International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 07 Issue: 09 | Sep 2020 www.irjet.net p-ISSN: 2395-0072

Design Automation Way Forward for Industry 4.0 Case Study on Material Handling Equipments

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Abstract: *The success of equipment and manufacturing companies depends on their ability to produce high quality products at the lowest cost, Knowledge based engineering (KBE) has become a practical method of visualizing manufacturing cost and enabling product analysis by simulating product development activities in design for manufacturing support tools. The aim of project work is to discover how KBE approach which includes engineering design and similar knowledge intensive methods, can be used to improve productivity of design which helps to cater need to Industry 4.0 (Smart Factory) where computers and automation come together in an entirely new way in which cyber-physical systems monitor the physical processes of the factory, Robotics connected remotely to computer systems equipped with machine learning algorithms that can learn and control the machine. Smart Factory enables new market's needs and customization of products. Design/Engineering plays a vital role in growth, efficiency & profitability of Smart Factory. As technological innovation changes the approach of design, industry now focusing on parametric modelling and master model technique, where they can automate the design process which reduces the mundane task which results designers are involved in more innovation. In Material Handling system each machines vary with different geometry and size as per the customer layout, use of traditional design and manufacturing system requires more time to design, fabricate, inspect, hence use of KBE technology faster the entire process which leads to reduce the design time for many mundane task automated design are error free and we can produce high quality design at lower cost.*

***Key Words*: Knowledge base engineering (KBE), Design automation, Single slat conveyor, Double slat conveyor.**

1. INTRODUCTION

The economic success of manufacturing firms depends on their ability to identify the needs of customers and quickly create products that meet these needs and can be produced at low cost. This is applicable for manufacturers aiming at optimizing design activities for manufacturing. Traditionally, design solid modelling tools are primarily used for activities that occur at the end of the design process, such usage of solid modelling (CAD) tools. Studies have revealed that 75% of the eventual cost of a product is determined before any full-scale development or a CAD tool usage actually begins [1].Most conventional computer-aided solid modeling design tools are not really "capture" tools. The need for "change" after a solid model is initially "built," however, is all but inevitable. Often, design solid models are built from scratch only when engineering activity is complete, and are validated via a series of design reviews. In recent days, during a product design, development and delivery process, emphasis is often placed on the methods used for capturing the lifecycle intent with ease of modifications in mind. 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" as opposed to a "static solid geometry," configuration changes could be made and controlled more effectively using the power of the computer than through the traditional solid model or CAD attributes (such as line and surfaces). Automation methodologies applied primarily to manufacturing operations have proven that it is possible to achieve dramatic improvements in cost, quality, and time by focusing on process performance. Design automation provides industrial companies with a complete arsenal to attack waste, both in how the product is produced and in what product gets produced. To be cost competitive design automation benefits in reduction of 80% design time [3, 4]. Material handling equipment (MHE) is mechanical equipment used for the movement, storage, control and protection of materials, there are various equipment's are used in material movement, we are considering automation of conveyer system which is widely used in industry for shorter as well as long distance.Conveyor Systems are mechanical devices or assemblies that transport material with minimal effort. While there are many kinds of conveyor systems, they usually consist of a frame that supports either rollers, wheels, or a belt, upon which materials move from one place to another. They may be powered by a motor, by gravity, or manually.

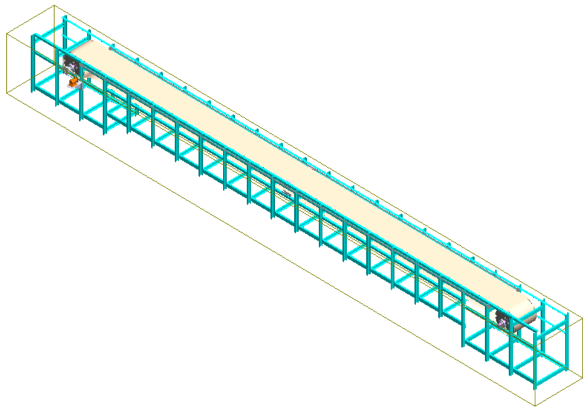

Figure - 1: Single Slat Conveyor

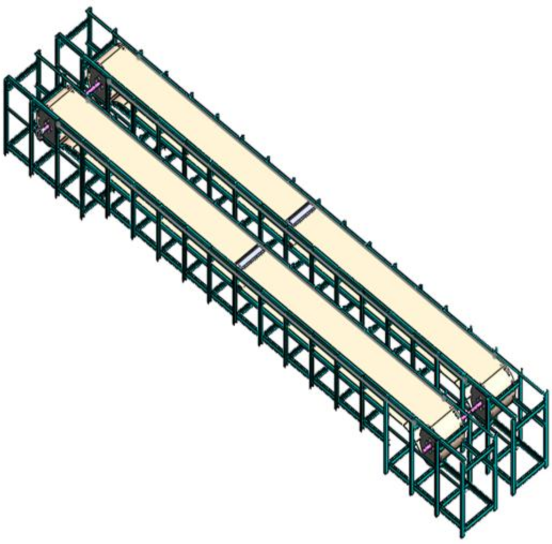

Figure - 2: Double Slat Conveyor

These material handling systems come in many different varieties to suit the different products or materials that need to be transported depend upon size and customer available space or layout. An important key about KBE systems is how to reduce the time to market by reducing different mundane task from enquiry to delivery. 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. These template based application enhance the designers productivity by automating various repetitive task and designers can focus on innovation and new product development, repetitive task are atomize and validate by senior design managers so moderate skill designers, operator, sales or marketing person can easily create the outputs in terms of Model, geometry, drawing outputs and quotation.

2. LITERATURE REVIEW

C.B Chapman et.al has discussed about to rethink the solution using knowledge based engineering. They discussed about the current limitations of Computer Aided Design (CAD) tools and report on the use KBE in the creation of a concept development tool, to organize information flow and as architecture for the effective implementation of rapid design solutions. They also discussed about the KBE tool along with supporting analytical solutions has been applied to the Body-In-White area of automotive design, the present methods of using CAD and Finite Element Analysis (FEA) systems do not use a unified product/ process model representation and lead to the creation of separate non-relation data models that only capture the result of the engineering process [1]. M. Pinfold et.al has discussed more detail about basic term of KBE as an engineering method that represents a merging of object oriented programming (OOP), Artificial Intelligence (AI) techniques and computer-aided design technologies, giving benefit to customized or variant design automation solutions. Wim J.C. Verhagen had discussed about KBE is a research field that studies methodologies and technologies for capture and re-use of product and process engineering knowledge. They also described about identification of research challenges. The objective of KBE is to reduce time and cost of product development, which is primarily achieved through automation of repetitive design tasks while capturing, retaining and re-using design knowledge. In the design domain, Knowledge-Based Engineering (KBE) technology has indeed been used to support mass customization KBE has its roots in the 1980s, when the application of Artificial Intelligence (AI) and Knowledge Engineering techniques in Computer Aided Design (CAD) became known as Knowledge-Based Engineering [6, 7, 8]. From literature review, Knowledge based engineering (KBE) has become a practical method of visualizing manufacturing cost and enabling product analysis by simulating product development activities in design. Use of KBE technology faster the entire process which leads to reduce the design time for many mundane task automated design are error free and we can produce high quality design at lower cost.

3. EXPERIMENTAL

The aim of this work is to discover how knowledge based engineering (KBE), an approach which includes engineering design, knowledge based engineering (KBE) and similar knowledge intensive methods, can be used to improve productivity of Material Handling industry in many repetitive activities such as, time consuming GA drawing preparation, Person dependent designs, Many product variations. Handling large assemblies in existing CAD tool is cumbersome, further advent of the SOLIDWORKS/ CADECPlus proved to revolutionize the way an organization looks at solving and automating repetitive engineering problems. 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 could be consumed from preparing GA and Detail design as per customer requirement is 2 to 3 hours.Software tool could be used: Solid WORKS and CADECWorks. Dassault Systems SOLIDWORKS Corp. offers complete 3D software tools that let you create, simulate, publish, and manage your data. SOLIDWORKS products are easy to learn and use and work together to help you design products better, faster, and more cost-effectively.

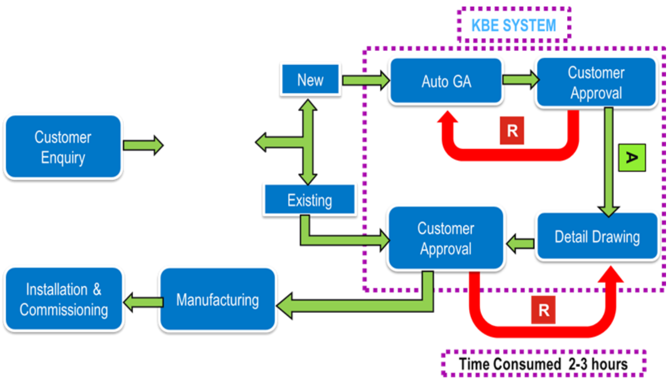

Figure - 3: New process with KBE

4. RDD AND CONFIGURATION OF CONVEYOR

4.1 Geometric Variation (Shape)

Geometry variation are related with shape variation, where subassemblies, parts, features are suppress/ unsuppressed as per the requirements.

Table - 1: Geometry / shape variation

Sprocket	Single
Sprocket	Double
Collant Tray	Yes
Collant Tray	No

4.2 Design Calculation and Rules

Table - 2: Design calculation and rules

ID	Name	Formula	Validation
1	'CC length of Conveyor'	'Work Station Qty'*'Work Station Pitch'	
2	'Actual CC'	'CC length of Conveyor'	Series
3	'No of teeth'	8	
4	'Pitch bet Teeth'	300	
5	'PCD'	('No of teeth'*'Pitch bet Teeth')/Math.PI	
6	'No of Structure Modules'	('Actual CC'/3000)-1	
7	'Width of Structure'	'Width of Conveyor'+400	
8	'constant'	400	
9	'Total length'	'Actual CC'+3000	
10	'Scale'	'constant'/Math.sqrt(Math.pow('Total length',2)+Math.pow(2000,2))	

4.3 Parametric equation

Both KBE system and Solid Works 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.

Table - 3: Parametric equation

prmEQ	prmVal
"CC dist bet conveyor@Sketch1@Part1^SLAT CONVEYOR-1@CONVEYOR.SLDASM"	'Actual CC'
"no of structure module@lpt structure module@CONVEYOR.Assembly"	'No of Structure Modules'
"Length Of Slat@Sketch1@Normal Slat-2@CONVEYOR.SLDASM"	'Width of Conveyor'
"Width of slat@Sketch1@Normal Slat-2@CONVEYOR.SLDASM"	'Pitch bet Teeth'

"length of slat@Base-Flange1@TRANSFER SLAT -1@CONVEYOR.SLDASM"	'Width of Conveyor'
"width of slat@Sketch1@TRANSFER SLAT - 1@CONVEYOR.SLDASM"	'Pitch bet Teeth'+50
"width of structure@3DSketch1@structure3-1@CONVEYOR.SLDASM"	'Width of Structure'
"width of structure@3DSketch1@structure.2-2@CONVEYOR.SLDASM"	'Width of Structure'
"D1@Distance2@CONVEYOR.SLDPRT"	'Actual CC'+3000

4.4 Reference Table

Table - 4: Reference table

Driving Variable	Driving Value	Driven Variable	Driven Value
Depth of Section H	100	Flange Thk T	7.7
Depth of Section H	150	Flange Thk T	9
Depth of Section H	100	Web Thk S	5
Depth of Section H	150	Web Thk S	5.7
Depth of Section H	100	Width of Flange B	50
Depth of Section H	150	Width of Flange B	75

4.5 Reference Table Series

Table - 5: Reference table Series

'Actual CC'	3000	33000	63000	93000	123000
	6000	36000	66000	96000	126000
	9000	39000	69000	99000	129000
	12000	42000	72000	102000	132000
	15000	45000	75000	105000	135000
	18000	48000	78000	108000	138000

5. RESULT AND DISCUSSION

Model Geometry output of Single slat conveyor

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

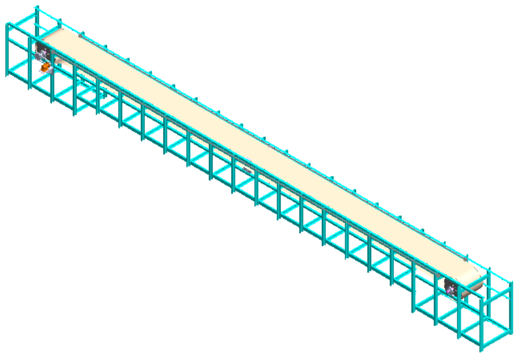

Figure - 4: Modified Single Slat Conveyor

Figure - 5: Structural Frame (Front View)

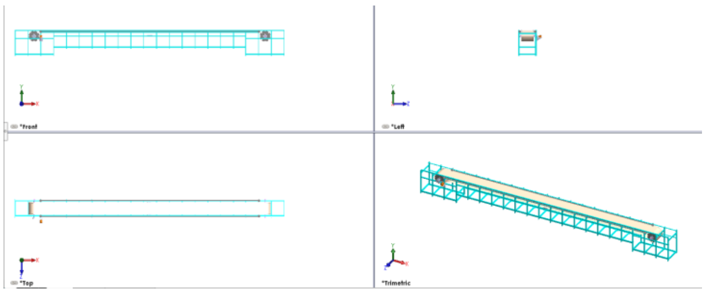

Figure - 6: Conveyor (All Views)

Drawing output of single slat conveyor

Once user click on "Create" the drawing output is generated includes all GA and manufacturing drawings as shown in Figure 7.

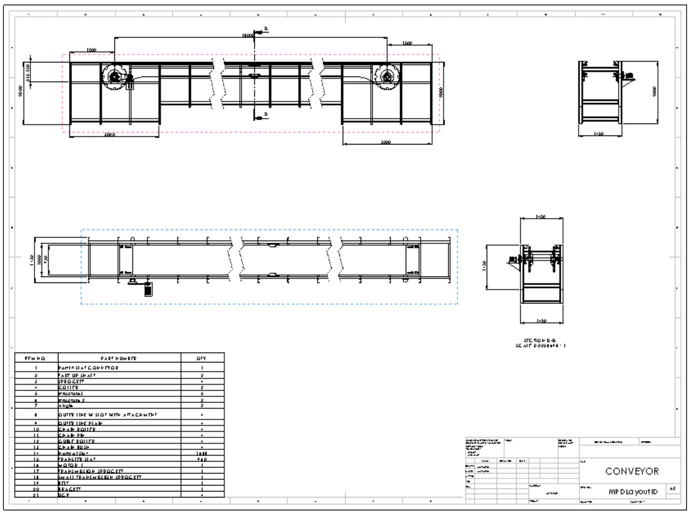

Figure - 7: GA drawing

Model Geometry Output of Double Slat Conveyor

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

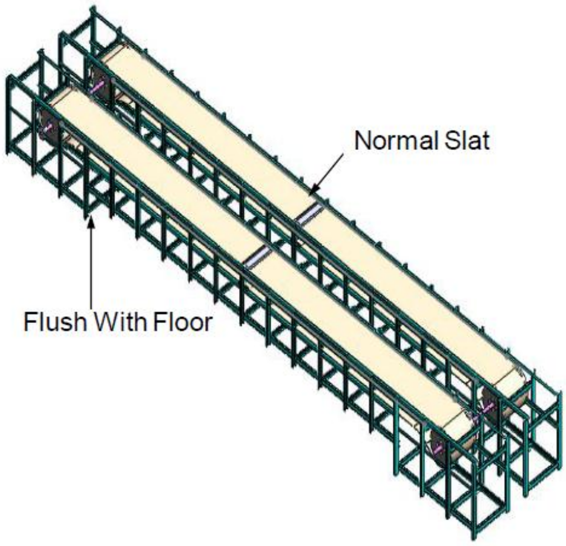

Figure - 8: Double Slat Conveyor (ISO)

Drawing output of double slat conveyor

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

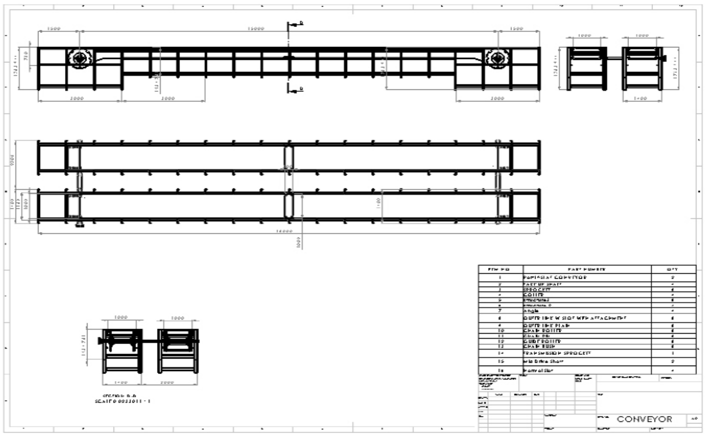

Figure - 9: GA drawing

6. CONCLUSIONS

This project work gives an idea about Knowledge Based Engineering (KBE) in product development. The following conclusions can be drawn from this research regarding the design automation and KBE:

Table - 6: Percentage Reduction in design cycle time

% of Reduction in Design Cycle Time	
Area of waste reduction	% of design Cycle Time Saved
Downtime while finding information, waiting for test, results, etc	0%
Unnecessary documents and prototypes	15-20 %
Underutilization of design knowledge	18%
Over design, such as features customers don't need	2%
Validating manufacturing errors early in design process	25%
Poor design producing product defects	20%
Increase In Innovation and Product Development Time	30%
Prodct and Process Standardization	80%

- 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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