials for sustainable products. This research project entitled therefore has been formulated to investigate applicable methodologies to support the sustainable development for small and middle-sized enterprises. We identify and focus on the main criteria of the respective company and product by checking about all possibilities of IPP activity. Subsequently effective methods are used to utilize the potentials. It is a practical approach for implementation of sustainable development in all phases of the lifecycle. Finally some of the achieved results of the application within the development projects of the industrial partners are shown.

Keywords: integrated product policy (IPP), sustainable development, method selection, method transfer

1. Introduction

The European commission started to define a new environment strategy in the year 1997, which is called the “Integrated Product Policy” or IPP. This new approach is a bigger change

compared to the environment protection of the last 30 years that has mostly been an action of the last phases of the product lifecycle based on laws and regulations. With the old focus the output of emission sources were reduced significantly for the better. Yet further progress is more and more limited because of technical and economical reasons. Therefore the environment ministers of the European Union discussed IPP at a Council in Weimar in the year 1999 and decided that IPP is essential towards a sustainable development in Europe. As a result the European Commission adopted a Green Paper on IPP with the objective of launching a debate on the role and possible measures that could be taken on a European Union basis.

What is Integrated Product Policy then? All products have environmental impacts in some way, whether from their manufacturing, use or disposal. The strategy of IPP wants to minimise these by looking at all phases of a products' life-cycle and taking action where it is most effective.

The life-cycle of a product is often long and complicated. It covers all live phases from the extraction of natural resources, through their design, manufacture, assembly, marketing, distribution, sale and use to disposal as waste. At the same time it also involves many different participants such as designers, industry, marketing people, retailers and consumers. IPP attempts to stimulate each part of these individual phases to improve their environmental performance [1,2].

2. The research project

Within this political process the Bavarian State Ministry for State Development and Environment started to support IPP pilot projects in order to facilitate and speed up the conversion of the theoretical IPP concept into practical applications. In this case IPP aims not only at ecological improvements, but also onto lasting concepts, which include the economical and social aspects. This was construed to be a good opportunity to test the practicality of the IPP. Therefore in total seven different pilot projects were supported by the Bavarian government since 2000.

Our research project "Introduction and adaptation of methods for sustainable product development in small and middle-sized enterprises" is one of the seven. It was initiated in order to develop and apply a methodical approach especially for small and middle-size enterprises (SME) with their characteristically small financial and personal resources. The

relevant product properties and environmental impacts can be improved most effectively by a methodical support of the product planning and design as the early phases of the product life to implement the Integrated Politic Policy. Consequently in SME especially the design engineer and his intensive collaboration with the different actors of the product life phases play a key role.

In co-operation with three companies the research group is able to analyze the processes of independent development projects on the basis of three different product samples. Our partners are Hans Huber AG, Knorr-Bremse - Systems for railway vehicles GmbH and Krones AG. In these projects the companies develop new innovative products for dewatering sewage sludge, preparation of PET recycling material and brake control for railway vehicles. In each company the design process is coached to examine their methodology and to utilize selected methods which are applicable in the companies actual design process [3].

3. The methodical approach

3.1. The developed and applied methodical approach

Our approach to motivate the companies to implement the IPP strategy into their product development was the focus towards the win-win situation of an environment-friendly and company-orientated product development [Figure 1]. For a successful implementation in small and middle-size companies with their small financial and personal resources it is essential that the company itself has a benefit out of the additional work and the investment has good returns.

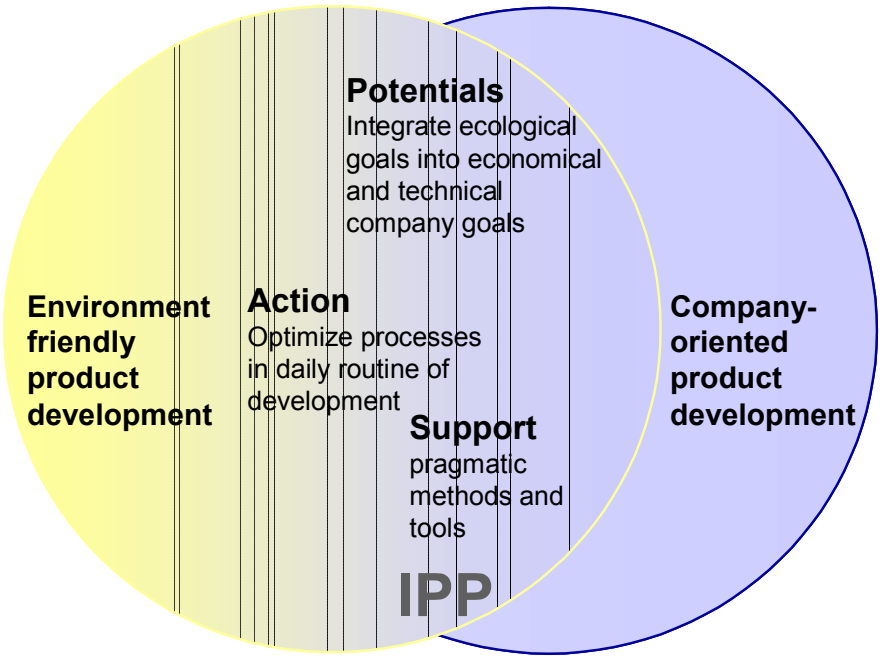

Figure 1: IPP as intersection of a environment-friendly and company-oriented product development

In general the IPP strategy has to offer a high potential for the environment and the SME itself. Compared to large-scale enterprises they have a lot of potentials by integrating ecological into economical and technical goals and to optimize the processes in the daily routine of their development. Therefore they need support through pragmatic methods and tools.

In our project we developed and applied the following general model [Figure 2] in the three participating companies. The utilization had to be flexibly adapted to the boundary conditions of the different development projects by the use of different methods, iterate loops or parallel processes for subprojects.

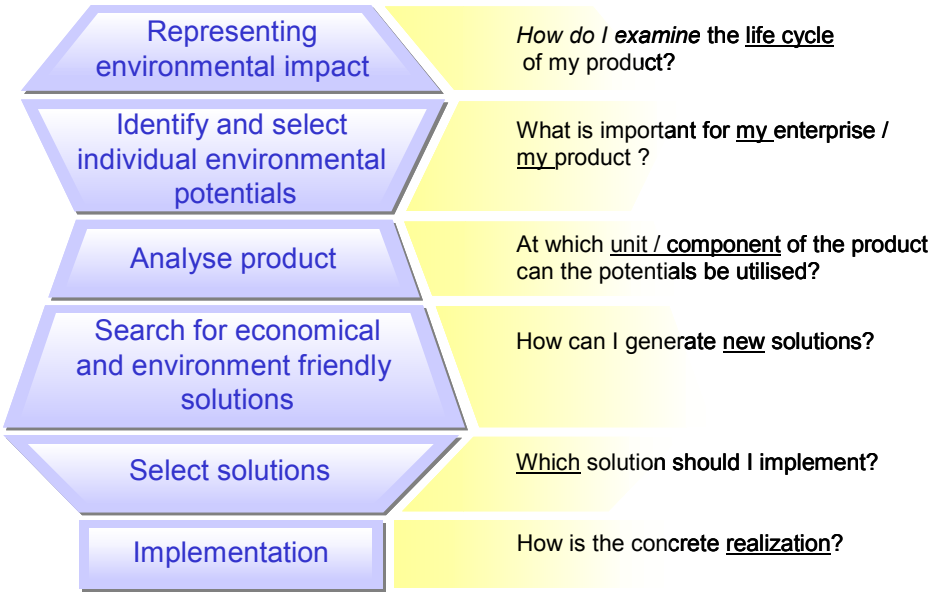

Figure 2: Developed and applied methodical approach

We divided our procedure into six basic steps which have been applicable in all projects to give the engineers a practical and easily understandable guideline for the implementation of IPP in their daily routine. More details of each of the steps are given below.

3.2. Representing the environmental impact and the life cycle

In the first step all the participating persons have to be informed about the concept of the Integrated Product Policy. It is important for the long-term success that they understand the potentials and advantages of this new approach and want to use the potentials and advantages of this new approach for themselves. In the most cases only a high inner motivation of the participants secures a consequent conversion in the daily routine which is mostly determined by a low regularized work flow.

In the second step the effects of the product which has to be developed and its related processes to the environment have to be analysed by the consideration of the different inputs and outputs of material and energy during the different life phases. During this process it has to be guaranteed that the participating persons have sufficient knowledge of all life phases as well as about the environmental aspects. According to knowledge and capacities this process can be done alone by the designer or in a team, for example with specialists from marketing, distribution, production, and service or environmental experts. It is advantageous to have at least two qualified persons to discuss the individual life phases and environmental impact. This step is combined with an inquiry of the current and important problems of the company

during the different phases of the lifecycle to find correlation and potentials as well as obstacles.

A developed Excel-tool supports this "Mini-LCA". It serves as stimulation in form of a check list by questing basics as well as to support and help to document this process. As a result of this step we have informed and motivated employees who recognize the potentials for improvements by the integrated analysis of the environmental effects of their products and organizational and technical problems, plus a documentation of the potentials for improvements.

3.3. Identifying and selecting the individual potentials

The weaknesses of the individual product became conscious to the involved persons through the preceding step. It offers an initial focussing onto the processes and life phases, and the resulting improvements produce the biggest advantage for the environment and company.

Strategies for improvements are assigned with the aid of a matrix to material and energy input and output flows of the different product life phases. Because of the limited financial and staff capacities of small and middle-sized enterprises it is essential, to concentrate the effort first onto the most promising ones. The strategies are a very extensive and comprehensive collection which can be an essential aid for most different product types and organizations. Some similar strategies can be found in [4,5]. The first step in this phase consists of an evaluation, if the improvement approach is relevant. This simple evaluation step only distinguishes between relevant or not relevant. In this case explanatory texts to the individual strategies are available for the users. Through the different associations and inspirations of the strategies new and often very individual solution strategies will be found and can be complemented in the list.

After this first explanation with a simple selection method a more detailed evaluation method is used. Our experience shows that for the voluntary and motivated implementation of the strategies it is important to develop some criteria In order to limit the necessary expenditure, however, we reduce the evaluation to three criteria:

- - *attainable benefit for the environment*, for the company and for the customers
- - *expenditure*, that is to be invested in financial or in the form of additional staff
- = *duration*, that is needed for the implementation and until the initial benefits are gained

These criteria will be assessed with "high", "middle" or "low" or "short-term", "middle-term" or “long-term”. With the aid of these individual valuations the relevant strategies can be divided in three categories “very interesting and important“, “interestingly” and “strikes too, but little relevant”.

This analysis and simple evaluation serves as a good basis for a decision which improvement strategies for the product should be utilized. It also documents the decision process in a clear and understandable manner. In this case a good documentation is also an essential aid within possible iteration steps or during further application in later projects. The number and extent of the strategies have to be adapted very individually onto the product, the organization and the current situation.

Each of this individually chosen strategies can demand a very different procedure regarding the expenditure, the time duration, the number of persons needed and the organizational boundary conditions. In spite of that three more steps of a strategy-related problem solving cycle can be identified which can vary a lot between the individual strategies [6].

3.4. Analysing the product

As a first step of the cycle to generate strategy specific solutions is the general analysis of the product and the relating processes. In this step all the necessary information have to be investigated from the different sources like the process participants, hardware, documentation, literature or cost calculations and needs to be processed to search for solutions.

Within this step four essential tasks can be defined. The first task is to transfer the selected solution strategy to the current product and the related processes. The proposed strategies are very generally formulated and have to be concretized for the individual situations. Upcoming questions within this process have to be clarified.

Many requirements and limiting conditions arise from the product and the related processes which influence the search for solutions. These are vital for a goal-oriented procedure as well as the knowledge about the interactions between different performance-influencing factors.

An essential result of these analyses is to recognize the achievable potentials of a good solution. This is an essential base for the following setting of realizable and achievable targets.

3.5. Search for economical and environment friendly solutions

If the requirements, boundary conditions and interactions as well as the potentials and targets are identified, specific solutions can be searched and generated.

According to the situation a great number of methods can be utilized, which can be distinguish by their effective principle as the stimulating of intuition or analytically and systematically methods. A great number of these methods are applicable for several strategies, but for some strategies some very particular methods and procedures have to be used [6].

The individual method can be adapted and combined relating to the individual context.

3.6. Select solutions

A great number of solutions can be found by the use of different methods. The most promising ones have to be selected from this great number in accordance to the available capacities.

Therefore three steps are necessary. First the solution ideas have to be analyzed and concretized regarding their properties. Following this a simple selection is possible as a second step. The ideas are evaluated to check whether they fulfil the necessary limiting conditions and requirements.

The remaining solutions will be evaluated according to their benefit, the necessary expenditure for the implementation and the needed duration. As a result we prioritize the suitable solution ideas and pursue the most effective ones.

3.7. Implementation

The implementation occurs independently according to the organizational and content-related boundary conditions. For example this step can consist of a simple change in a drawing, parts list or process instruction or begin with the planning of experiments for a feasibility analysis where further progress can be very different.

According to the extent, attention has to be paid to a continuous controlling of the implementation and target reaching.

4. The achieved results in the companies

We applied the shown methodical approach in the individual development projects. Individual deviations are caused by the chronological development of the procedure.

4.1. Hans Huber AG

One of the projects with the company Huber is the further development of a screw press to dewater sewage sludge [Figure 3]. With the IPP approach we identified as the promising environmental and economical potentials:

- Reduce chemical consumption
- Reduce energy consumption
- Increase dewatering performance
- Reduce disposable sludge
- Reduce wear

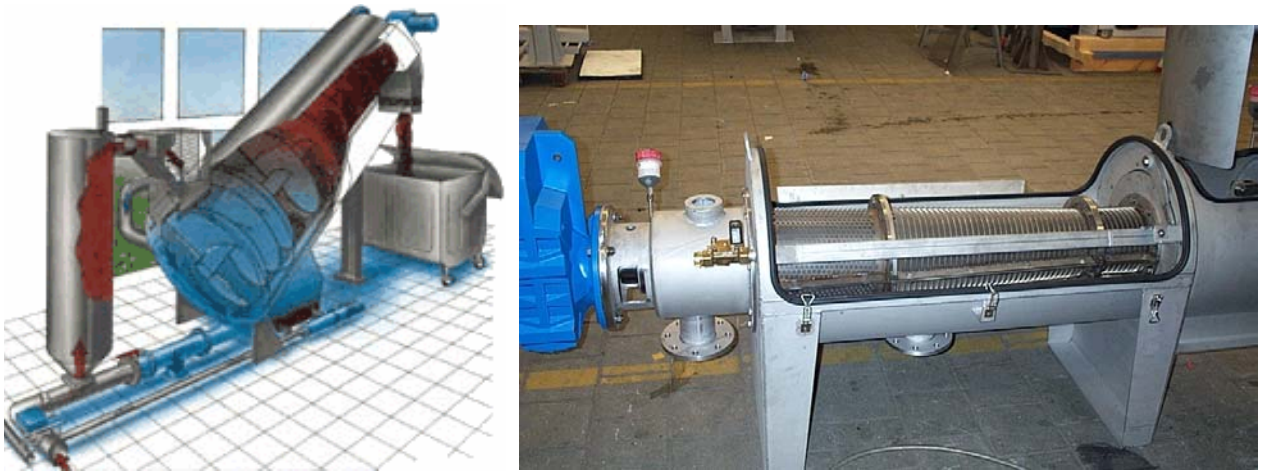

Figure 3: View of the old machine (left) and the new developed one (right)

Numerous improvements led to a basically new design concept for the screw press. The efficiency increased in many aspects:

- 35% less material combined with cost savings of 3.000 €
- 25% less use of flocculants with savings of 35.000 € during the product life
- 25% less sludge volume to be disposed combined with about 7.500 litre of petrol for transportation

- Reduced need of wearing part, for example the cleaning brush by 50%

4.2. Krones AG

The project with the company Krones AG a new washer has been developed which chemically and mechanically cleans PET-flakes [Figure 4]. Particularly the glues of bottle labels have to be sufficiently removed in order to enable a PET-recycling for new beverage bottles.

- Reduction of parts
- Reduce material usage
- Reduce energy consumption
- Enable bottle to bottle recycling-process

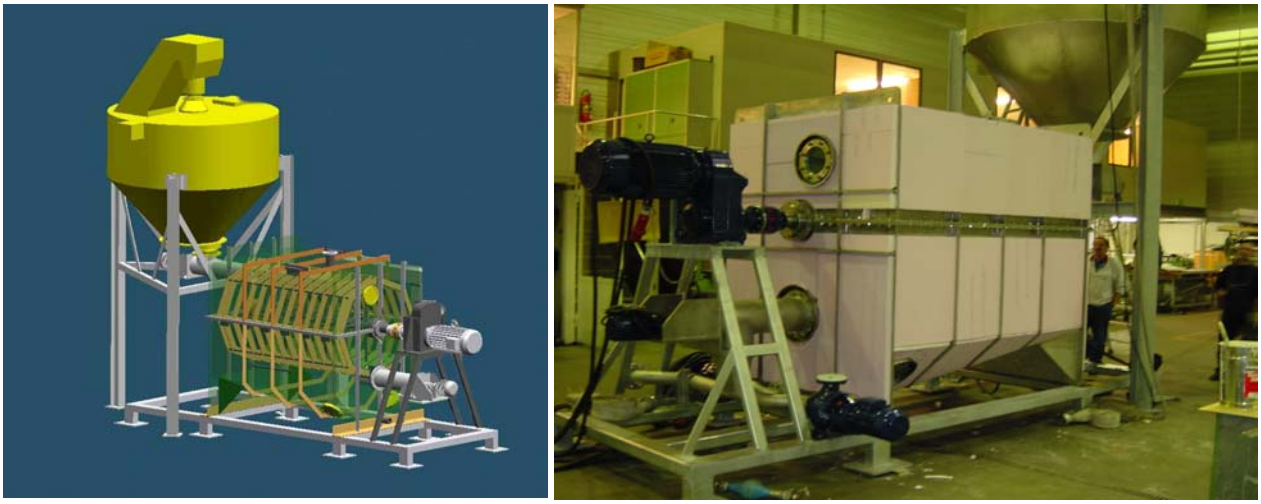

Figure 4: Design and production of a first PET-flake washer

Numerous ideas were introduced in the design in the new PET-flake washer. Many new innovations and solutions have been introduced in a redesign. First results are: a low number of different parts and a low variety of the used materials. The energy consumption of around 170 000 kWh/a could be avoided and the reliability could be increased be reducing failure possibilities. Currently the new design will be evaluated and it seems to show comparable results like the ones in the other companies.

4.3. Knorr-Bremse - Systems for railway vehicles GmbH

In the IPP-project the company Knorr-Bremse SfS GmbH developed a new innovative brake system for railway vehicles. With a new concept to define a new order of components to

functional units, essential advantages result for the operator, customer and manufacturer. The new exchangeability of the functional units significantly improves the availability of the railway and reduces the need of resources and life cycle costs.

The achieved efficiency-increase can be shown at two examples like the trestle and the control box [Figure 5].

Figure 5: Example of improved modules like the trestle and the control box

By the design of the trestle for the function units the number of parts could be reduced by 80% and the weight by 35%. Also the new costs are around 35% of the initial design. By the design of the control box 90% of the parts and 20% of the weight was reduced. The final costs have been reduced to 40%.

5. Conclusion

The shown methodical approach proved to be very effective in our project with good results for the environment and economic benefit. By the use of pragmatic methods and tools more optimal products can be designed.

Also the IPP strategy supports the communication and integration among different departments within the enterprise as well as with external subcontractors and customers. As one of the partners discovered the benefit to use the ISO 9001 bringing benefits in the short run as well as on the long-term.

References

[1] European commission: "Green paper on Integrated Product Policy". The study can be downloaded form the Commission IPP website (http://www.europa.eu.int/comm/enironment/ipp/home.htm)

[2] European commission: „General information about Integrated Product Policy". The information can be downloaded form the Commission IPP website (http://www.europa.eu.int/comm/enironment/ipp/home.htm)

[3] Lindemann, U.; Hutterer, P.; Hessling, T. Mörtl, M.: „Methods for environmental sustainable development based on experience with companies". In Recovery, Recycling, Re-integration, 6th World Congress on Integrated Resources management

[4] BIRKHOFER, H.; SPATH, D.; WINZER, P; MÜLLER, D.: Umweltgerechte Produktentwicklung – Ein Leitfaden für Entwicklung und Konstruktion. DIN Deutsches Institut für Normung e.V. (Hrsg.). Berlin: Beuth 2000

[5] WIMMER, W.: ECODESIGN Online: The New Internet Tool for Environmentally Conscious Product Design. In: Titsworth, F.; Jacobs, A.; Werner, B.; IEEE (Eds.): 2nd In-tern. Symposium on Environmentally Conscious Design and Inverse Manufacturing (EcoDesign 2001), Tokyo (Japan), 11.-15.12.2001. USA: Printing House 2001, pp. 240-243.

[6] Lindemann, U.; Mörtl, M.; Heßling, T.; Hutterer, P.: The Guideline "Design for Upgrading" as a Medium for Sustainable DESIGN. In: 7 International Design Conference - DESIGN 2002, Dubrovnik(Croatia), 14. – 17.05.2002. Zagreb: Sveucilisna tiskara 2002, S. 1331-1338.

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