ISSN 2348-9928
Doi:10.46532/ijaict-202108031 Published on 05 (11) 2021

Analysis of Design and Fabrication of Gear Tooth Chamfering Machine

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ArticleInfo
International Journal of Advanced Information and Communication Technology
(https://www.ijaict.com/journals/ijaict/ijaict_home.html)
https://doi.org/10.46532/ijaict-202108031
Received 10 July 2021; Revised form 01 August 2021; Accepted 20 September 2021; Available online 05 November 2021.

Abstract - Life of any gear is increased by providing chamfering on the gear tooth. Most of the gears used in practical application today are not chamfered. This due to the high cost involved in the chamfering process. To reduce the chamfering cost, we have designed a novel simple machine and fabricated. In this work, modelling, design calculation of the chamfering machine and the working of the machine is explained. Introducing chamfering in gear tooth helps to avoid the noise, breakage of gear tooth and to increase the gear tooth. The fabricated machine was tested and found working satisfactorily.

Keyword - Gear; Chamfering; Gear life; Breaking system.

1. Introduction

The gear chamfering is important process in gear manufacturing. It is used to avoid damages after the heat treatment process and also to avoid breakage of gear tooth, when one gear mesh with another gear in moving conditions. The gear chamfering process increases the lifetime and the performance in transmission system in automobile vehicle. At present gear tooth is chamfered by using files or by using some gear making process but there are only limited machines like CNC for gear tooth chamfering that too they are costly in the market. Therefore, small scale industry cannot be afforded to buy that machine on their own. To overcome these drawbacks, we have designed and manufactured gear tooth chamfering machine which can chamfer at accurate angle with fastest and easiest method. Also evidenced this type of product is not available in the market.

2. Literature Review

In this paper, a review of previous research project that are related of this project is discussed. Mallapur et al. [1] initiated need of gear chamfering process when the gears are mesh with another gear. Design and Calculation of rounding and chamfering machine are explained in this paper and it gives the clear view of existing machines. Wang et al. [2] states the design and analysis of gear shaped profile chamfering process. The study of gear chamfering process and design of chamfering tool are detailed in this process. It gives the overview of chamfering process and the importance of gear chamfering process with full calculations.

Gear chamfering process method based on machine vision measurement was studied by Jun, et al. [3]. In this paper, gear parameter measurement method and machine vision and laser sensors are explained in this paper. In these days machine vision technology is one of the leading technologies in industries, so this paper explains how machine vision technology is used in gear chamfering process using laser sensor.

Baud et al. [4] states the static and dynamic tooth loading in spur and helical geared system with experiments and model validation. The main objective of this paper is to validate a static and dynamic tooth loading in spur and helical gear with simulation process and to validate the mesh time. This helps to do modelling and calculation of the machine and during fabrication.

Xu et al. [5] explained circle center positioning error by fitting of measurement system of gear chamfering. This paper gives the complete details of non-contact measurement system of gear chamfering based on computer vision technology and laser range-finding technology. As computer vision technology method, it helps to take the project to the next level of thinking and also to learn the importance of circle center during chamfering process. The high precision collaborative vision measurement of gear chamfering profile was studied by Zhou et al. [6]. This paper proposed the machine vision technology for collecting image of the gear using area array image sensor, to process image edges, to fit the gear centers etc. to get high accuracy on gear chamfering.

Zhang et al. [7] researched on empirical gear profile Micro modifications for gear transmission. This paper explains the importance of gear chamfering in gear tooth and also the effects of gear chamfering process and it gives solutions for high accuracy gear chamfering and also the importance of gear chamfering process in transmission

system. Hardening of gears and critical components was studied by Rudnev [8].

The paper shows the methods to improve wear resistance, hardness and contact fatigue strength without affecting material properties by induction hardening technique.

Prasad et al. [9] explained the modeling and analysis of spur gear for sugarcane juice machine under static load condition using FEA. This researcher explained the working of spur gear in sugarcane juice machine with design and analysis, and the method to reduce weight and noise of the machine. The method used for analysis is finite element analysis. This also explains that how a machine is designed and fabricated at less cost, frictionless, corrosion resistance etc.

Lev et al. [10] carried the research on the gear tooth smoothing and shaping process. This paper details importance of the smoothing and shaping process in gear manufacturing. This method is used for gear tooth to increase lifetime of gears and to reduce wear resistance.

Gear tooth Stresses at high speed was studied by Tuplin et. al. [11]. This shows the stress acting on the gear tooth at high speed and their cause and effects. This paper shows the importance of gear tooth stress calculation and the methods to calculate the gear stress during high speed.

Martin et. al. [12] stated review of friction predictions in gear tooth. This gives detailed explanation on importance of friction in gear tooth and the various types gear tooth friction with calculation and proper explanation. It gives that coefficient of friction can be predicted by electrohydrodynamic (EHD) regimes.

This kind of surveys was carried out as one of the tools to have some ideas on available gear chamfering machines. From the literature survey, it is evident that there is no simple chamfering machine is available at present.

3. Methodology

Methodology followed in this research work is outlined in the Fig.1.

3.1 Problem identification

In this project, various types of techniques were used to solve the problems. First, problem was identified by visiting many gears manufacturing industries and asked them what are the major problems that they are facing in the industries. Lot of problems are found but most of the gear manufactures finally, a problem for this research was selected based on maximum frequency.

The problem identified was, in gear making process the gear chamfering process makes them difficult, so they source it for some vendors it leads more cost. Due to this the cost of the gears increase in the market. Moreover, the capital cost of this machine is also high. Therefore, this research considered this as a major problem.

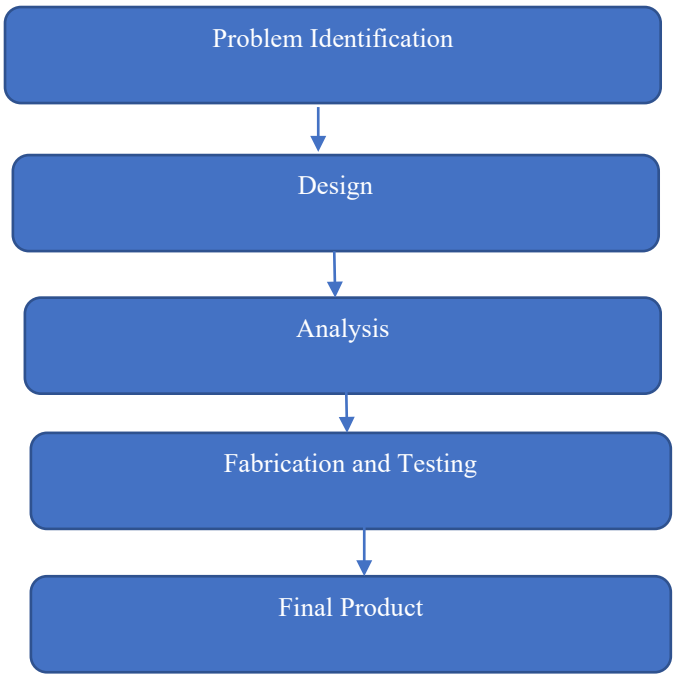

Fig.1 Outline of methodology

3.2 Calculation and Design

After the problem finding, research moved forward to modelling and design using the gear calculation. For this gear calculation lot of surveys done using journals, review papers related to gear chamfering process. With the help of these papers, machine is modelled and designed the machine. After doing design, simulation process also done, where the materials are selected, and the failure analysis are also selected.

3.3 Analyze

In the next phase, analysis is done using Analysis software. In this, analysis is done for the stress and deformation of the frame of machine while the load is acting. And, the material selection is also verified.

3.4 Fabrication

Next step is fabrication, where first we made a check list for purchasing the materials required. Then we found a workshop for doing fabrication and made frame with the use of welding technology and next fixed the motor with work piece holder. Finally, tool holder is fixed. Chamfering tool also prepared with the use of grinding machine.

3.5 Testing

In testing process fabricated machine is tested by running the machine with 10 number of gears, the machine may vibrated more due to motor speed, tool angle, tool position etc. therefore, in this phase optimum parameters are to be found and set.

3.6 Final product

Finally, the machine is successfully completed with help of optimum design values. All the details are given in the Fig. 2 -5.

3.7 Problem Solving through 8D Methodology

D1: Establishing Problem Solving Team / Project.
Task - Chose team members.
Work steps -
• Associates with the relevant professional competence will be chosen based on the available description of the failure.
• A team leader as well as a sponsor will be named.
Result - Confirmation of the team configuration and responsibility assignments to the team members.

D2: Problem Description:
Task - Collect numbers, data and facts.
Work steps - Describe the problem (defect/divergence) as exact as possible with quantitative information.
Answer questions (7 W)
• Who?
• What?
• When?
• Where?
• Why?
• hoW?
• hoW often?
Result – For the associates, entrusted with the solving, a clear image of the defect must be created based on facts.

D3: Containment Actions:
Task - Determine the most suitable containment actions. Immediate measures must be installed to ensure that the defect does not appear in customer hands (again).
Work steps -
• Immediate measures act as a protection and often have no reference to the actual problem root cause.
• Cost aspects are immaterial at this point.
• A plan for the installation of immediate measures must be worked out and their effectiveness must be controlled.
Result - Implemented containment actions incl. documentation, Information to the customer.

D4: Cause and Effect Analysis:
Task - Identify root causes.
Work steps –
• All possibilities that might have caused the defect must be taken into consideration.
• Causes must be identified and matched with the problem profile using quality tools and appropriate methods to determine physical, chemical and technical relationships.
• The asking "Why" method helps to analyse the root cause.
Result - Documented derivation and description of the root cause with evidence.

D5: Defining Corrective Actions & Proving Effectiveness:
Task - Confirm "ideal" corrective measures.
Work steps -
• All measures that are able to solve the problem and eliminate it permanently must be listed.
• The effectiveness of the measures must be proofed and side effects must be rated.
• The "ideal" corrective measures to be determined.
• A schedule for the implementation to be defined.
Result - Defined and released Corrective Actions with effectiveness evidence.

D6: Implementing Corrective Actions & Tracking Effectiveness:
Task - Develop plan for the implementation of corrective actions.
Work steps -
• Based on the approved measures from D5, as many measures as needed and as few measures as needful will be implemented.
• A continued existence of the immediate measures will be decided.
• The required documentation for process monitoring will be defined.
Result - Established and in effectiveness confirmed Corrective Actions, Containment Actions from D3 removed.

D7: Establish Preventive Actions:
Task - Prevent occurrence of comparable problems in other business or production processes and products due to the identified root causes.
Work steps -
• The view at process aspects and the process analysis are in the main focus.
• Involve equal and similar products and processes.
• Use findings to improve processes.
Result - Updated standards, exchange of experience.

D8: Final meeting:
Task - Final conclusion of the 8D-team.
Work steps -

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• The problem-solving team critically evaluates every 8D-step and the measures.
• The 8D-Report is being closed officially.
• Common efforts are being acknowledged and appreciated by the superiors.
• The customer is being informed about the completion and receives the signed 8D-report.
• The completed 8D-report will be stored / archived.
Result - Finished 8D process / report, customer informed, acknowledgement of the teamwork by the sponsor.

4. Modelling

Complete dimension and final model is presented in this section. (Fig 2-5)

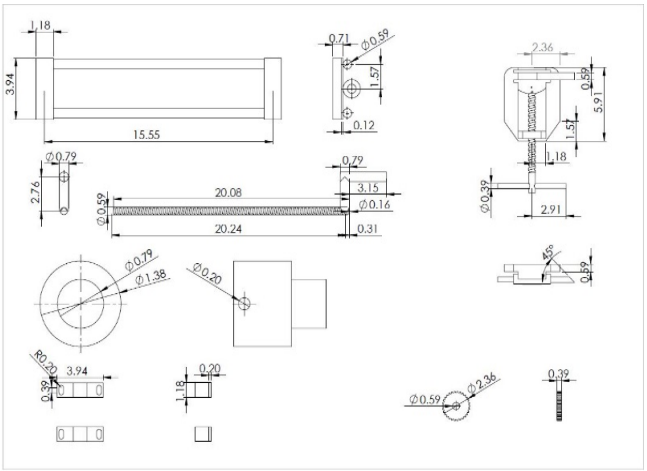


Fig 2. Detailing 1

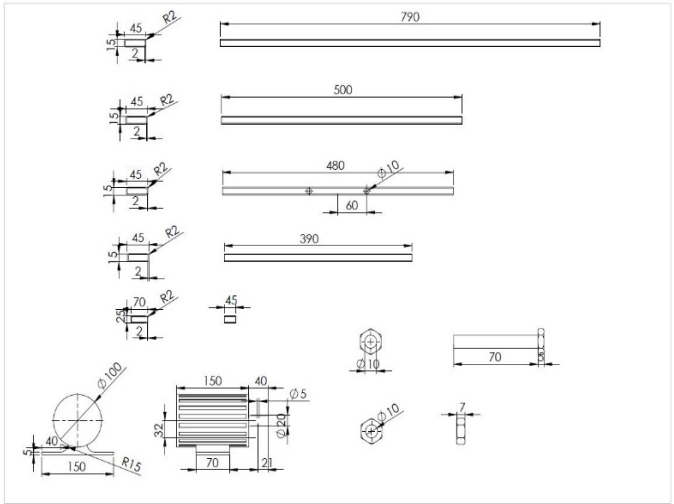
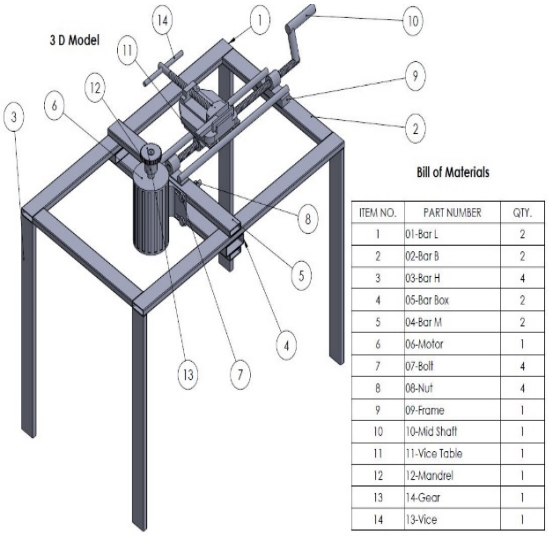


Fig 3. Detailing 2



Bill of Materials

ITEM NO.	PART NUMBER	QTY.
1	01-Bar L	2
2	02-Bar B	2
3	03-Bar H	4
4	05-Bar Box	2
5	04-Bar M	2
6	06-Motor	1
7	07-Bolt	4
8	08-Nut	4
9	09-Frame	1
10	10-Mid Shaft	1
11	11-Vice Table	1
12	12-Mandrel	1
13	14-Gear	1
14	13-Vice	1

Fig 4. Final 3D model

5. Working Principle

In this design, three important parts are used namely, motor, workpiece holder and tool holder. Apart from these parts the spring tension is also given to avoid oscillation of the tool during the chamfering process. The workpiece holder is fixed with the motor using thrust bearing (they are designed to support a high axial load), the internal chuck is used as workpiece holding device. When the motor rotates the chuck also rotates with the help of the bearings. The spring tension is fixed in the tool holding device. In the tool holder we can change the angle of the chamfering tool according to the customer's satisfaction. And also we can move the tool holding device according the type of gears used.

Fig 5. Final product overview

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A. Applications

Chamfered gears are used in transmission systems in automobiles and also in some machines such as lathe, milling, shaper etc.

These gears are also used in all fields of engineering and agriculture.

B. Merits

1. Easiest Method.
2. Cost less.
3. Accuracy is high.
4. Time taken to chamfer is less.
5. Increases the life time of gears.

6. Conclusion

In this paper, design and working of portable gear chamfering machine are explained. The solid works software is used for the modelling. In addition to this, paper also gives the importance of gear tooth chamfering. This modelling is executed and had become successful in fabrication. This machine is suitable to chamfer all type of gears. The rounding/chamfering machine is a conceptual design with no particular component taken into consideration. Even though, it chamfers well for selected gears. The machine can be redesigned as per the requirements of an industrial component. Electrical circuit diagram, sensors interfacing and PLC programming can be planned with the consultation of electrical and electronics engineers

Declaration of Competing Interest

The authors declare no conflict of interest.

Acknowledgments

Thanks to the reviewers for their constructive comments on the revision of this article.

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