Design and Analysis of Bevel Gearbox Having Two Output Shaft

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Design and Analysis of Bevel Gearbox Having Two Output Shaft

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ABSTRACT:
At the beginning of the industrial revolution, belt drives were used for transmitting power, but they were inefficient due to the high rotational speed and friction between the belt and the pulley. The huge loss of energy prompted the need for an alternative mode of transmission and thereafter gear came into existence. Once they were installed in machines it became clear that they are more efficient than the belt drive system. Hence, the revolution arrived with the use of gears in different locations and in combination with other components in order to reduce the load acting on the teeth while they mesh. The revolution phase didn't stop there, the focus shifted on the appearance of the gears and other components in the casing to make them more aesthetic and efficient. The gear manufacturing industry started to thrive as a result of this revolution.

Gear is a major component of my thesis work. We use toothed cylindrical wheels, also known as "Gears" if we want to transmit power from one revolving unit to another in the mechanical elements. [1] Bevel gears are the most suitable choice to use in any machinery or mechanical systems if we want to adjust the direction of transmission or transmission ratio. In my thesis work, I'll discuss the various types of bevel gears, the comprehensive method for designing a bevel gear, the materials that can be used to manufacture bevel gears, various types of lubricants that can be used when the gear is working in its actual location, various types of failures that can occur in bevel gears while in operation, and various applications of bevel gears in various industries. In addition, I'll go through two main concepts in the field of design: CAD (Computer- Aided Design) and FEA (Finite Element Analysis).The primary goal of this thesis work is to develop a gearbox with two output shafts. I'll start by designing bevel gears geometrically so that I can get the design parameters needed to create the gears in any CAD software, such as Solid Edge, Solid Works, Gear Teq, etc. The next step will be to design the rest of the gearbox's components and assemble (bring them together) them in a housing or enclosure so that we will have two output shafts and just one input shaft. Then, I will perform a Finite Element Analysis of gear assembly when gear teeth are meshing each other, Specifically Static structural analysis to obtain equivalent stress, strain, deformation, etc. I will use either Ansys or Simscale to do FEA. After finishing all of these steps, the last step will be conducting feasibility of the gearbox, determine various manufacturing possibilities & applications of the designed gearbox and provide recommendations on which process will be suitable to produce this kind of gearbox.

I. INTRODUCTION
Bevel Gear
[1]Bevel gears are the gears having intersecting shaft axis and conically shaped tooth-bearing faces. These types of gears are mostly used when shafts are intersecting at 90 degrees but they can be designed to work at other angles as well.

[2] These gears allow mechanical advantage to be changed by changing the number of teeth on each wheel. For example, differing the ratio of teeth between the driver and driven wheels may differentiate the ratio of rotational speed and torque.

Gearbox

The **gearbox** can be defined as housing that contains a gear train, or a mechanical unit or component consisting of a series of integrated gears.[3] The main function of the gearbox isn't different from any gearing device; it also alters the torque and speed between a driving device like a motor and a load.

Inside the gearbox, there are several elements like gears, shafts, bearings, casing, etc. There can be used any type of gear in gearboxes such as one of the several types of bevel gears, spur gears, helical gears, and others like planetary gears. There will be shafts passing throughout the casing, which won't only be supported but also rotated by

Designing of Assembly of the whole Gearbox
Design of Shafts

A shaft is a rotating machine element which has a circular cross-section and which is used to transmit the power from or to a machine which generates or absorbs the power. It's one of the most important elements of any type of the machines which usually support the other rotating parts of the machine such as gears, pulleys, etc. I've designed

bearings. And the gears are mounted on shafts. Gearboxes are used at many places like machine tools, in industries as key equipment, conveyors, and any rotor motion power transmission device which requires changing the torque and speed as well. [3]

The term "**Gearbox**" is often used interchangeably with "**Gearhead**". Most of the people and/or even motion industries aren't making a differentiation between these two terms. They are almost similar but still different. The term "**Gearbox**" defined as specifically housed gearing as described in the last paragraph. Where the term **"Gearhead"** refers to open gear assemblies that are mounted within a certain same frame. two shafts in Solid Edge software, which are almost similar in appearance but they are different according to their fixation method with gears. The material used for shafts is **Structural steel**.

Key Joint method: One approach is the key-way joint relation, which consists of three parts: 1. Key-way in one section, 2. Key-way in the other part, and 3. key as seen in the diagram. [23]
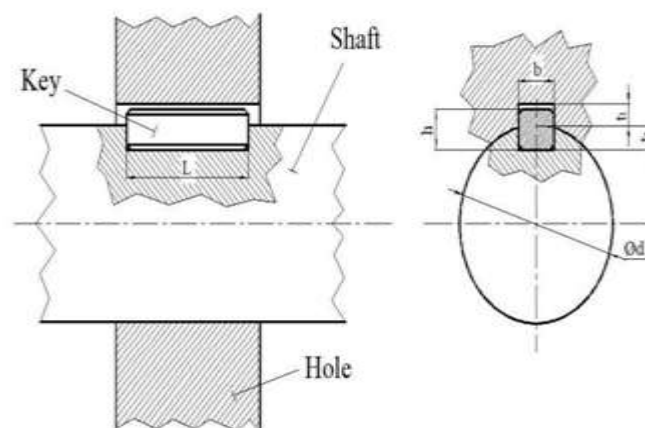

Figure 22 Key joint [23]

Spline fitting method: It's nearly identical to the key-joint system, with the exception that the spline surface (which resembles a key) is designed on the shaft rather than being distinct from it. As a result, there are two main elements in this method: 1. a shaft with single or multiple splines, and 2. another section with a keyway. [23]

As we all know that any kind of lubricating material (oil, grease, etc.) will be filled in the casing so that gears can rotate without friction. Hence, to prevent the leakage of this lubricating material this kind of seal we normally use in the gearbox. It was also designed in Solid Edge software. This type of part should be soft material so that It could be fiber material, copper, silicon material, etc. Fiber material isr this part.

(a) Single Spline Shaft (b) Multi Splined Shaft
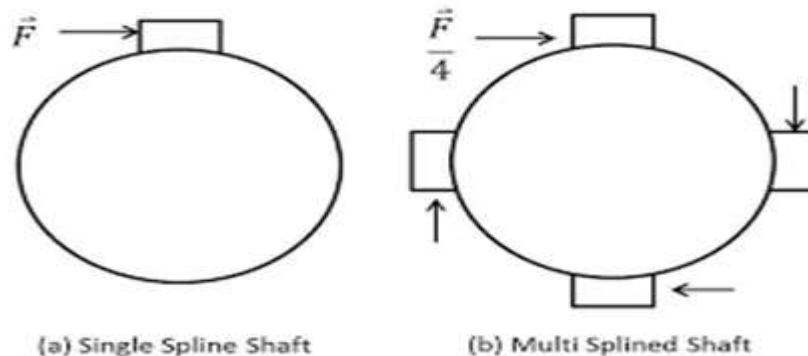
After designing all these parts, I tried to fix the gear and the shaft in two ways as we discussed earlier. In one method I used the key-way joint method and fastened the shaft by using a hexagonal bolt. While in another method, I used split-pin and nut to secure the gear with the shaft.

Figure 31 Method 1 for Fixation

Housing / Casing of the GearboxA gear housing is a mechanical enclosure that houses the mechanical components of a gearbox. It offers mechanical assistance for moving parts, mechanical shielding from the outside environment for internal components, and a fluid-tight reservoir for the lubricant that bathes those components. There are only main two types of casing, such as **split housing** and **bathtub housing**. Generally, it is traditionally constructed out of **Cast iron** or Cast aluminum, using permanent mold casting or shell molding techniques. Composite materials have been used in experiments, though. I constructed a bathtub-style housing with a translucent cover in Solid Edge software to enable us to see how the gear rotations operate within the gearbox.

Assembly Process
To begin, I used the GearTeq program to build gears and a pinion, as we mentioned earlier and then assembled the three gears. Which looked something like this:
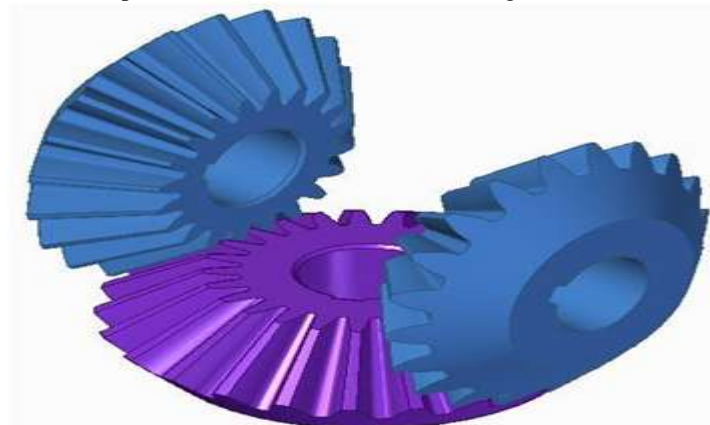

Figure 37 Assembly of Gear and Pinions

The next move was to use some sort of fixation system to rig the shaft with gears. As a result, I made two different versions: As seen in this diagram, the first version used the key-joint system and secured the shaft with a hexagonal bolt:
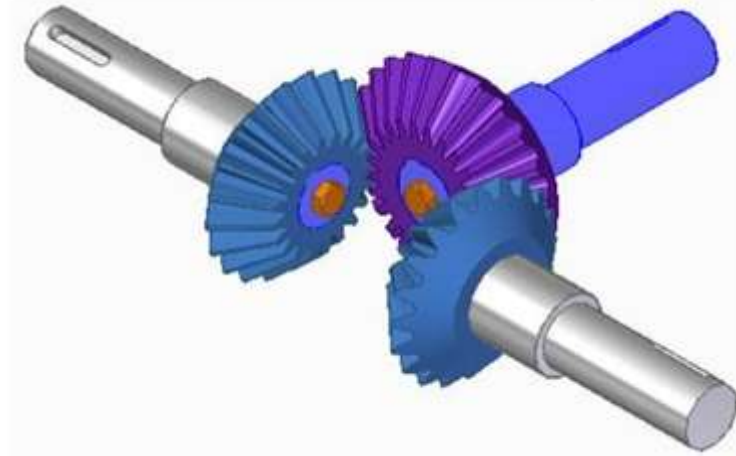
Figure 38 Version 1 of mounting the shaft with the gears

The second version has splines on the shaft and is sealed with a nut and split screw, as seen in the illustration.
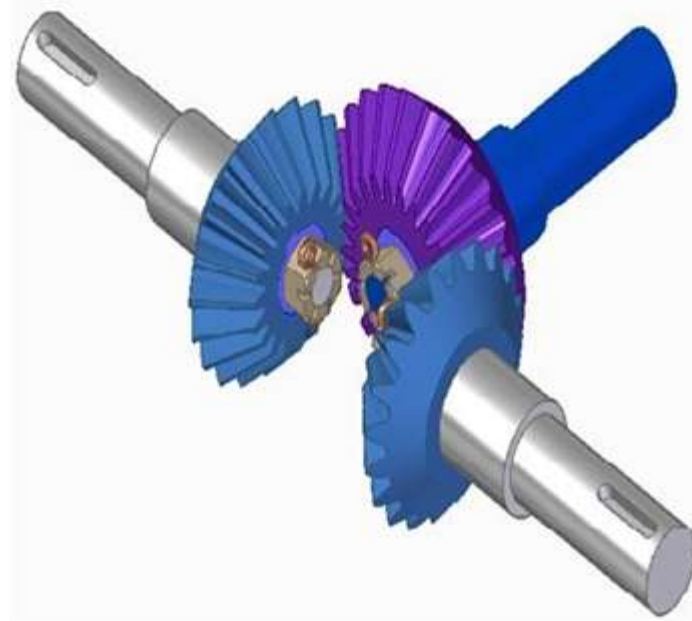
Figure 39 Version 2 of mounting the shaft with the gears

Now that we have shafts with gears fixed on them, the next step would be to position this \ assembly in the housing with the bearings and cover it with the top cover.
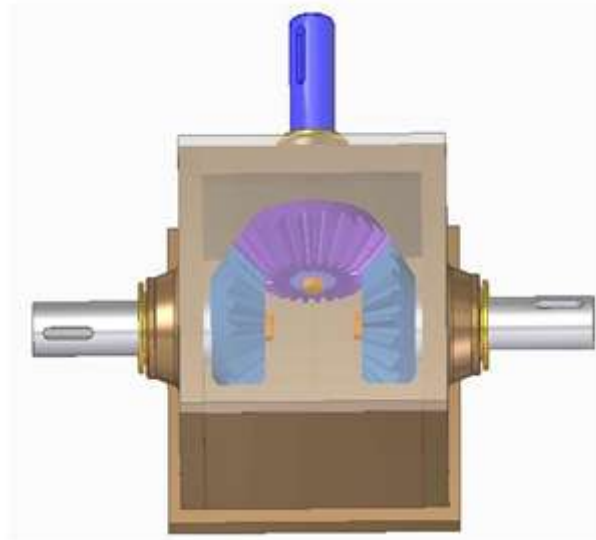
Figure 40 Final Assembly of the Gearbox (Version 1)

Exploded View of the Assembly

An exploded-view drawing is a diagram, illustration, schematic, or technical drawing of an entity that shows the connection or order of assembly of different components. A three-dimensional exploded diagram explains the design of an object that is somewhat isolated by distance or floating in space. [24]

Following the formation of the assembly, I exploded it to take a shot of the view so that we could see how each aspect was connected to the others. And This is the table that includes details about the various parts used in assemblies.
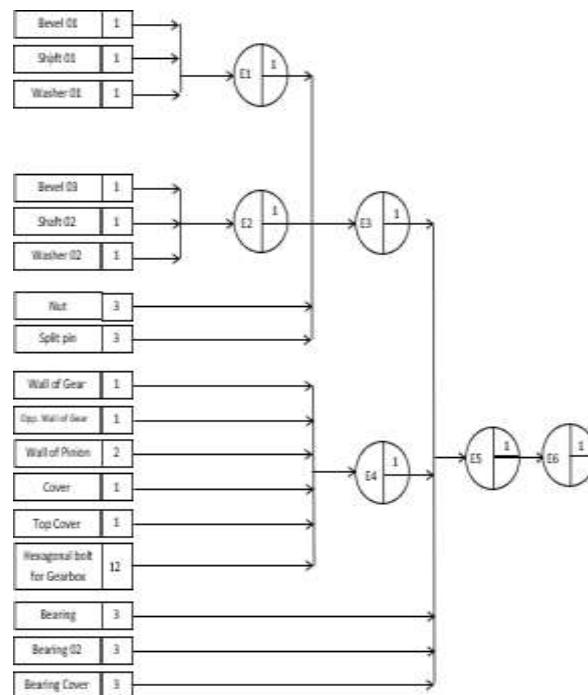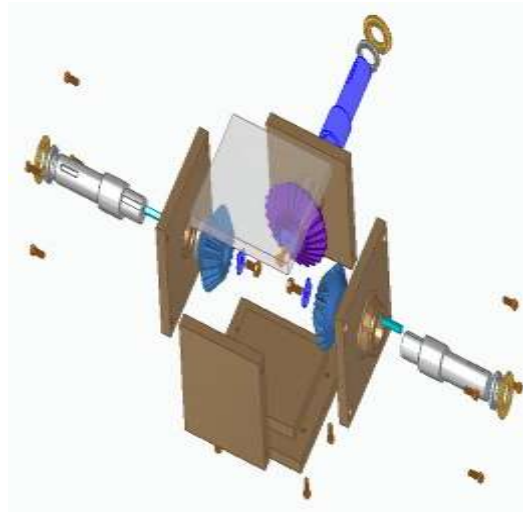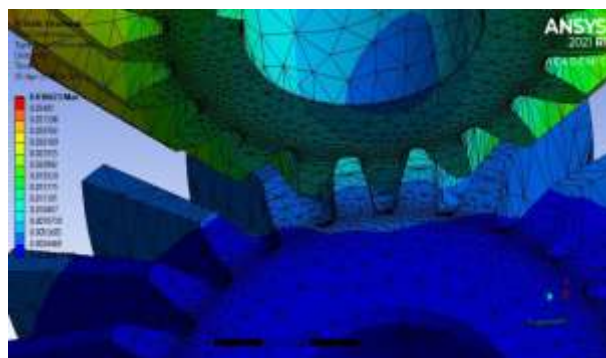
Exploded View of the Assembly
Simulation Run: After completing all of the steps outlined above, we can run the simulation and see the results in the simulation tree's solution portion. Here, I've attached some results.

Figure 51 Equivalent stress (MPa) occurs at the moment of 1400 Nm

As we previously mentioned, I received results at various moments. This is the maximum moment which could be provided to the pinion.

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because after that, the maximum Stress (256.15MPa) will exceed the material's yield point (Structural steel- 262 MPa) and our engineered product will be failed. From a moment of 1400 Nm, I was able to obtain maximum normal stress of 88.232 MPa. As a result, we may conclude that our

engineered gears have proven to be reliable up to   this point.
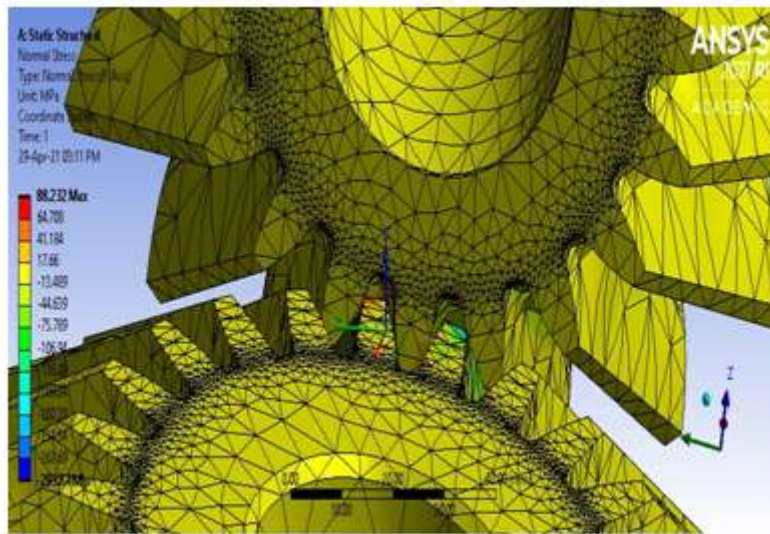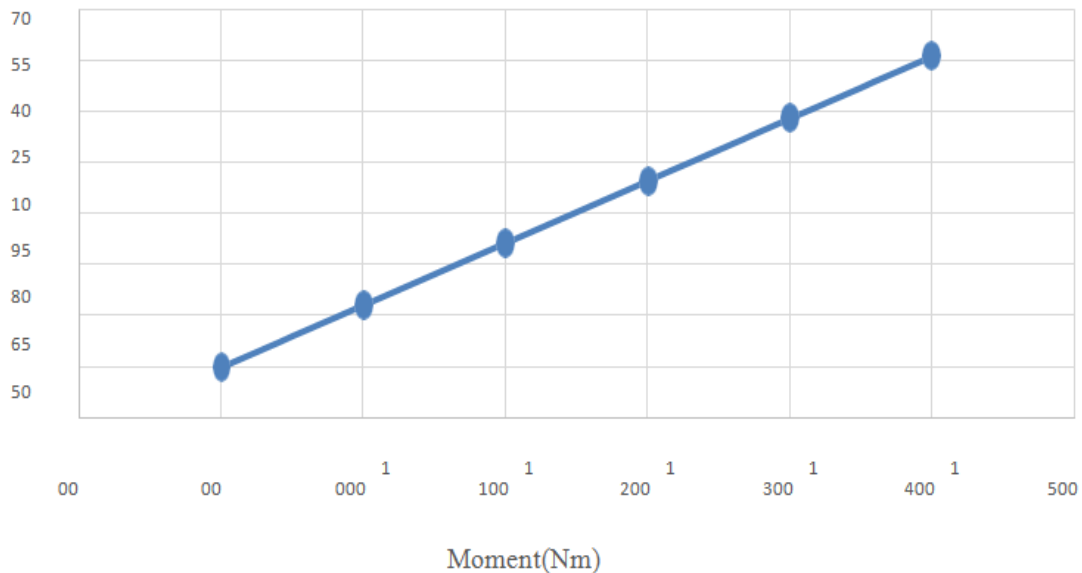

Normal Stress (MPa) at the moment of 1400 Nm
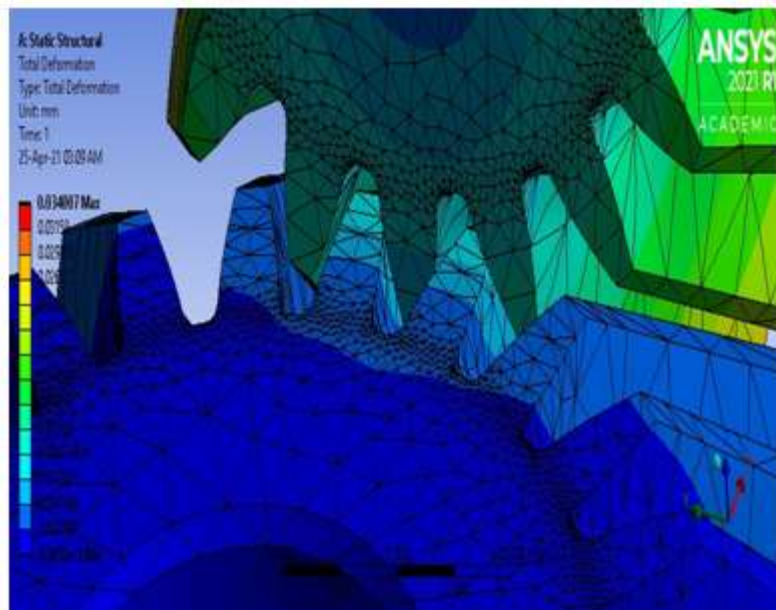
II. RESULTS AND DISCUSSIONS

After obtaining these results, I summarized them in a table and compared them using a graphical representation for gear and pinion separately as well as the assembly of the gear and pinion.

Moment vs. Max. Stress

Moment(Nm)

Applications of the designed Gearbox:

i. **Standard application:** This kind of gearbox can be used where the power transfer limit is relatively low. Often, these gearboxes are used in factories where we need to move items from one location to another. [10] Such as,

☐ Grain dryer,
☐ Power rake,
☐ Rack picker,
☐ Food handling,
☐ Stereo garage,
☐ Conveyor drives,
☐ Crushers,
☐ Mixers,
☐ Rubber industry,
☐ Paper industry,
☐ Packer,
☐ Textile machine,
☐ Food processing machine,
☐ Vertical turbine water pump,
☐ Lifting gear,
☐ Cane Installation,
☐ Rolling mill,
☐ Cable installation,
☐ Agitators,
☐ Massive ball units,

ii. **Special application:** Special mechanical components like Cooling Tower, Heat Exchanger, Super Heater, Wind Turbine, etc. where we need the special type of gear which can withstand at high temperature also. And for that, we have to harden them at the time of production.

III. CONCLUSION

FEA has been run on a single gear pair only, using **Structural Steel (yield point: 262 MPa)** material and compared the effects at different moments, and excellent results have been received; the **maximum moment** that could be provided was **1400 Nm**, and the **maximum stress** applied to the gears was **256.15 MPa**, indicating that engineered gears are reliable up to those moment limits. Normal stresses could be found at different moments by providing a new coordinate system at the point of meshing. During the meshing, the **maximum normal** stress was **88.232 MPa** at a **maximum moment** of **1400 Nm**. If we keep raising the moment, there is a risk of failure, which may result in a fracture. As a consequence, we must use a material with a higher yield point than structural steel if we want to increase the moment after this point.

The last but not the least step was to conduct feasibility of the gearbox, determine different manufacturing possibilities (Such as, milling, hobbing, CNC, etc.), applications for the engineered gearbox, and make recommendations for the manufacturing method which could be the best for producing this type of gearbox. Hence, After conducting a feasibility study on the gearbox, **CNC machining** could be a proper suggestion for

producing this type of bevel gear-pair, as well as some application areas where this type of gearbox could be used.

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