Failure analysis of a helical gear used in Conveyor belt

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Abstract. This paper reports the investigation on the failure of helical gear used in the conveyor belt. The gear has failed about 7000 hours before the service of the component which is estimated to have an average life about 40000-45000 hours. In this failure it is concluded that the gear has subsequently failed due to the stress developed on the surface of the gear during the working condition of the gear. The main reason of the failure is caused due to the contact stress, fatigue stress, surface pitting on the surface of the gear tooth. The selected working material should withstand the stress concentration levels during the gear motion. After the brief analysis on the helical gear and the working condition, it is learned that one must be careful while analyzing the results and the replacement of any parameter must be thoroughly analyzed before the final decision made.

Keywords. Helical Gear , Conveyor Belt , Contact Stress , Fatigue Stress , Stress Concentration, Gear tooth

I. Introduction

Gears are used to transmit power and motion from one shaft to another shaft. Power transmission has always been of high importance. The efficiency of any machine is always been seen in the amount of power loss in the process. The gear plays a major role in the many automobile industries. Gears with involute teeth have widely been used in industry because of the low cost of manufacturing critical evaluation of helical gear. Design performance, therefore plays a crucial role in estimating the degree of success of such gear system in terms of stress and deformation developed in gears.

II. Design Methodology

The main aim of this paper is to design and analyze the helical reduction gear box with least or nominal flaws that are occurring during the function of the gear box. The flaws are been observed occasionally break down and the constant maintenance of the gear box. The design procedure even make a note on the materials which are selected for the components of the gear box such as gears, housing and shafts. The materials for this will be selected according to the price or the weight that will not affect the functional characteristics of the gear box. The designer will always see the low cost with high and better performance of the gear box for long time. The gear oil also plays a major role because the oil selected for the gear in always see the low cost with high and better performance of the gear box for long time. The gear oil also plays a major role because the oil selected for the gear is always should be adaptable to the condition of the gear box and the temperature range. Due to this the selection of the gear oil will be made on the special temperature range of the operational condition of the gear box. Once the material selection is made then the minimum dimensions of the gear has to be made for the gear to reduce the unwanted materials and to reduce the cost and the
weight of the gear box. Standard dimensions to the minimal dimensions are selected and the modelling in the design software. Various profiles on the gear are studied as per the standards and to ensure the structural integrity and the weight factor to be minimal

III. Understand The Problem Statement

Gear problems are commonly seen in the industry where the large or frequently gear boxes are used. The reasons can be so many types of which the failure of gear may occur. In this paper we are going to deal with problem occurred in the industrial helical gear box which is used to run the conveyor belt which is used to transmit the load of 3 TON. In this paper the main aim is to reduce the failure of the gears in the helical gear box which can be the many reasons such as material selection, improper design of the gears and the working conditions of the gears in the working environment. In this paper am going to deal with the three possible cases in which we can overcome the problems faced in the helical gears.

3.1 To Increase The Module Of Gear

When the module of the gear is increased. The strength of the given gear can be increased and the maximum stresses occurred on the gear can withstand the load. This can be used to decrease the deformation rate of the gear profile. Existing model has the gear. Model has Module 3 the gear module has been increased to 4 and 6 and the analysis has been done on the gears and the deformation.

3.2 Change Of Material

The material change to the gears and the Shafts can show the various changes in the behaviour of the gears efficiency and the parameters like the deformation, stresses induced on the gears and the life of the gear can be improved when the materials with high strength and the ductile properties should be strong. The materials for the gears are selected by the ask-by chart in which the composite materials are selected to strengthen the gear profile where the machine will be done by tooth driver and driver gears.

Table 1: Existing Material

| MATERIAL | TENSILE STRENGTH |
|----------|------------------|
| EN-353   | 1004             |
| EN-34    | 480              |
| C-40     | 500              |
| 45C8     | 500              |

Table 2: Modified Material

| MATERIAL | TENSILE STRENGTH |
|----------|------------------|
| NICRMO   | 820              |
| 17CRNIMO6| 550              |
| AL-BE ALLOY | 510          |
| 15CRMOV6 | 1180             |

IV. Design Process

The design process start out with initial existing design addressing all the parameters of the design the constraints of the designs are followed and the optimization of the design is done by using the assumptions made in the initial design or existing design. The initial design is analysed by using the ansys software and the selection readings or the parameters are calculated. The analysis is done by using working condition of the component in the industry by having a brief observation of 2-3 weeks in the industry. The design process is done by using the “SOLID WORKS” for the existing and the optimized model of the helical gear. The model results are taken back to the analysis software ansys to regine the results generated with the existing design. According to the arriving condition, the materials are selected by the ash by chart with the with the different material properties to withstand the stresses developed in the component during the working condition of the gear.
V. Design For Manufacturability

Figure 1 existing gear

Figure 2 existing pinion module-3

Figure 3 modified gear module-4

Figure 4 modified pinion module -4

Figure 5 modified gear module-6

Figure 6 modified pinion module -6
The primary objective was to reduce the stresses developed in the gears deriving the covering condition of the gears. The design parameters were adjusted at the design process of the gears to reduce the damage, maintenance and service period of the gears. This stresses developed in the existing design and the optimized designed can be found and deriving the analysis of the component by its objectives and constraints as per the working condition. The components should not effect any parameter of the design. The principles as design for manufacturability has to be impacted in the optimized design with out any in adequacy in the final product.

VI. Assumptions In Simulations

In order to simplify the following simulations were made in the design and analysis process:

- Material deformation is mainly considered in the assumptions.
- The materials are selected as per the working conditions to withstand the stresses developed in the component during the working condition.
- The design parameters are the gears from the existing gears are optimized by using the accurate formulae from the AGMA standards.
- The properties are the materials and the cost as of the materials are selected by using the ash by chart and the market value.
- The maintenance of the components during the working conditions should be accurately performed with good technical knowledge in the precautions and the operation department.

VII. Simulations And Analysis Results

| TABLE 3: RESULTS FOR MODULE- 3 |
|-------------------------------|
| MATERIAL | TOTAL DEFORMATION | MAXIMUM PRINCIPLE STRESS | MINIMUM PRINCIPLE STRESS | DAMAGE | LIFE |
| -------------- | ---------------- | ------------------------- | ------------------------- | ------- | ----- |
| AISI 9310 | 0 to 1.45e^5 | -282.5 to 1419.7 | -1006.1 to 482.37 | 1000 to 3.2511e^6 | 307 to 1e^5 |
| 17CRNIMO6 | 0 to 1.1e^5 | -420.7 to 1746.8 | -1219.8 to 563.92 | 1000 to 6.09e^6 | 164 to 1e^6 |
| AL-BE ALLOY | 0 to 1.27e^6 | -324.84 to 1656.5 | -1129.8 to 514.42 | 1000 to 8.5e^6 | 117.4 to 1e^6 |

| TABLE 4: RESULTS FOR MODULE-4 |
|-------------------------------|
| MATERIAL | TOTAL DEFORMATION | MAXIMUM PRINCIPLE STRESS | MINIMUM PRINCIPLE STRESS | DAMAGE | LIFE |
| -------------- | ---------------- | ------------------------- | ------------------------- | ------- | ----- |
| AISI 9310 | 0 to 1.866e^5 | -268.73 to 753.09 | -886.87 to 164.33 | 1000 to 1.363e^5 | 730 to 1e^5 |
| 17CRNIMO6 | 0 to 18753 | -87.562 to 373.96 | -441.84 to 46.385 | 1000 to 2.3148e^5 | 5562 to 1e^6 |
| AL-BE ALLOY | 0 to 1.2e1^5 | -83.87 to 818.6 | -500.9 to 190.01 | 1000 to 1.4e^6 | 684 to 1e^6 |

| TABLE 5 :RESULTS FOR MODULE-6 |
| MATERIAL             | TOTAL DEFORMATION | MAXIMUM PRINCIPLE STRESS | MINIMUM PRINCIPLE STRESS | DAMAGE       | LIFE           |
|----------------------|-------------------|--------------------------|--------------------------|--------------|----------------|
| AISI 9310            | 0 to 51809        | -135.11 to 718.47        | -563.09 to 151.49        | 1000         | 981.41 to 1e^6 |
| 17CRNIMO6            | 0 to 5010.6       | -45.751 to 123.64        | -252.82 to 9.2247        | 1000 to 52540 | 19033 to 1e^6  |
| AL-BE ALLOY          | 0 to 72297        | -241.7 to 294.19         | -932.51 to 252.01        | 1000 to 1.2e^6 | 541 to 1e^6    |

**Figure 7 Total Deformation 17crnimo6 M-6**

**Figure 8 Damage 17crnimo6 M-6**
Figure 8 Damage 17Crnimo6 M-6

Figure 9 Max Principle stress 17Crnimo6 M-3

Figure 10 Max Principle stress 17Crnimo6 M-4

Figure 11 Max Principle stress 17Crnimo6 M-6

Figure 12 Min Principle stress 17Crnimo6 M-3

Figure 13 Min Principle stress 17Crnimo6 M-4
Figure 14 Min Principle stress 17Crnimo6 M-6

Figure 15 Damage AISI M-3

Figure 17 Damage AISI M-6

Figure 16 Damage AISI M-4

Figure 18 Total Deformation AISI M-3
Figure 20 Total Deformation AISI M-6

Figure 21 Life AISI M-3

Figure 22 Life AISI M-4

Figure 23 Life AISI M-6

Figure 24 Max Principle stress AISI M-3

Figure 25 Max Principle stress AISI M-4
Figure 26 Max Principle stress AISI M-6

Figure 27 Min Principle stress AISI M-3

Figure 28 Min Principle stress AISI M-4

Figure 29 Min Principle stress AISI M-6

Figure 30 Damage AL-BE M-3

Figure 31 Damage AL-BE M-4
Figure 32 Damage AL-BE M-6

Figure 33 Life AL-BE M-3

Figure 34 Life AL-BE M-4

Figure 36 Total Deformation AL-BE M-3

Figure 37 Total Deformation AL-BE M-4
VIII. CONCLUSION

The design introduced in this phase has a good quality of work in the industrial work with lot of issues facing within less than of time or life than the estimated life of the component. The optimized design parameters shows the better results than the existing design parameter by using the ANSYS analysis software can predict the values of stresses at any required face of the gear.
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