Axle Failure Case Study

Figure 1 shows a photo of a grain drill. A grain drill is an agricultural implement towed behind a tractor. It is used for planting for grain that is spaced closely together such as wheat, oats, barley and sometimes, soybeans.

Figure 1. Grain drill, Note that the left side wheels are no longer attached to the grain drill due to an axle failure.

This grain drill has been in production and use for 10 years without any problems. The marketing department created a new heavy duty model with larger seed hoppers that can carry more seed. Unfortunately, the grain drill was not redesigned to withstand the increased forces and field failures such as that shown in Fig. 1 are now common. Figure 2 shows one of the failed axles from an unhappy customer.

Figure 2. Fatigue failure of the axle.

An illustration of the wheel assembly is shown in Fig. 3. Power to operate the grain drill planting mechanism comes from being pulled along the ground behind the tractor. Power is taken through a chain drive attached to the wheel shaft with a pin. This pin hole is the failure location in Fig. 2.

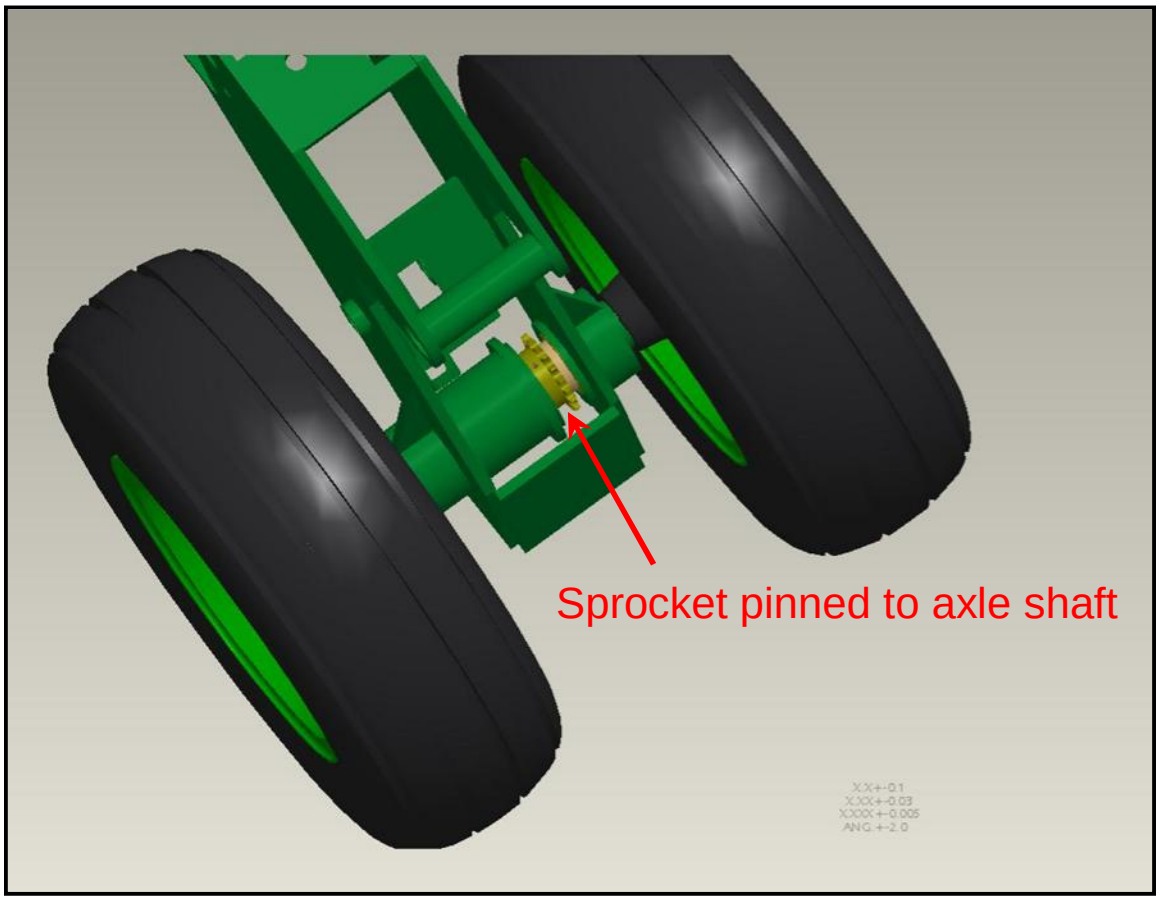

Figure 3. Wheel Assembly

The forces acting on the wheels are shown in Figure 4. In the original design, the draft force was 3000 N per wheel. This force was increased 25% to 3750 N per wheel. The draft force resists the pulling force of the tractor and is a result of friction and inertial forces. There is a small torsion force on the sprocket which can be neglected. The static vertical wheel force was increased from 10,000 N to 12,250 N. Experience has shown that dynamic loading can increase the vertical wheel forces by as much as a factor of 2.5.

Figure 4. Wheel Forces

Dimensions of the wheel assembly are shown in Fig. 5. The axle rotates with the wheels like a railcar wheel assembly. Two tapered roller bearings 225 mm apart connect the axle to the planter frame. The centerline of the wheels is located 175 mm from the bearing. A chain sprocket 75 mm from the right bearing drives the planting mechanism on the planter frame. A wheel hub attaches to each side of the axle. Stamped steel wheels are bolted onto the hubs. Typical speed of the axle shaft is about 75 rpm. It is manufactured from cold drawn 1045 steel. The axle (Fig. 2) is a simple design, a straight shaft 50 mm in diameter with an 8 mm hole drilled into the shaft to attach the sprocket with a pin.

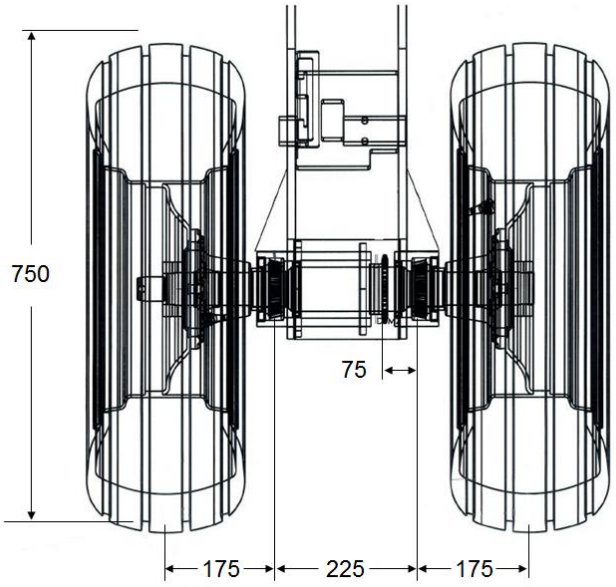

Figure 5. Wheel Assembly Dimensions

Calculation Exercises / Discussion Questions

1. Preform a fatigue analysis and estimate how much the fatigue life is expected to change from the old to the new heavy duty grain drill design.

2. There are many grain drills already in service that need to be retrofitted with a new axle shaft. Recommend a way to improve the fatigue life of the axle shaft that will not require any modification to the existing frame and wheel design.