Design Exercise 01: Power Transmission Hub Design

System Description:

Hubs are used to transmit mechanical power from a drive motor by coupling it to an output wheel. Below Figure 1 shows an exploded view of a typical motor/hub/wheel assembly. In this illustration the hub-to-be-designed is connected to the output shaft of the drive motor. The wheel center hub is connected to the other end of the hub.

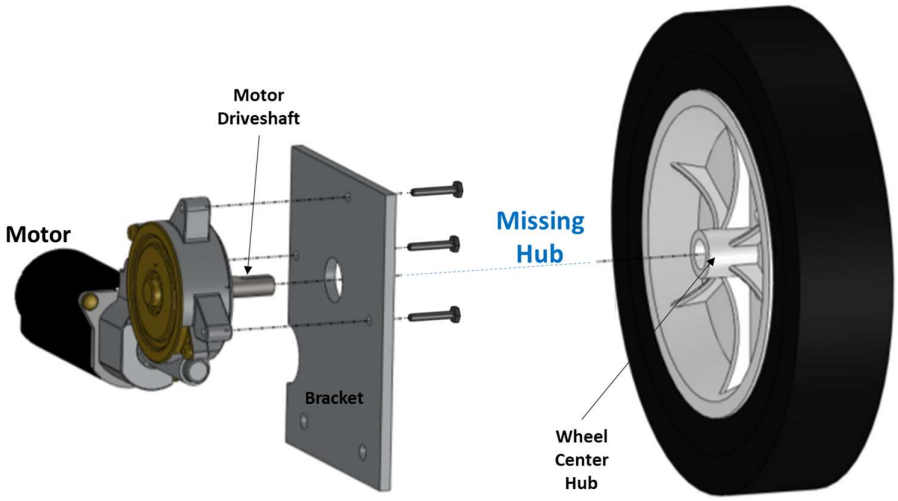

Figure 1 Exploded View of Drive Motor/Hub/Wheel Assembly

A locking bracket is used to bolt the motor onto the vehicle chassis. Space between driveshaft end and wheel center hub is 33 mm.

Power specs of the motor is rated to deliver 25 hp at 30 rpm. The output shaft of the motor is 45 mm and the shaft is made of AISI 4340 material, Q&T at 800°F. Note that motor is an expensive capital equipment; therefore, it should not fail before the hub in all circumstances. Also, per motor supplier, nominal diameter of the driveshaft can't be changed.

The hub will be designed to have its inside diameter of the bore slightly tighter with respect to the outside diameter of the motor driveshaft. This generates an interference fit which allows torque transmission from motor to wheel as well as maintains the hub to rotate concentrically with the shaft.

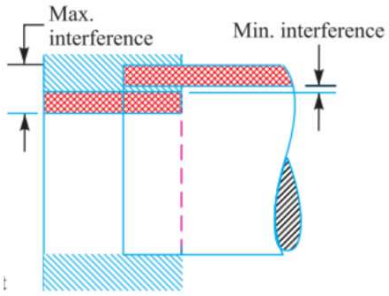

Figure 2 Illustration of Press (Interference) Fit

The next step in designing a hub is to determine how it will attach to the wheel. Wheels are attached by mating the hub to the center hub in the wheel and by mating the hub to the end face of the wheel center hub. The hub is designed so that its outside diameter is a very close clearance fit with respect to the inside diameter of the wheel center hub. This allows the wheel to slide freely onto the hub during assembly. A key and key way design will be used to transmit the torque. Width of the center hub is 10 mm.

Length-to-diameter (L/D) ratio for interference-fit prefers to be kept between 1.0 to 2.5.

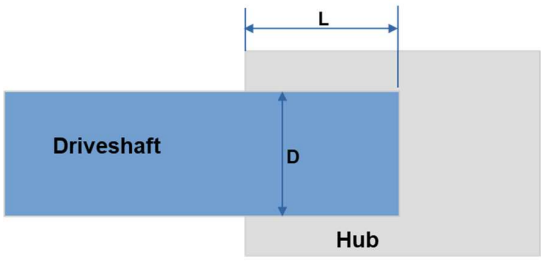

Figure 3 Illustration of Driveshaft/Hub Joint

Scope of Work:

- Provide engineering sketches to specify all major dimensions (including tolerances) of the designed hub relevant to the required fit conditions.
- Design fit conditions per ANSI B4.1 standard.
- Recommend dimensions and tolerances for the wheel center hub.
- Suggest tolerance band for the driveshaft. Discuss the impact to your design if tolerance of the driveshaft diameter is ±0.025mm according to motor supplier.
- Document all design assumptions and calculations supporting your design decisions.
- Specify material selection for the hub.
- Estimate the factor of safety of critical components under the worst case scenario.
- Critique your design decision on critical design parameters, such as length-to-diameter (L/D) ratio and appropriateness of safety factors, etc.
- Recommend a process to apply the specified interference fit and explain your rationales
- Key and keyway design at hub/wheel interface can be ignored in this DE.

Notes:

- Outline all assumptions made in your design process and provided reference sources.
- Provide citations of referenced material and technical data.
- Cost is always an important factor in making design decisions.

Typical Safety Factor for Mechanical Systems (Ductile Materials)

Safety Factor Range	Design Condition
1.25 to 2.0	Design of structures under static loads for which there is a high level of confidence in all design data.
2.0 to 2.5	Design of machine elements under dynamic loading with average confidence in all design data.
2.5 to 4.0	Design of static structures or machine elements under dynamic loading with uncertainty about loads, material properties, stress analysis, or the environment.
4.0 or higher	Design of static structures or machine elements under dynamic loading with uncertainty about some combination of loads, material properties, stress analysis, or the environment. The desire to provide extra safety to critical components may also justify these values.