Product Customization through Knowledge Based Engineering Tool

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ABSTRACT

There are many ways to grow business the success of equipment and manufacturing companies depends on their ability to produce high quality products at the lowest cost this applies to all industry verticals, manufacturers have a tough job competing in today's global environment, global competition, price sensitivity, time to market pressures, and increasing complexity all make it very difficult for manufacturers to be successful, that aims to create customize designs as per Engineer To Order (ETO) product, Knowledge based engineering (KBE) has become a practical method of visualizing manufacturing cost by design automation and enables you to achieve all of these and more by streamlining repetitive, time consuming tasks and leaving designers more time to focus on innovation, improving product quality, adding value, and winning more business.

Keywords*: Customize product, Design automation, ETO, KBE, Streamline repetitive task.*

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1. INTRODUCTION

Customized products and services is a great competitive differentiator, leading to more sales, higher revenues, increase in customer satisfaction but in other hand all these customize enquiry required special attention from design and hence designers are involved in handling enquiries and creating GA and supporting sales team to prepare quotation, results in less innovation in product design, Knowledge Based Engineering is a tool which captures knowledge from the product life cycle, these knowledge is stored in database and linked to the CAD system.

Traditionally, design solid modeling tools are primarily used to design and visualize the artifact as pert heir application needs later the 2d drafting is released as production drawings, CAM systems are conventionally used to program machining or cutting instructions on the CNC/ DNC machines sometimes prototype is created for complex geometry to check the form fit and function, CAE systems are used to check the reliability of the designed artifact (such as structural analysis for stress, thermal, FOS, etc.), this methods tells a designer what the final design looks like but how it has come to be with the help of CAE tools.

If changes are required in the design, a new CAD solid model is recreated using some type of computer-aided "re-do" or "back-tracking" methods or use of Product Data Management (PDM) backdated revision, these can be extremely time consuming and costly being that late in the life-cycle process, in such cases a geometry and size solid geometry, configuration changes cannot be handled easily, particularly when parts and dimensions are linked.

The power of a "knowledge capture" tool comes from the methods used in capturing the design intent initially so that the anticipated changes can be made easily and quickly later if needed by capturing "design intent" sometime custom software is created as per the need or automation need to speed up the operation. [1]

1.1 Traditional Process

Fig- 1 shows the current process from enquiry to installation and commissioning at customer end, once the enquiry come design engineer in coordination of sales prepare the GA and quotation and process for approval, if customer approves the GA and quotation then it is process for detail design, if customer reject then again rework is required after customer approves the detail design the machine is build or manufacture as per drawings, once machine is build the all the part are integrate together and performance testing is done as required based on this final installation and commissioning is done at customer location, blue dotted line highlight the process and time consumed from preparing GA and Detail design as per customer requirement is 5 to 10 days as per customization required. [2]

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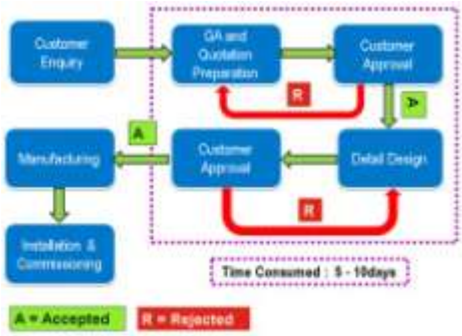

Fig-1: Traditional Process

1.2 Challenges in Traditional Approach

Many repetitive activities
Time consuming GA drawing preparation
Person dependent designs
Many product variations
Revision Control
Search & reuse of available data
Organization wide Collaboration

1.3 Challenges in Traditional Approach

To overcome challenges in traditional process the automation methodology is primary applies to reduce the mundane task includes, time consuming GA drawing preparation, technical quotation, bill of material, part numbering, cost sheet generation, designers are involved in many of these non-engineering activities results in delayed in manufacturing so it is always economical to avoid, reorder, refined or automate these task.

Design automation is a methodology to automate the various mundane task by identifying bottlenecks, brain storming with designers about the design process, productivity improvement parameters, define possible multiple approaches and documenting current and expected productivity improvement, It is also of interest to optimize the use of KBE for Small and Medium sized Enterprises (SMEs), it is expensive for SMEs to implement KBE-systems and therefore methodologies for KBE development have been proposed, hence to utilize the KBE methodology a generic template based application is used, these package based solution are cost effective for SMEs to enhance their productivity using KBE application.

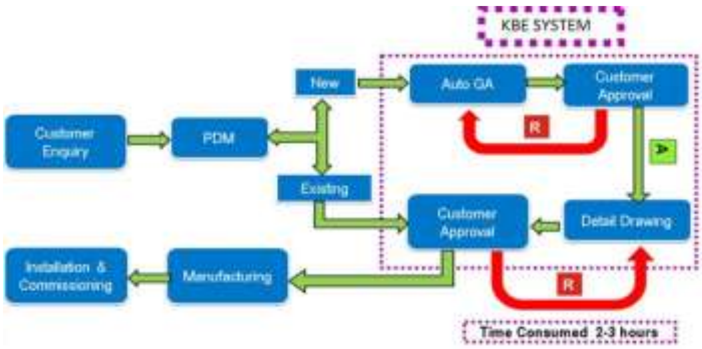

Fig-2: New Process with KBE

Fig- 2 shows the new process with KBE from enquiry to installation and commissioning at customer end, once the enquiry comes it is added to PDM system, use of PDM will faster the customer approval process if similar enquiry is already handle by an company and the same output of GA and quotation we can send for customer approval this faster the process and omit the entire design and development process even many cases designers are not involved for repetitive enquiry, PDM system enables organization secured and up-to-date drawings and quotation to customer after customer approves the detail design the machine is build or manufacture as per drawings, once machine is build

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the all the part are integrate together and performance testing is done as required based on this final installation and commissioning is done at customer location, blue dotted line highlight the process and time consumed from preparing GA and Detail design as per customer requirement is 2 to 3hours. [3][4]

2. NON PROGRAMIGLESS KBE SYSTEM

This includes configuration of the KBE application by mechanical engineering having good knowledge of its own domain skill and end user interface is used by non-technical person. Configurator is used by a design engineer called as champion user and creator is used by sales or marketing or draft person. Creator user need to select the master product class, define the enquiry details and generate the manufacturing or general arrangement drawings, CADECWORKS is a KBE (Knowledge-Based Engineering) tool specially developed for equipment manufacturers and is based on parametric 3-D CAD technology.

It is programming-less and any mechanical engineer can create and maintain his / her own rules and applications. The created applications can be deployed for web-based configuration, ERP-integrated configuration as well as In-house manufacturing drawings creation, CADECWorks Bundle consists of three modules – Configurator, Drawing Configurator & Creator. [5][6]

2.1 Configurator

Configurator allows the champion user (Product designer or expert) to create design calculation rules to manipulate the master model.

2.2 Drawing Configurator

Drawing Configurator allows the user to link master drawing formats to existing configured product class. Also user can set configuration for master drawings such as, View Positioning, View Scale and inserting Centre Mark, Centreline, Note for selected edge.

2.3 Creator

Once the product class is defined (master models, design logic & model linking), it can be used by end user (novice or non-technical user) to create product instances. The generic user interface to use services of any product class is called Creator. It allows the user to select shape & size variations and get output in 3D or 2D format,Input specification form will change based on the product class chosen. End user can specify various shape and size inputs and get modified product geometry. [5][6]

3. TOOL IMPLEMENTED

It is the life cycle of KBE divided in various steps as following,

3.1 Product Definition

Decide on the product class and its variations to be automated. Every instance of a product class has its requirements such as the purpose, size, shape, weight, cost, and so on. Jot down these requirements before you start configuring the product class, review existing information. Check to see what designs and standard components exist so that you can use them in your assembly design, plan your assembly structure on paper or on a computer file (MS word or MS excel) first. Try and keep these requirements in a file at a shared location, if you are working with other engineers. [5] [6]

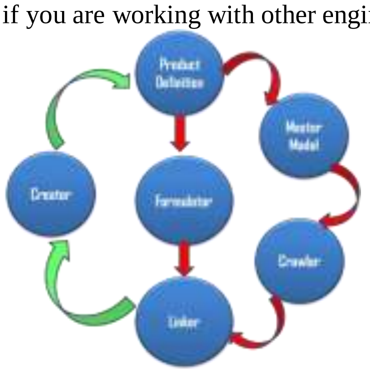

Fig-3: Tool Implemented in CADEC

3.2 Formulator

Size Variables decides the physical dimensions, proportions, magnitude or extent of a component or part. Size variables are the dimensions related to every part or assembly. Thus, the Size Variable Values are fixed numerical, formulae, expressions, or functions.

3.3 Master Model

Master model is a class of variation where all 3D CAD model is created through parametric modelling technology and object with different instances can generate as per requirements.

3.4 Crawler

CADEC Works captures the model tree information of Components, Features, Parameters and stores in relational database. To crawl the assembly means capturing and saving the product class details in configurator, the crawler function reads the assembly and captures or saves the details in Configurator. The details captured are part name, sub-assembly name, part feature name and dimension name as well as mates and mate dimension, the crawled details of the Solid Works master model then can be linked to the Product Class defined in Configurator to create several instances of the master model [6]

3.5 Linker

Configurator can store and manage the product class variations and you can get the drawings or designs of the respective variations created in 3D CAD in minutes instead of hours. For this, the assembly parts and features of 3-D CAD should to be linked with the variables and values of the product class in Configurator

3.6 Creator

It is end user application where technical or non-technical user specify the input and get output in terms of model, drawings and quotation. [6]

4. REQUIREMENT DEFINITION

It covers all the information relates with product includes various, geometry variation, size variable, design logic and calculation, output formats.

4.1 Geometry Variation

Geometry variation are related with shape variation, where subassemblies, parts, features are suppress/ unsuppressed as per the requirements, typical geometric variation includes conveyor type as belt conveyor / roller conveyor, cooling tray arrangement, drive mechanism, foundation details.

4.2 Size Input

User will specify the size input includes, Width of conveyor, Conveyor Height, Roller Details, Customer specification

4.3 Design Rules and Logic

All the detail calculation is included in variable table; this includes the analytical, logical, and mechanical or thumb rules, or product knowledge in above format. In traditional approach all the calculation has been done in excel table and for every change in design designer needs to recalculate the required dimension as needed. We are providing all the design calculation to KBE system so for every change in enquiry all the calculation happens automatically

ID	Name	Value
1	Roller Width	40
2	Conveyor Length	(No of Roller*Roller Pitch)
3	Shaft Length	Width W+115
4	Shaft Hole Dist	(0.5*Width W)+76
5	RL Middle	Roller Dist C-Roller Width
6	RL End	((Width W*0.5)-(((10.84+Roller Width)+(RL Middle*0.5))))
7	Tie Rod Start Dist	220
8	No of Tie Rod	If(Conveyor Length>1500,3,2)
9	Pitch Bet Tie Rod	(Conveyor Length-(2*Tie Rod Start Dist))/(No of Tie Rod-1)
10	Tie Rod Length	Width W-16
11	Leg Height	Height H-(117+(Roller Dia*0.5))
12	Top Plate L	Width W+80
13	Leg Width	Width W+240
14	SQ Inside L	Width W+110
15	No of Legs	If(Conveyor Length>2000,3,2)
16	Pitch Bet Two Legs	(Conveyor Length-(2*130))/(No of Legs-1)
17	Drive Posi Mate Dist	(Drive Position SQ-1)*Roller Pitch+(0.5*Roller Pitch)
18	Conveyor Length1	Conveyor Length-137.5
19	Half Roller Pitch	Roller Pitch*0.5

Table-1: Variable Table

Index	Parametric Equation	Parametric Value
1	LegH@Sketch1 @Conveyor Leg.Part	Leg Height
2	LegW@Sketch1 @Conveyor Leg.Part	Leg Width
3	W_80@Sketch1@Conv Leg Plate.Part	Top Plate L
4	Shaft Length@HexBoss-Extrude1@Shaft.Part	Shaft Length
5	Sleeve Length Inside End@Sketch1 @Sleeve-1.Part	RL End
6	Roller center L@Sketch1@Sleeve Center.Part	RL Middle
7	EXTRUDE L@Plane4@Extrusion Rework.Part	Act Conveyor Length
8	D1@LPattern1 @Extrusion Rework.Part	Roller Assembly Pitch
9	D1 @LPattern1 @Extrusion Rework.Part	Act No Of Roller
10	ROD L Inside@Base-Flange1 @Tie Rod.Part	Tie Rod Length
11	Pitch@Leg LPattern1 @Conveyor.SLDASM	Pitch Bet Two Legs
12	No@Leg LPattern1@Conveyor.SLDASM	No of Legs
13	Pitch@Tie Rod LPattern2@Conveyor.SLDASM	Pitch Bet Tie Rod
14	D1 @Boss-Extrude1@Extrusion Rework.Part	Act Conveyor Length
15	TRAY LENGTH@Boss-Extrude1 @Cable Cover.Part	Act Conveyor Length
16	D1 @Sketch8 @Extrusion Rework.Part	Roller Assembly Pitch
17	D1 @Sketch9 @Cable Cover.Part	Roller Assembly Pitch
18	RP@Distance6@Conveyor.SLDASM	Drive Posi Mate Dist
19	Drive Pos@Distance4 @Conveyor.SLDASM	Sprocket Distance
20	RP@Sketch1 @Chain.Part	Roller Assembly Pitch
21	CD@Sketch1 @Belt-1@Conveyor.SLDASM	Conveyor CD
22	Belt Width@Extrude-Thin1 @Belt-1@Conveyor.SLDASM	Width W-100

Table-2: Parametric Equation

4.4 Parametric Linking

Both KBE system and SolidWorks are independent software, as all the details of 3D model (Dimension Variable) are captured in the form of (D1@Sketch) in KBE system called as parameter, further we have link those parameter with the variable defined in variable table, once the linking is done any change in enquiry details, user will change the inputs and respective link dimension parameter will modify as per requirements.

5. DEFINE PRODUCT CLASS

To configure any product class you must have to open that product class manually or from product class.

To start new configuration, click 'Class', select master model (Assembly Or Part) and click 'OK'. It will ask for database creation for selected product class click 'Yes' to create new one.

5.1 Crawler

Crawls into assembly, sub-assembly, parts and captures parts, their features and feature dimensions. The details captured by Crawler are as follows – Part name, sub-assembly, part or assembly's feature and dimension name.

5.2 Lock Components

Locking of part(s) is applicable only for assembly configurator. Locking of part(s) is used when geometry change of some components (parts/sub-assemblies) is not required. (Accessories e.g. Nut, bolts, Bought out items) Procedure to lock parts/subassemblies: Click 'Crawl', a 'Lock Components' window will appear in property manager page which shows list of parts and subassemblies. Check parts or subassemblies to lock them. [6]

Fig- 4: Lock Component

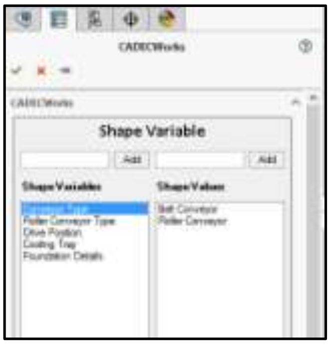

Fig-5: Shape Variation in CADEC

5.3 Shape Variations

Shape Variables are independent shape geometry classification possible in the product, Shape Values are different options available for a particular shape variable, to define Shape Variable and Value enter the Shape Variable and value in the text field and Click Add, repeat the procedure for other shape variable and shape value, all the detail calculation is included in variable table; this includes the analytical, logical, and mechanical or thumb rules, or product knowledge in above format. In traditional approach all the calculation has been done in excel table and for every change in design designer needs to recalculate the required dimension as needed. We are providing all the design calculation to KBE system so for every change in enquiry all the calculation happens automatically.

5.4 Shape Linking

Shape linking is a method of linking shape values to suppress / unsuppressed subassemblies, parts and part-features. After crawling the master assembly, 'Components' palette will show part list in Assembly configurator and in part configurator it will show part name as master model. There are two steps to Linking shape values to master model.

5.5 Make Mandatory

Mandatory parts / features are compulsory geometries in the assembly or part. These are always unsuppressed. (The product may/may not have mandatory parts). To make a part mandatory: Right-click on the part, and Click on 'Make Mandatory'.

It is not necessary that all features of the mandatory component are mandatory. Select a mandatory component and tick its mandatory features in the Feature Tree.

Fig-6: Make Mandatory

Fig-7: Make Optional

5.6 Make Optional

Optional parts / features are unsuppressed based on shape variable and shape values chosen. To specify Optional components, you need to choose a shape value first, then choose the optional components one by one and right-click to add the component to 'Optional Components' palette. It is not necessary that all features of the optional component are optional for that shape value. You can select an optional component and tick its optional features in the Feature Tree. [6]

5.7 Variable Table

Variable table is a tool for size calculations where you can add variables in structured table format. You can use simple expressions, conditional expressions, logical expressions, functions for validations etc. Image below shows variable table, Define any variable by simply typing its name in the variable table in the Name column. If user starts to enter a variable name and if it starts with "s_" then CADEC gives you the list of all shape variables. The formula can be typed in the value cell or use equation editor for this. To add formula, select the 'Add' Radio button. You need to create equation LHS = RHS in the Equation Editor. You can add any variable to equation editor by clicking on its name in the variable table. [2][6]

5.8 Size Linking (Parameter Equations)

Create equation in equation editor by selecting a parameter (from crawler information) on Left Hand Side (L.H.S.) and a variable on Right Hand Side (R.H.S.) When equation editor is in 'Add' mode, you can add any

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parameter (from crawler info) or variable (from variable table) to equation editor by selecting it. The parameter equation gets added to parameter equations list by clicking Add button, parameter equations on RHS side can also contain variable expression, to delete any parametric equation, and you can Right-click on the equation and select Delete. [6]

6. DESIGN AUTOMATION OUTPUTS

User will browse this application from Creator and specifies the enquiry details as following,

6.1 Instance I-Roller Conveyor

End user need to fill the enquiry details as input for conveyor application to generate customized model and drawings

Fig-8: Size Input Screen

6.2 Model Geometry Output:- Instance I-Roller Conveyor

Once user click on "Modify" the model geometry is generated as per the enquiry details specified by user.

Fig- 9: Roller Conveyor:-ISO

6.3 Drawing Output:- Instance I-Roller Conveyor

Once user click on "Create" the drawing output is generated includes all GA and manufacturing drawings.

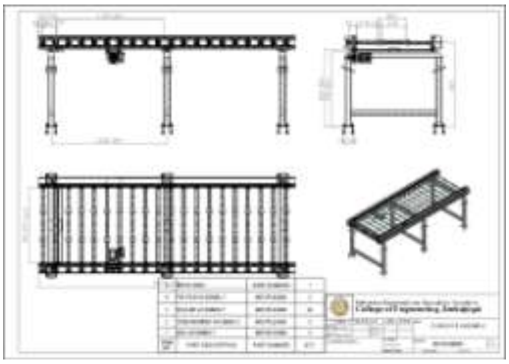

Fig- 10: GA Drawing

Fig- 11: Leg Fabrication Drawing

7. CONCLUSION

This research gives an idea about Knowledge Based Engineering (KBE) in product development. KBE can be seen as a tool for capturing knowledge and reusing it. This automated design tool helps in bridging the gap between design engineers and computational experts when analysing product development process. An automated design system has been developed as a case study for rectangular turret a component of transformer. The following conclusions can be drawn from this research regarding the design automation and KBE

- KBE is used in product development to automate mundane time demanding tasks.
- Design automation though KBE allows freedom to designer from above routine work so that more time could be used to come up with new innovative solutions.
- Automated Process of GA and Manufacturing drawing
- Reduction in Design time from 5-10 days to 2-3 hours.
- Completely Person independent

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