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(CAD) model

DESIGN PRESENTATION

C A D model

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HNC MECHANICAL ENGINEERING

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LEVEL 4

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Abstract (summary)

Design of a flap actuator is a critical process that enables alleviation of loads causing vibrations which results from an unsteady environment. They are relatively small in size with their scale compared with the other parts of the airplane. Flap actuators operate at rotational speeds which are relatively high so as to meet the desired Mach number. In design of this flap actuator consideration of its location to rotor radius has been considered from the standard of 65% to 85%.

For the suitability of the flap actuator, a mechanism is designed that gives a flap deflection of $\pm 4^\circ$ from the actuators of which its test should be checked by use of test bed.

In this report specifically a flap actuator has been designed with the drawing as shown in orthographic views and longitudinally. CAD software has been used.

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Introduction

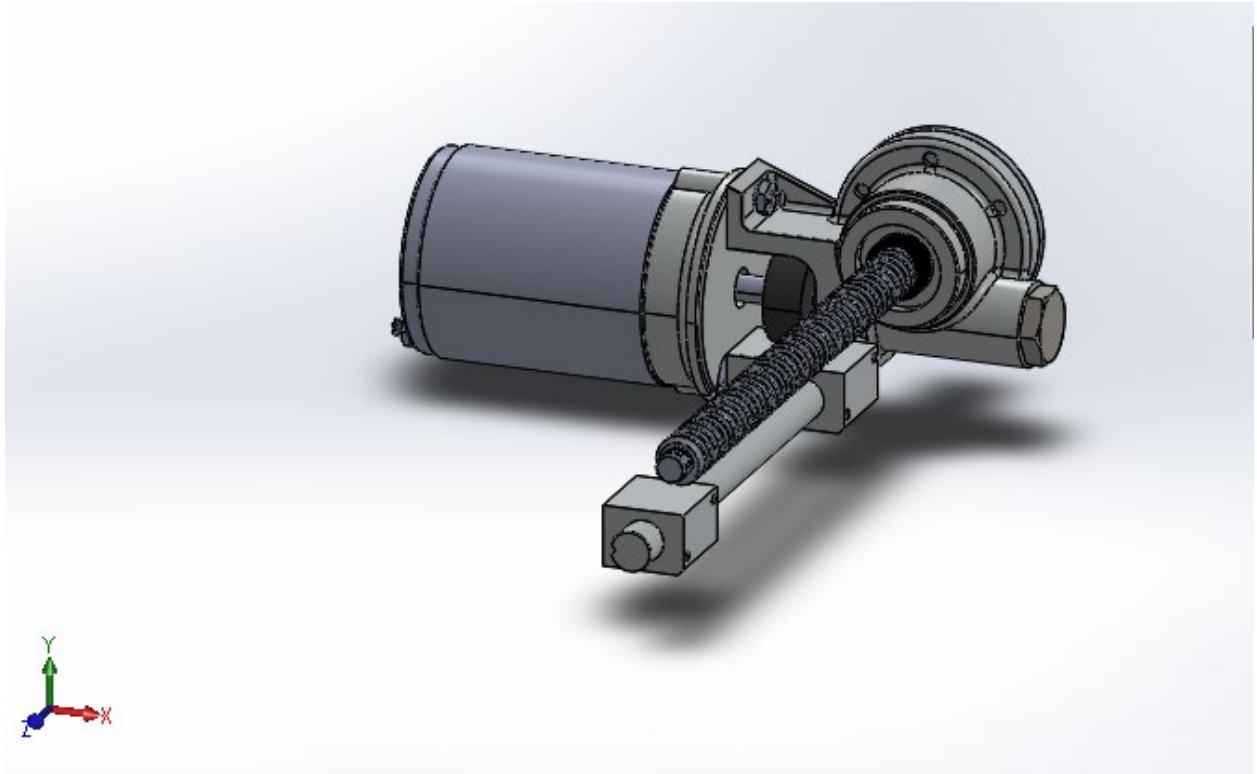
Calculations from the Design

Technical specifications for the actuator:

1. Max force: W Newton (7000)
2. Power screw/actuator linear velocity underload: 10.0mm/s
3. Reliability 95%
4. SF: 4-6
5. The compatibility
6. Max. extension: 200mm
7. Life 8years, assume the motor works 10hours per day at top speed.
8. Max. temp: 50°C
9. The gearbox can accommodate any type of Bevel, Spur or Helical gears but not Worm gears.
10. Screw actuator material should be aircraft grade aluminium.
11. Gears and shaft can be steel or aluminium.
12. Max. size of large gear 150mm

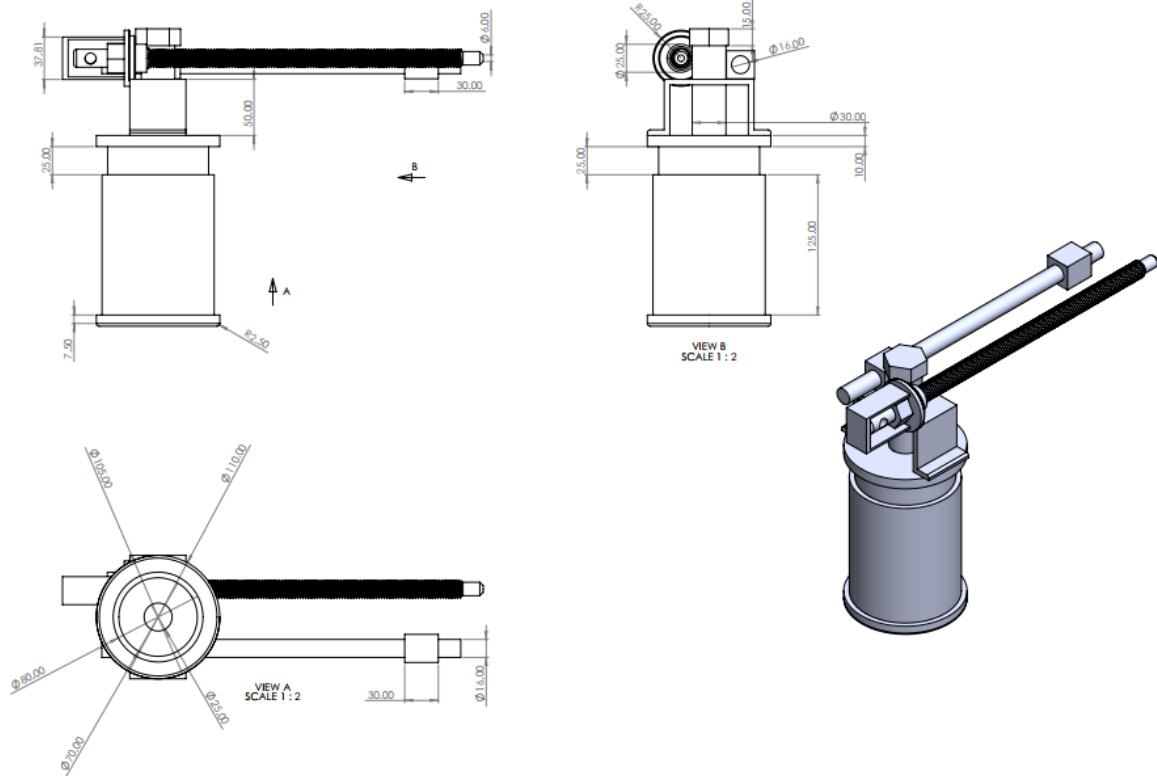
Developed designs in CAD software

No spur gears
used?



CAD.

Longitudinal cross-section of the gearbox



Gearbox specification

When considering the existing gear mechanisms, there are multiple types based on mating geometry as (Cavallie 2002),

Spur gear boxes – Most general type gear systems

Helical gear boxes – Same as spur systems, but teeth are inclined

Worm gear boxes – Worm and pinion systems

Bevel gear boxes – 90^0 angle deviation in power transmission direction

From the above-mentioned gearbox types, the design will be carried out as a spur gear box, which is an optimal choice for a design of simple, low-cost gear box (Anaheim, 2018).

- Spur gears are simple and cost effective when it comes to manufacturing, also are able to transmit huge power amounts.
- Most significant advantage of helical gear systems over spur systems is the less noise during operation.
- Worm gears are mainly used in high precision applications. They are rather expensive than both helical and spur types.

In order to maintain the compactness, the gears will be designed under minimum as possible diameter criteria

Shaft Designing Criteria

Material Selection of the Shaft

The shafts should be able to withstand the necessary torque (twisting moment) applied on it when in the operation of the conveyor line (Khurumi R S, Gupta 2005).

- Availability of the materials – The selected material should be readily available in the open market.

- Possessing enough strength to withstand operating forces
- Ability to being machined easily
- Wear resistance and fatigue resistance (endurance)
- Feasible heat treatment characteristics

There are several types of shaft types and materials to manufacture they are such as solid or hollow shafts with circular or square cross sections, manufactured by steel or non-steel materials. (Rangaswamy, Vijayarangan, Chandrashekar, Venkatesh, Anantharaman,).

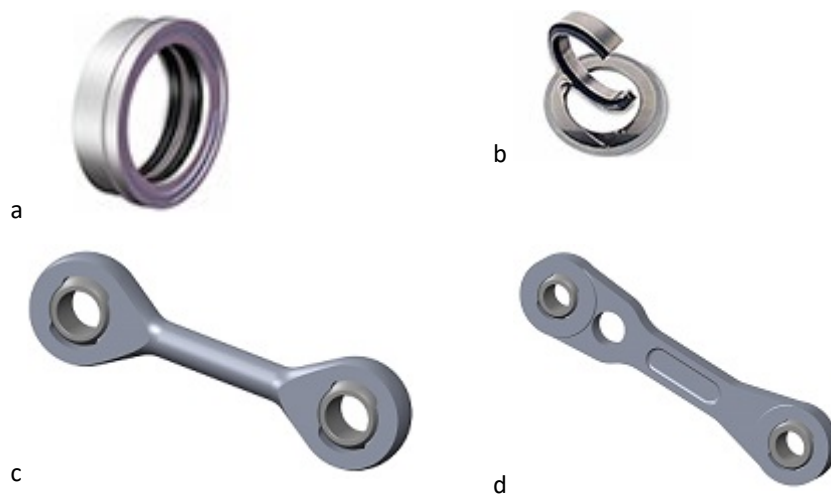
- When in operation, the shaft is rotating at a nearly constant speed transmitting the necessary torque
- Shaft is manufactured in a dimensionally accurate manner; cross section is circular throughout the length and the center of mass is located at the middle
 - The operational and functionality of the developed flap actuator involve transverse and rotary motions along with its socket and joints. This implies that bearings have to be used in the joints to minimize the rate of wear among other effect of frictions on the sliding or rotating sections. According to fabrication of the aircraft flanges and wings, the flaps are installed right inside the wings, with minimal allowance between the actuator and the adjacent components (Xu et al. 2019, p62). It therefore implies that devices installed in hidden sections are not subject to regular inspection neither is they frequently maintained (Kondratov, 2017, p.103). One key design consideration on such devices is the durability, reliability and life span of the materials used in fabrication of these parts.
 - The design utilizes rolling bearing type in the joints and sockets of the flap. For safety verification, fatigue analysis, reliability and service life of rollers, raceways and bearings were considered in evaluating the best material for bearings, sealing and casing compatible with the gear specifications (Nicholas, et al. 2020, p76).

Bearing selection and life calculations

Bearing selection

Bearing selection commenced in the initial flap design phase, where sustainable and satisfactory rating life of the whole gearing system was analysed. Based on the allowable working deflection and stress of on the shafts and gearing system, the size of bearing was evaluated first to permit the evaluation of bearing bores (Patel et al. 2021, p.49). However, manufacture of bearings has an established range of ISO standard dimensions and specifications of bearings available in the market, therefore the design calculation of the bearing specification for this design was largely influenced by the gearbox specifications and the ISO commercially available bearings

The bearing specification for the design was simplified, the speeds and loads had been established in gearbox specification. Under this section, the number of hours of rating life, reliability and maximum operating temperature were the key consideration. The design of the flap bearings and sealing are shown below.



- Gearbox sealing (a&b) and bearing mounts (c&d)

Conclusion

Aircraft actuator systems are normally based on ball-screws and are linearly designed; flap actuators, on the other hand, utilizes irreversible ACME screws while other flap actuators are designed in rotary reversible ACME screws. It is unrealistic to have uniform parts or components design specifications for all types of airplanes. Components and systems to be used in any specific aircraft are determined by various factors such as size, capacity, and purpose of aircraft operations' flight and speed.

APPENDIX

From the previous inventions that have been carried out in the past, need for a design of a flap actuator that portrays characteristic of simplicity in its installation and servicing it has become important. This is made possible only through incorporation of redundant loads in designing of their paths. Also, flap actuator needs to ensure that the position of the flap of airplane is maintained as compression loads are considered. Flap actuator is a component used on an aircraft wing so as to move flaps to produce a lift and minimise stalling chances of an aircraft during flight. They are located on the wing and parts that move the nut on the leadscrew that has a bracket mounted on the flap of the assembly

In the modern design of flap actuators, provision for controlling the movement for flap on the wings of an airplane has been incorporated with the main components of the actuator including a shaft that extends along the longitudinal axis that has terminal end that is capable of being connected to the flap in its operation. The shaft is designed in such a way to allow movement between a retracted position marked first and the second position (extended). An assembly (a no-back) is connected in operation so as to allow for the engagement and disengagement of the drive shaft from a ball nut with respect to the force on it. The housing of a flap actuator has a trailing and a leading end, this housing supports the ball nut during rotation. On the longitudinal axis a ball screw extends so as its end is connected to the flap during operation. A roller clutch is used between the housing so as to prevent the ball from rotating in a direction that might result in compressional forces on the ball screw by the flap.

Gimbal assembly comprises of a first and second gimbal which connects the house to the wing. A mounting pin is also used so as to connect the wing during operation. First and second pins are used to connect the first and second gimbal respectively to the wing. Rotation of the ball nut in the forward direction allows the screw to extend while rotation in the opposite direction retracts the screw this is enabled by introducing a rotatable drive shaft in the forward and the

opposite direction. Clutches are also mounted so as to allow for engagement and disengagement of the ball nut. Forward points in the air foils are the leading points and all of the point make up Leading Edge (LE). Leading Edge commence on the left air foil and ends air foil. Creating a reference line in the transverse direction which starts from Left Air foil to the Right Air foil of the plane. The reference line has two planes created that is the Start and End Plane. These planes define where the left and right air foil's control surface begins and end. These two parameters control the plane position of both planes.

FP- Flap Actuator

GA-Gimbal Assembly

LE-Leading Edge

SP- Start Plane

EP- End Plane

RA-Right Air foil

LA-Left Air foil

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