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HOW INDUSTRIAL DESIGN INTERACTS WITH TECHNOLOGY – A CASE STUDY ON DESIGN OF A STONE CRUSHER

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1. Introduction

Industrial design (ID) is perhaps better known from the field of consumer products. Currently, ID is also entering the field of mechanical engineering in process and metal industries. Metso Corporation, the company under the focus of this study, produces process industry machinery and systems and has utilized industrial design for more than 30 years. Metso has outlined ID as one of its strategic assets and across its subsidiaries there are several successful examples of the use of ID.
The key statement of this article is that the benefits of ID are not automatically realized after well-informed strategic decisions and resource management. Processes and formal structures are not enough since each project needs to succeed also on the level of most ordinary interactions. Efficient project practices are needed before ID can become a strategic asset.
The purpose of this paper is to outline critical settings and situations that should be taken into account when ID is introduced to engineering oriented product development. It is based in a case study on a design project organized at a subsidiary of Metso Corporation. It describes the work between the company and an external ID consultant; how the project proceeded and how designs were discussed and evaluated. My purpose is not to evaluate the designs or success of the project, but to dissect the working methods in one product development project – keeping in mind the strategic position and history of ID within Metso.
Also, I do not intend to generalize my findings. Instead, this study remains localized and true to the principles of *action research* [Stringer 1999: 6-7, 167-168]. I will describe some aspects of the social life that existed for one particular team - and leave it for the practitioners in design to discuss how well the case represents first encounters with ID in general.
Meetings are inherently social situations. Thus, there is always the possibility for the objectives to break down at the level of mundane interactions [Boden 1994; Koskinen 2000]. However, more important than the success of one project, is whether as a result of such project the working practices of the team develop for the benefit of future projects.

2. Data

This study is based on videotaped project meetings of a design team at Metso Minerals (hereafter MM). MM produces stone crushers for wide range of applications including quarries, road construction sites and recycling of demolition debris, i.e. concrete, bricks and asphalt.
The purpose of the project was to design a new stone crusher. At the launch of the project, MM had no internal industrial designer and an external design consultant was commissioned into the project. Although MM had engaged an industrial designer a in smaller project few years earlier, for this team

this project was their first experience with ID. In addition to the design consultant, the design manager of Metso Corporation, another industrial designer, participated the design meetings.

Figure 1. The stone crusher

Obviously, design meetings in the beginning of the project were somewhat different to the later ones, when the key features of the design were fixed. In this paper I focus on the meetings in the beginning of the project, because I believe they make a prototypical example of initial contact between industrial designer(s) and engineers in a technology intensive context.

At launch, the project was given several ambitious goals. (1) The industrial designers wanted to raise not only the quality of the product, but re-organize the work. They made a clear distinction between re-design and design. In the re-design key properties of the product are defined and the looks of the product is improved by superficial means. In real design the functional key principles are outlined first and details are not touched until there is a clear design vision of the product [Lawson 1997]. It was agreed that this project would not be a mere facelift. (2) The project was a design pilot; it should serve as an encouraging example of utilization of industrial design at MM. At Metso, pilot projects are instruments for disseminating knowledge across subsidiaries. (3) The ID working group of Metso communicated that the project should not focus on current problems only but also create a future vision of the project. (4) The outcome of the project would be not only a concept, but also a real working product that going into production at a given date. (5) The manufacturing costs of the stone crusher should be reduced. At minimum, a better looking and better functioning product should be built with the same amount of money. This would be achieved by reducing the number of parts and each performing more tasks than before. The approach had proven successful in e.g. in paper machinery designs within Metso Paper.

The project started with a meeting between the consultant, project manager and engineering manager. In this meeting the product and aims of the project were roughly introduced to the consultant. Based on the meeting, the consultant wrote a memo that also performed as an initial design brief for himself.

Because the product is quite complex, during the briefing it was split into functional subcomponents. These included for example the engine module, frame, crusher, working platforms etc. Some of the subcomponents were designated to other projects and the consultant only received the external dimensions of the components that he should accommodate.

3. The structure of the design meetings

The first meetings after the design brief were very similar. The consultant had created some designs at his office and he presented them to the team. There was a three-part structure to the meetings.

First, the consultant presented the key features of his designs with illustrations and animations. Others mainly listened and asked only short specifying questions. At each meeting, the consultant usually had more than one design to present. Instead of showing details of designs, he displayed illustrations of complete stone crushers. Quite often, he used animations to illustrate how some of the moving parts function, e.g. how doors and shields open.

Second, the team discussed the details of the designs, pros and cons of some of the solutions. After the concept introduction, the conversation started from this entity towards particular features or details of the design. In these conversations, some of the design solutions were identified as developable while others impossible to carry out. The team evaluated mostly single, concrete components. The value of the crusher concept as a whole was seldom addressed, except when some clearly visible feature labeled the whole design.

Third, the conversation was summarized and the consultant was given a new brief. Again, the brief was mostly built by the consultant who revised what had been discussed and turned this into a brief, that was either as such or with some adjustments approved by the team.

At the end of the meeting a time for the next meeting was agreed. The average time between the meetings was 20 days. Immediately after the meeting the consultant wrote a memo with special emphasis on the brief, and emailed the memo to the team. As a result of the design meeting, the concepts were split into pieces, and the developable ideas were sorted out. The consultant then combined this set of ideas into new designs for the next meeting. The most concrete outcome of the meeting was the new design brief based on the evaluating conversation by the team. The updated brief was prospective in nature, listing the conclusions but not the reasoning behind the design decisions. Although the meetings were labeled as industrial design meetings, most of the time the team handled issues related to the expertise of the participating engineers. Perhaps this is typical to this type of industry. If so, how is the ID approach visible in the details of the actual work?

3.1 The opening statement

The ID approach was most visible in the opening statement of the ID consultant. The opening statement brought the overall tone to the meetings [Boden 1994]. Due to confidentiality issues, I have omitted those parts of the transcriptions that describe design ideas.

Example 1 (C=consultant)

C well, we are mow in the phase that we have received a message from the big guys at the headquarters that we should raise the profile of the design. And I'm sorry I have perhaps approached this too engineer-like and too seriously. That there is not enough the spirit of (- - -). But I am happy we are aiming for features like this (- - -) and (- - -). The ideas in this ((animation)) are about the (- - -) ((feature))

The opening statement begins with review of the current status of the project, including the received feedback from the previous meeting and suggestions from the ID working group of Metso Corporation. This leads the team into examining the key features of the current design.

3.2 Design as a topic in conversation

After the opening statement, design as such was hardly ever raised as a topic of conversation. The fact that it was a design meeting became visible through negative cases, when it was clearly stated that this particular issue was *not* about design. This was achieved e.g. by framing part of the conversation as *non-design*. In the following example the project manager opens a ten minute long conversation on the screening system at the feeding end.

Example 2 (PM=product manager, P=project manager)

01	PM	could we check the- those issues so- I have to leave soon
02	P	yes- we have this type of technical problem here-
03		first, we have the ((walks to the flip board))
04		((conversation on the screening system, 10 minutes omitted))
05	P	I don't have any more open issues but I guess related to design we
06		have lot's of interesting questions

In the example above, product manager (PM) is about to leave the meeting. Earlier he had discussed the screening system issue with project manager (P), with whom they now suggest this as a topic for conversation (lines 1-3). P marks the topic as a technical issue (line 2) and during the following ten minutes the designers do not participate in the conversation. When the screening system problem is finished with, P turns the focus back to design (lines 5-6).

Design questions were mostly handled in between technical issues. The symbiosis of ID and technology was observable in attempts made to talk about design alone. For example, on occasion the engineering manager, asked the participants for purely esthetic or general assessments about the design. Questions that were too abstract were typically followed first by a very long silence that escaped only through a technical or more detailed viewpoint. For example: ”the one with the groove on the side might be good if these stairs are moved to the front”. Or: ”this could work also in the 320-series crusher”. Design talk was notably difficult in the beginning of the project although later some engineers encouraged themselves to talk about even purely aesthetic issues. Learning was a two-way process. According to the design manager industrial designers, internals and externals, learn the constraints and possibilities of the technology in conversations within similar projects all across Metso. He clearly prefers this learning by doing approach. It is not only that individual projects meet their deliverables, but that the engineers learn to utilize ID in their future work, while designers acquaint themselves with the technology.

3.3 Design inspiring topics

As mentioned above, for the engineers of the team the project was their first contact with industrial design. Perhaps that is why, instead of opening new possibilities for design, the conversation often focused on the aspects of the current design under evaluation. In short, the consultant visualizes his ideas and the engineers evaluate the details of the designs within a freely flowing conversation.

Example 3 (C=consultant, E=engineer, PM=product manager)

01	C	I have some transparencies here, should we take a look
02		((E puts transparencies on the projector))
03	PM	its upside down
04		((E flips the transparencies))
05		(8.0)
06	PM	it was better upside down
07		(laughter)
08		(26.0)
09	PM	what material are the (1.0) shields made of

In the example above, the design consultant has just finished his opening presentation and the conversation has not really started. After the consultant places the transparencies on the projector, the whole design is under evaluation only for a while – in deep silence (lines 5 and 8). After the silence, the conversation begins on the material of the shields. There was nothing especially new about the shields and the conversation could have started on any feature of the design. After the shields discussion, a new topic is found. Again, what is to be selected after any topic is based on at least two resources: the visual representation of the design and whatever was said about the previous part under evaluation.

Design inspired a series of conversations on technological matters. Although e.g. market and end-user information was often referred to, documents or other material from these areas was only seldom presented. While the freely flowing conversation generates ideas to some problems, it is possible that the conceptual and systemic aspects of the design are neglected. If so, an essential part of the substance ID is supposed bring in is at risk of getting lost in the details. The product, the stone crusher, and its applications are so complex that for any given part of the design, it is possible to raise a nearly infinite number of constraints and criteria for evaluation.

3.4 Design summarizing topics

After a discussion on a topic, the ID consultant often summarized the conversation into a preliminary design idea. In the example below, there has just been a lengthy conversation on the side conveyor, about its structure, transportation and whether it should be left- or right-handed.
Example 4 (C=consultant, E=construction engineer, PM=product manager)

10		(5.0)
11	C	so am I getting this right, there is a short belt as wide as the frame
12		that unloads to either side and from there the material goes-
13	E	no that is part of the conveyor
14	C	but could it be like that? then we could put the conveyor to either side
15		(- - -)
16	PM	the potential problem is where (- - -)
17		it is not impossible

The consultant starts his wrap up with a specifying question (lines 2-3), followed by a design idea for the structure of the side conveyor (line 5). The idea is described as possible to implement, on condition that some details can be solved (lines 7-8). After the conveyor issue the conversation moves on to the next topic. The consultant summarizes the side conveyor issue into his memo as follows:

- Side conveyor, 6m long, unloads 50/50 right/left, must fit in the transportation, width?

As mentioned above, the memo was mostly a to-do list for the consultant himself. Although the memo was emailed to the group, the other members hardly ever corrected or commented on the memo in any way. The memo was reacted to only when it contained some direct questions.
In sum, the design consultant summarized the conversation in three ways. First, as presented above, he summarized some of the topics already in the meeting. Second, in the memo, he listed some of the issues treated in the conversations. The third, and perhaps most important tool were the static and animated visual representations.

4. Virtual models and visualizations in the design meetings

The ID meetings were structured around illustrations, virtual models and animations and only seldom by agendas or other documents [see: Koskinen 2000]. In product development, as noted by Kathryn Henderson [1998], models and illustrations enable the integration and development of the perspectives of the individual participants. With images, professional skills and expertise can also be manifested [Ochs et al. 1994]. During the meetings not only the designers but other participants also copied the presented illustrations and sketched new ideas into their notebooks. Images make useful and natural documents of the handled issues and they are the bases for evaluation of design ideas. Despite of all the advantages, images have also their downsides.
In technology intensive industries one key aim for industrial design is to locate and create connections across dispersed and large entities. An industrial designer may have to be aware of a large set of constraints across the lifecycle of the product [Gotzsch 1999]. Despite the holistic approach ID seems to have authority over aesthetic aspects only. Authority over the visual appearance of products is quite problematic. It covers everything that companies produce, but nothing that could be explicitly defined beforehand. Whenever the designer concretizes the looks of the product, he is bound to drift into an area that is not his expertise. Since visualizations are inherently open-ended, it is impossible to predict whose realm he is about to enter – and how do those who claim its authority perceive this entry. Both the strength and weakness of industrial design lies in visualizations. Images can be used to present far-reaching concepts of how things could be in the future. Sometimes visual scenarios develop into self-fulfilling prophecies that shape the future of the organization [Henderson 1998]. However, visualizations rarely weigh as evidence and are a nearly infinite source of critique and reservations.

5. Interaction and the nature of design problems

Normatively thinking, activities should be evaluated against their pre-defined objectives. This case had five goals: thorough and appropriate process for working, successful and encouraging design pilot, future-oriented vision, functioning new stone crusher, and reduced production costs. Whereas the first three goals are open to various interpretations, functionality and production costs would come into view very concretely, and possibly carry more weight.

How are individual design proposals evaluated in practice? ID literature proposes that design work should be steered by specifications from early on [Ulrich & Eppinger 1995]. In the beginning of the project the designer should be given *all the relevant information* about the product. However, too much information may block fresh ideas. The balance is critical since the need for original, never-thought-of ideas is one of the key reasons for externalizing design [Kristensen & Lojacono 2002].

What is relevant and what is not? In the case MM, the consultant was expected to create new ideas for the frame of the crusher. In the second meeting he suggested a design where the straight diagonal beam of the frame at the feeding end of the crusher was replaced with an arc shaped construction.

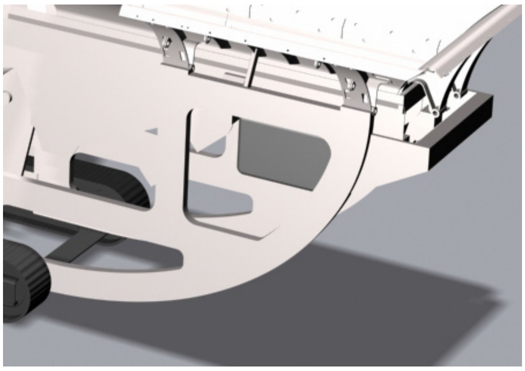

Figure 2. Detail of the frame design

In the meeting the proposal was criticized from multiple angles. The product manager said the arc gets in the way of backing up the crusher close to the gravel heap. The construction engineer suspected that the bottom end of the arc is structurally weak. The project manager pointed out that the solution would not allow alternative transportation on trucks.

Example 6 (DM=design manager, C=consultant, EM=engineering manager, e=engineer)

18	DM	it’s a bit troubling that these surprises keep popping up
19	C	yea, and then the designer feels really stupid
20	DM	wasn’t I stupid ’cause everybody else knew and I didn’t.
21		it's a really slow way to proceed that you do a proposal after
22		which the group says that its ok but its not ok
23	EM	its kinda- we don’t really have a complete description what you can do
24		with the machine and how it works (- - -)
25	E	we also like you don’t notice all the constraints you have to take into
26		account and then someone remembers that this also must fit in (- - -)

Lack of information can not be completely removed by providing more information. First, giving *all relevant information* might block fresh ideas. Second, design question or problem is often found only after a proposal is made [Rittel & Webber 1984]. There was no problem with the detachable trucks until the consultant suggested a design that was internally logical yet in conflict with a use situation unknown to him. It is not only that an exhaustive description of what the product does might be hard to accomplish (lines 6-9). In addition, it is impossible to put together a list of all functional properties of all possible future designs of the product. Thus, some of the constraints of design are found only by designing and evaluative criteria can not be completely listed in the beginning of the project.

But surely there must be something to base the design evaluation on? In the stone crusher project, the key source of criteria was the previous version of the same product. Thought I have no evidence to base generalizations on, it would be tempting to claim that this pattern is very common in design.

The previous version is not a straightforward measuring stick against which candidate designs are evaluated. Instead, just like the new design, the old one is an equally indexical resource for interconnected sets of topics in the conversation. When benchmarked against the old version, the new design is defendant in many respects. Take for example functionality and production costs. While MM is already a market leader in stone crushers, there is no evidence that the new version works. Also, production lines are adjusted to the current product and changes will cost something.

The new design had to defend its existence, which oftentimes accelerated the pull towards technical details. Repeatedly, a proposed design was rejected because it was in conflict with external dimensions of some component in the current design. Seeking alternative solutions to this component or module was not always possible. Some of the components were fixed because they were passed to subcontractors, some for no particular reason, and some key components were not to be touched because they were commissioned to another project. In one meeting the design team could not fit protective shields inside the maximum dimensions for road transportation and they had to visit another team to bargain for 50 mm more space.

In many ways design work in technological context is like putting together a puzzle. The designer is to use a set of pieces to create an entity. Alas, just like in a puzzle the best fit is achieved by putting the pieces exactly as they were before. Therefore, the worthy input of the consultant was at the end directed mostly to areas outside the key components of the crusher, e.g. to shields and parts that open outside the transportation width. This was not due to great design potentials in these areas, but because these areas were available since no one else operated there.

6. Implications to the organization of industrial design projects

Studying human interaction is a topic of analysis in its own right. In this article I have shown how we can locate structures in apparently coincidental aspects of design work. I also suggest that companies utilizing ID should be concerned about not only appropriate organization and resource allocation, but also the caveats hidden in mundane interactions – as non-interesting as they first may seem.

What to take into account when starting ID activity in a technology intensive area? First, as design literature suggests, the process should be started early enough. It takes time for the designer to learn the technology just as it takes time for the engineers to familiarize themselves with design.

Second, the organizational position of the project is important. In case of the crusher, there were also other projects working on the same product. The responsibilities and decision-making power between projects was distributed in terms of the physical geometry. Thus, the design project had to tack in between and outside the frozen modules. Creating a product that is perceived as an entity instead of collection of independently designed items is especially difficult if most of the key areas of the product are frozen not only by geometric constrains but also by organizational division of labor.

Third, not all design projects are the same. For example, product concept design projects are quite different to projects customized to the needs of a particular client. A key question is can the project afford to fail. Concept creation is about forgetting old solutions, even at the risk of not achieving anything useful. This is seldom possible with client projects. There is no orthodoxy in product development, but perhaps not all types of expectations should be loaded on one project.

Fourth, you can not brief a designer hoping he will return with a solution after a month. Iteration is important especially in the beginning of the project. In the stone crusher project the consultant worked at his office collecting feedback in the meetings. The average time between the meetings was 20 days. At the same time, a parallel project had commissioned an engineering consultant who worked together with the rest of the team at the premises of MM. Similar arrangements would be most appropriate also for ID work. Instead of gathering the whole team to criticize impractical design ideas, they could be easily rejected within informal coffee-break conversations.

The fifth challenge relates to the visual tools. When an old version of the product is available as a 3D virtual model, it is tempting to start designing on top of that. However, this places preliminary and fragile design ideas parallel to current solutions, which encourages the participants to locate conflicts between the two – instead of seeking potentials in the new design. Imprecise representations, process instrument schemes, written documents and lists can help the participants to forget the current design for a while. Sixth, the meeting practices can be improved. A chairperson who is not personally involved in the project work can better steer the conversation away from the details. Also, the design team should be allowed to reorganize their work when necessary. In this paper I have touched on several items relating to the management of design projects: briefing, scheduling, power of decision, distribution of work, quality of feedback, pace of iteration etc. The people I observed were not blind, but most reflective to most of these items. Though in the project there was no slot for addressing the organizational issues, the team was able to recognize and at least discuss them, as they became relevant to their work.

7. Industrial design is a way of thinking

In the strategy of Metso Corporation industrial design is a way of thinking. It is not submitted to industrial designers alone. Appropriate and efficient product design is not a consequence of education or organizational titles. Indeed, there was some evidence that new ways of thinking emerged. In the project, in addition to the work of the consultant, the engineers re-designed parts of the frame by combining several features into one component. Consequently, also a new visual element was created. The new idea for a frame was inspired by a particular design meeting where the team had a lengthy conversation on this area of the crusher. Although the solution was not created in the meeting, the endless-looking conversation proved not altogether useless.

The consultant has similar experiences of other projects within Metso. He told how in a paper machine project a key design idea crystallized after similar conversations. He does not even remember who it was that first articulated the idea. In addition, after the project was successfully closed, the client developed the idea even further, merely informing the consultant about the progress.

According to the design manager, following successful ID pilots, some engineers don't want to work *without* industrial design anymore. At best, the ID approach sticks on like glue. Just like glue has no shape on its own, industrial design is molded by technology, organizational constrains and structures of social co-operation.

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