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AUTOMATIC CREATION OF A COMPANY MODEL USING FUNCTIONAL REQUIREMENTS

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Abstract: *Modeling a whole company and the production process as a set of functional requirements is relatively new approach. For companies with big manufacturing facilities and a large number of different workbenches this kind of representation is especially interesting. It allows to review and reorganize manufacturing process more easily and give alternatives to different workstations that may already exist in some other part of the production. To make the modeling easier STEP NC format is used to create a functional requirements model automatically*
Key words: *functional requirements, automatic model creation, STEP NC, default company model*

1. INTRODUCTION

There are different ways on how to model the production process and there are few methods that model the entire process, from the customers wishes to the recycling of the product. The research in recent years has been going in the direction of using functional requirements (FR) to model a production process in different fields and more widely. This kind of approach is especially needed if the model has many different aspects which are not comprehendible without some sort of visual representation. First FR models were used to determine what kind and, if at all, to use large scale manipulators in different stages of construction (Bathelt et al., 2010). FR models have also been used to help engineers with factory planning (Haas & Hsieh, 1994) and to develop new products as shown in this cases study concerning product packaging (Ten Klooster & Lutters, 2008). This papers goal is to show how a whole production process can be represented as a FR model using Requirements Management Planning (RMP) tool (developed in ETH Zurich by Inspire workgroup). This model shows that a complete model of a company can be made using FR and that the model can be created automatically to certain extent using STEP NC format. Further research is required on creating a more detailed model and looking into different kind of file formats that could be used to create the model automatically.

2. DEFAULT COMPANY MODEL USING RMP TOOL

By using RMP tool we can make a default company model that could be the basis for every company using FR. The basic structure and needs of the company are very similar even if the physical product or the size of the company are very different. This model can be represented in three different ways as described in (Sonk, 2010). This allows us to offer a default model of the company that the model maker has to customize and make it resemble the actual company and its production. This usually means adding new stakeholders and specifying the FR (the needs) of the customer, operator and especially product itself. In the future there can be more specific templates for different industries when there are more models but at the moment a very general model is proposed. Note: this model can also be used on non-physical products, for example: computer programs.

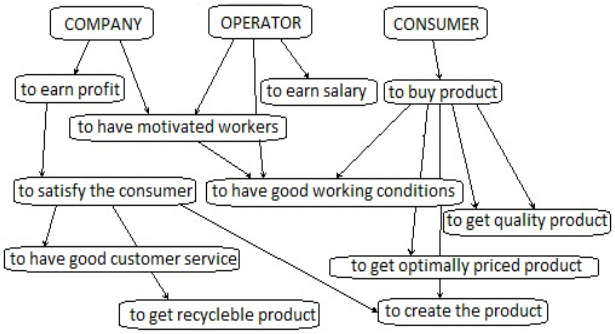

Fig. 1. Default company model using functional requirements

FR model starts with the customer. It's the first stakeholder and everything else derives from him/her. As you can see from Fig 1. we took an example from a laminated floor boards production company. The customer has the requirement of covering his/her floor. This has a sub-function "to buy the boards". And now we can define with other FR, what these floor boards should be like. Should they be made out of wood, should they have certain dimensions etc. These functional requirements also have properties where we can describe the exact type of wood or maximum length of the floor boards.

The companies' main goal is to earn profit and be sustainable in the long term run. Of course company wants motivated workers, loyal customers, bigger market share and produce good cost efficiently but all of these FR are there to serve "to earn profit". And how does a company earn its' profit? It satisfies the customer needs, which in this case is "to buy floor boards". Only now comes in the companies' desire to actually produce the boards. These boards have to have certain physical and esthetic properties that derive from the customer.

If it would be possible then company could produce as cheaply as possible. The result would be boards that will break in two weeks, wouldn't fit together etc., but if there are customers willing to pay for that kind of products then all the stakeholders in the model would be satisfied (which is the main goal). But because customer has standards about quality, company must make investments to guarantee the quality properties i.e. the quality functional requirement actually comes from the customer not from the company. The company is interested in the quality product not directly because it wants to make quality product, but as it wants to satisfy the customers' needs.

Next we add the stakeholder "operator" to the model because we need to physically manufacture the product. Interesting note: the operators' and the companies' basic FR are very similar: they both want to earn (profit/salary). In the operator's case we also have functional requirement "to have good working conditions" which reflects the motivational part of the model. Good working hours, interesting and non-

monotonous work, long vacation: all these things can be considered as the motivation and it is quite hard to measure. Difference between different workers also adds difficulty/complexity. But motivation should be sub-functions (secondary) to the "earn salary" because people are more willing to work without some of the good working conditions than people who are willing to work for free.

To earn the salary the operators must participate in the manufacturing of the product. Depending on the complexity of the model we may divide the operators into 5 main groups to make the model more transparent. Different operators for assembly, transport, storing, physical transformation and packaging makes it possible to see the specific FR that are connected to the transport system or what FR are needed for the physical transformation processes. Packaging process itself can be also remodeled using similar techniques that are used in (Ten Klooster & Lutters, 2008). And now we come to the actual production itself. Different sub-functions that are connected to the operators make up the physical domain of the production. All of the tolerances, machines and materials needed to make the product are added last to the model.

3. AUTOMATIC CREATION OF FUNCTIONAL REQUIREMENTS MODEL

To make the creation of the FR model easier, efficient and quicker some ideas and concepts are proposed on how an automatic creation of the FR model can be achieved. The idea is to have a semi-automatic model where the model maker can also put in his/hers engineering know-how. To create the model, we use the STEP NC file type (also known as AP238). It's a protocol that makes the machine code between CAM programs and CNC machines easier to read for humans. And by analyzing the data extracted from the file, we can find out the features that the product has. This in turn allows us to create a FR model automatically.

For example let's take a product that has a hole in it. When using STEP NC file, this feature is described as shown in Fig 2.

```
#239=ACTION_RESOURCE_TYPE('milling cutting tool');
#300=RESOURCE_PROPERTY_REPRESENTATION ('effective cutting diameter',
'user defined milling tool',#325,#275);
#328=MACHINING_TOOL('11','user defined milling tool',(#2054,#2055,#2056,
#2057,#2058,#240);
#339=INSTANCED_FEATURE('','toolpath', 'Plane tolerance feature',
'toolpath',#86910,.F.);
```

Fig. 2. Extract from a STEP NC file

This is just an outtake from a larger file of the command lines that are connected to the cutting of the hole. In this case the hole is made by milling machine. The person who made the STEP NC file has already defined the tool to be used and the tool paths for cutting. Also we have the tolerances for the milling and actually all of the information required for the physical creation of the hole. This in turn means that by recognizing certain features from the file we can automatically look for the entities connected with that process. For example we can automatically add CNC milling machine to the entities list in the FR model. We also can add the tool used in the process, space occupied by the machine, necessities for milling (power/coolant/chip removal), storage needed before and after the milling and also the transportation to and from the machine.

All of the above named entities are all physical in nature. By using just the STEP NC file we can make a FR model that consists of just the product, machines and tools. But we need to also add customer, company, operators etc. to the model. This can be done by combining the default FR model with the information from the STEP NC file. Each feature adds a new functional requirement with its' entities which in turn allows us to deduce the persons and sub functions that are connected to that process. The automatic creation of new functions has to be checked by an engineer because not all of the functions created may not be necessary or can be done in different way. For example, there is more than one way to create a hole. Instead of milling we could use drilling or water jet cutting. This is the place where the engineer can decide which kind of machine to use and what kind of machines already exist in the company.

One way to solve this dilemma is to prompt a window when a feature is recognized and the engineer can choose from different kind of machines. With a product that has hundreds of features this could be very time consuming and stressful so the feature identification should check if there aren't any entities that could do the job. For example if we have a CNC machine, we can perform drilling and milling in the same machine but with different tools. But this is part of further research in this field.

4. CONCLUSION

The paper demonstrates that FR can be successfully used to model a company and its' production. The model consists of all the parts of a products' production cycle starting from raw material and finishing with recycling. STEP NC (and in the future possible other file formats) can be used to create the FR model semi- of completely automatically. Further research planned in this area is in developing a feature identification for STEP NC files and using FR to describe machines. One of future goals is to make the FR model responsive in real time. This can be achieved by using real time monitoring proposed by (Aruväli et al., 2011).

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