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DEVELOPING A BASIC CAD MODEL OF A SPUR GEAR USING AN AUTOMATED APPROACH

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Abstract- When power transfer between shafts is required, the spur gear is a frequent machine part. There is always a desire for better spur gear in the present market. As a result, specialists are always working to improve the design and productivity of spur gears. In this field, companies are trying to develop a more advanced approach for designing and developing spur gears. A knowledge-based system may make the design process much more efficient. As a result, a knowledge-based solution is required to address design and CAD modeling issues automatically. This article provides a basic approach for automatically producing spur gears with CAD software utilizing basic design criteria inputs. Advanced modeling methods, such as parametric modeling, are utilized to attain the objective. Furthermore, the suggested technique has been demonstrated to outperform the standard human-assisted CAD model generation method.

Keywords: Spur Gear, Parametric Modeling Technique, SolidWorks, Knowledge-Based System, Macro.

1. INTRODUCTION

Automotive, shipbuilding, aerospace, industrial, and architectural design are just a few of the sectors where CAD (Computer Aided Design) is widely utilized as a tool. CAD is frequently used in engineering applications to perform extensive engineering methods such as 3D modeling and/or 2D drawing of actual parts. As a result, customization is required to maximize their performance. Modeling is a time-consuming procedure due to a shortage of experienced experts accessible for CAD modeling and the intricacy of the design. Alternative procedures are being investigated by industries and experts alike. The requirement of the present era is just to personalize and increase CAD/CAM efficiency and productivity. This need necessitates the use of a Knowledge-Based System (KBS) for engineering and design. When compared to humans, the problem statement/task can be recreated in a fraction of time using parametric modeling. The dimension-driven parametric modeling approach enables automatic reuse of previously processed designs based on engineering analysis.

1.1. Spur Gear

The simplest form of gear is spur gears, often known as straight-cut gears. It has a tooth profile that is cut parallel to the shaft's axis. They are just utilized in the event of parallel shafts because of the tooth's parallel contour. The tooth profile is formed like an involute curve that stays the same over the full breadth of the gear. When spur gears are employed, shafts are usually exposed to radial loads. The terminology for Spur Gear is shown in Figure 1.

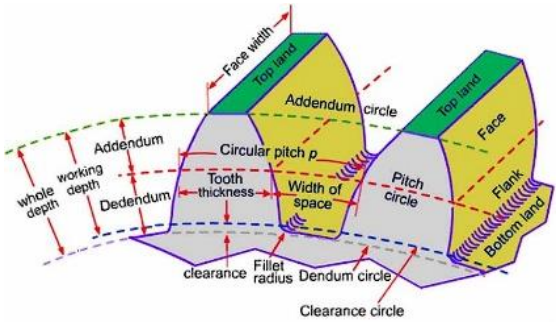

Figure 1. Nomenclature of the spur gear [1]

The CAD modeling of spur gear is a lengthy and time-consuming process, and the requirements are constantly changing depending on the preferences of the customer. As a result, automated modeling is significant. The parametric modeling approach, which is a more advanced CAD modeling technique, can help with this. Although it is a developing subject, several academics have recommended utilizing specialized approaches such as KBS to minimize modeling time. The automatic development of a KBE framework based on general knowledge will have the most dramatic impact. By establishing a CAD modeling system for a Spur Gear, this study suggests a KBS to reduce CAD modeling time.

1.2. Knowledge-Based Engineering (KBE)

KBE is an engineering method that represents the combination of CAD methods with Artificial Intelligence (AI) technology. This has benefits for specialized or various process automation solutions [2-4]. The goal of

the KBE system is to collect and process product information data. It also includes modeling the design process system and then automating all or part of it using the model. The computer-generated product model is an internal representation of the product's design procedures. It provides product information as well as production methods. The goal is to offer accurate product representational data that is captured in the product model. The goal/intention of the KBE system is to compile the most advanced design approaches and technical abilities into a corporate knowledge base [3].

1.3. SolidWorks API

The Application Programming Interface (API) is a communication system that permits different applications to communicate with each other. It is done by embedding a computer language code into another program. Hundreds of methods are included in the API, which may be utilized with VBA (Visual Basic for Applications), Visual C++ 6.0, Visual C++/CLI, Visual C#, and VB.NET. These methods offer the users to use the SolidWorks features like drawing lines, adding a pre-existing component into something like a part, and examining a surface's properties. The SolidWorks API may be used to automate the modeling and assembly of components by developing custom scripts. The SolidWorks API is a tree-like hierarchical structure that includes all of the program's capabilities [5-7].

1.4. Visual Basic Language

In 1991, Microsoft released Visual Basic (VB) as a third-generation programming language. It is a user-friendly programming language which lets us to develop the GUI (Graphical User Interface) windows programs rapidly. In addition, VB is a powerful engine for developing Macros in all Microsoft programs. As a result, Visual Basic has grown into a flexible way for writing computer codes for a number of programs, including SolidWorks [8].

1.5. Macros

A macro is a code that specifies how particular data set should really be converted into expected output based on a specified process. Engagement with the model environment is essential for improving the design automation process. API interfaces in CAD systems allow users to utilize macros to interact with the model environment. And, with the requirement for data exchange across disciplines to tackle real-world challenges. In some cases, a complicated algorithm must be created to do a computation that is not accessible in commercial software [9].

1.6. Parametric Modeling Techniques

The parametric modeling technique, which offers approaches to conventional 2D drawings, is one of the most sophisticated CAD modeling techniques. It allows the user to access pre-existing processes to make rapid modifications based on pre-existing engineering standards [10].

2. LITERATURE REVIEW

To produce easy and precise solid form CAD modeling, macro programming may be used with parametric modeling methods [4]. These tools may be utilized extensively for creating CAD models of Spur Gear [3] since they assist to reduce the complexity that arises during the modeling process. Furthermore, these technologies make CAD modeling more automated, especially for activities that may be mechanized and simplified with the aid of a preset algorithm or code [5].

Cockerham and Waite [11] and Bo Sun et al. [12] suggested a completely integrated set of processes for creating the design of Spur Gear using computer-aided manufacturing. Myung et al. [13] introduced parametric modeling methods for modeling tools and products. These methods aid in the decrease of CAD modeling time, which resulted in a quicker pace of manufacturing. Yangshou et al [14] demonstrated a novel method for creating the dynamic Gear model and conducting structural analysis on it.

Bharat et al. [15] attempted to study the spur gear's stress analysis to determine how it performs when made of composites. Similarly, Kumar et al. [16], Dheeraj et al. [17], and Jayakiran et al. [18-21] developed a model for optimum design on the SolidWorks system that employs a knowledge-based CAD modeling method.

Information-Based Systems are a kind of Artificial Intelligence (AI) technology that collects human expertise to accelerate strategic decisions [22]. This is the kind of computer software that assists in the generation of long-term simulation and experimental software within the constraints of provided inputs and requirements [23-25].

To summarize, although considerable work was put into creating the parametric modeling of different components, Spur Gear received little attention. Hence, the authors believe that in the present industry and research scenario, a specialized automated CAD modeling system for creating a Spur Gear is required, as it is a critical component of the energy transmission system through the shaft.

In conclusion, a substantial contribution was made to CAD modeling and manufacturing via the use of parametric modeling methods, which reduced modeling time and resulted in quicker production capacity with specified inputs. SolidWorks may create the CAD model using Virtual Basics (VB) as a strategic instrument. An automatic CAD model may be created by studying geometric properties included in pre-defined text data.

The objective of this paper is just to demonstrate how to design spur gear with KBS and the parametric CAD modeling method. According to the literature, there are no solutions that are specifically designed to create a CAD model of the spur gear. Though there are a few spur gear design methods available, they aren't fast or simple enough to satisfy today's market demands.

3. METHODOLOGY FOR MODELLING AND AUTOMATION

The majority of commercial CAD software is designed to create component part models that used a conventional method and take inputs in text format linked to the model. Furthermore, this text input may be fed into a computer program [3, 11]. In this research, the input data was fed using this technique. VBA, C++, Lisp, and other programming languages may be used to create this software [18]. VBA is considered to be the most useful of these languages. VBA is the programming editor used in SolidWorks CAD software. Hence, the authors decided to use SolidWorks as the CAD software for developing the suggested technique for creating an automated Spur Gear CAD model. Besides that, macro code is utilized to generate a CAD model of a spur gear as it enables the production of the CAD model to be automated.

3.1. Generating Graphical User Interface

The user may focus on developing their custom GUI inside SolidWorks using VB. Fig. 2 depicts the interface that was developed to produce the CAD model for Spur Gear. Fig. 3 displays the button which was developed to produce the CAD model for the spur gear. The user interface was designed in such a way that it could collect the required input from the user and transmit everything to the logical algorithm, which will then do the design calculations. A logical algorithm is one that interprets data logically to make the system quick and easy [26].

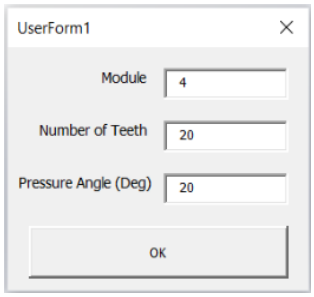

Figure 2. GUI for Spur Gear

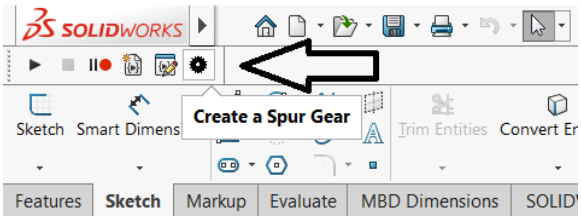

Figure 3. Button for CAD model generation of the spur gear

3.2. Development of a Design Calculations Program

The suggested approach as previously stated allows for logical computing techniques. This function facilitates the entire system design calculations. Manually calculating the necessary dimensions using traditional empirical techniques is time-consuming and complex. In an effort to overcome this complexity, computer programs for design calculations are being created.

For calculation, the suggested system adheres to AGMA (American Gear Manufacturers Association) requirements. This computer software executes all of the intricate designs and calculates the geometrical dimensions of the spur gear. The output results from the program will be sent to SolidWorks, that will create a CAD model based on the calculated geometrical parameters. As a response, activities like design and modeling are now automated. Figure 4 depicts the proposed system's process flowchart.

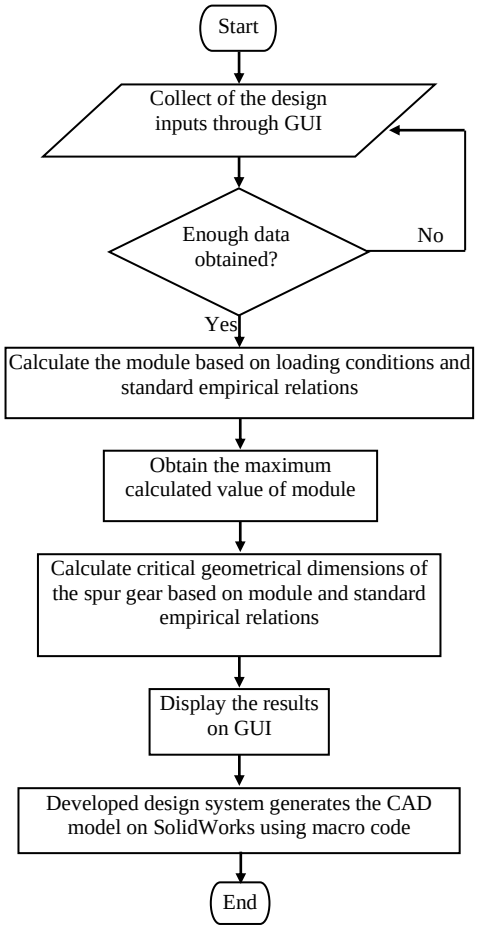

Figure 4. Process flowchart of the proposed system

4. RESULTS, DISCUSSION AND LIMITATIONS

The sample result produced by the established KBS is shown in this part. If all of the design calculations and CAD modeling for spur gear are carried out manually, it takes around 150-200 hours [3]. However, when using the proposed methods, the overall time needed for the whole modeling process on SolidWorks 2020 was 15 seconds. In comparison to conventionally produced CAD models and indeed the technique described in the literature [3, 7], the suggested method generates the same CAD model with extremely near dimension accuracy. Table 1 shows the proposed system's sample input data, whereas Table 2 shows the proposed system's output data (spur gear dimensions). Figure 5 depicts the proposed system's output (Spur Gear).

Table 1. Sample inputs for the proposed system

Parameter	Input Data
Module	4
Number of teeth	20
Pressure angle	20°

Table 2. Spur gear dimensions (Output data)

Parameter	Output dimensions from the proposed system (mm)	AGMA dimensions (mm)
Addendum circle diameter	88	88
Pitch circle diameter	80	80
Base circle diameter	75.175	75
Dedendum circle diameter	70	70

Table 2 shows that the proposed system's suggested dimensions are almost identical to those of AGMA standards.

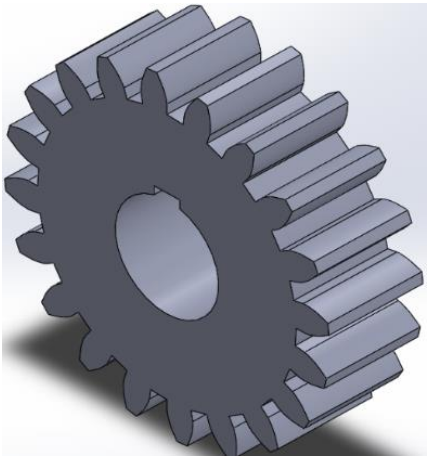

Figure 5. Spur Gear CAD model created by the proposed system

This paper outlines a knowledge-based strategy. This technique is thought to be more flexible than traditional approaches, as KBE approaches can create more dramatic geometric topology modifications than the standard CAD approach. Furthermore, because the KBE approaches were developed in an object-oriented context, they may be reused. Macros can be used to initialize KBE approaches, and the same Macros can be utilized if the KBE approaches are significantly modified. It was observed that the proposed approach is useful in making preliminary spur gear models.

The application of the proposed approach is in the industry where the design and/or manufacturing of the spur gear is carried out. Especially, this approach can be used in the design section of the industry where preliminary design is under consideration.

The performance of the proposed system is restricted to the SolidWorks software package. Furthermore, having standards from the ISO or AGMA uploaded is not dynamic. Human involvement could be needed to update its knowledge-based, which will be a time-consuming and expensive process. Since the suggested method is restricted to SolidWorks software, it could be extended to other CAD systems and make gear design more acceptable to inexperienced designers. However, translating the SolidWorks macro file to the appropriate format of the selected CAD software is an extra task.

5. CONCLUSION

A KBS for generating a CAD model of spur gear is proposed in this article. The proposed system makes use of VBA and SolidWorks rebuild tools. This system uses the design process by using parametric modeling. The suggested design method could be implemented across any computer that has SolidWorks installed. The suggested system is a simple and easy-to-use tool. In contrast to conventional methods, this system has shown to run quicker and produce a CAD model of a Spur Gear.

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BIOGRAPHIES

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