Fastener Failure at Elevated Temperature

by:
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FTI EMPHASIS: Fastener Failures

Some grain roasters incorporate a chain conveyor connected to baffles moving soybeans over a perforated floor, as shown in **Figure 1**. A burner heats air, which flows through the perforated floor, roasts the grain and exits through a flue. The baffles attached to the chain conveyor move the grain along the floor until they exit at the end of the machine.

Bolts attach the baffles to the chain conveyor, which must tolerate temperatures in excess of 500°F. The choice of fastener is a design decision that dictates the success or lack of performance of the machine. This case study serves to illustrate a fastener failure that severely damaged one such machine.

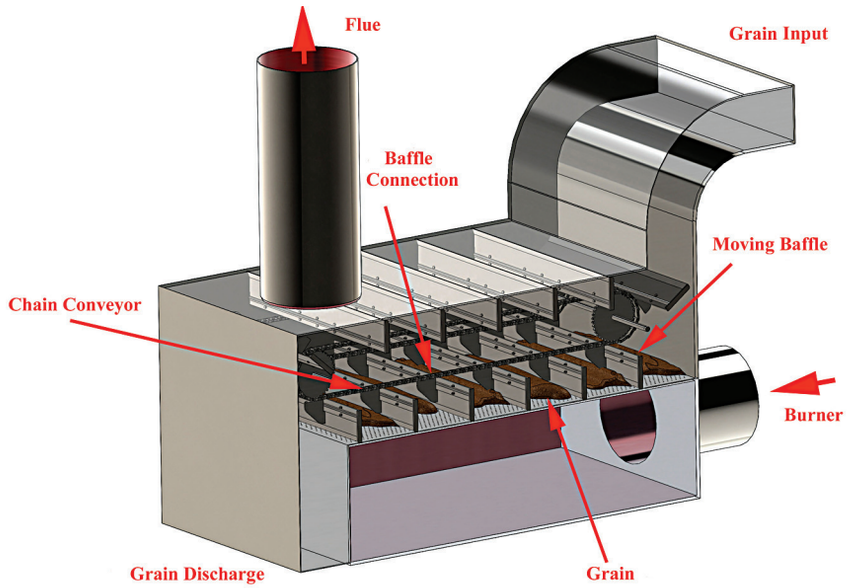

Fig. 1 — Grain roasters incorporating a chain conveyor connected to baffles moving soybeans over a perforated floor.

Case Study

In the grain roaster, several baffles had failed, jamming the machine and causing loss of production. The failures occurred in the bracket that attached the baffles to the chain conveyor, see **Figure 1**.

Figure 2 is a close-up of the remains of a bracket attached to a baffle after failure. The bolt to the lower right has backed out, reducing the clamping force between the bracket and the baffle. This caused the baffle to rock back and forth, causing a fatigue failure. The fractured chain drive bracket is carbon steel and the baffle is stainless steel. The bolts are 304 stainless steel (*ASTM E593*), size 3/8", course thread.

The lower right bolt was removed and examined. The stainless steel lock washer that was removed, shown on the left in **Figure 3**, illustrates the change in configuration when compared to a new lock washer on the right. Stress relaxation has occurred as a result of temperature and bolt preload. It should be noted, that the coefficient of thermal expansion of stainless steel is typically higher than that of carbon steel, suggesting that in this design, bolt tension would be reduced at higher temperature. The loosening of the bolt is a combination of thermal expansion, relaxation of the spring tension in the lock washer and alternating loading. In this condition, the locking capacity of the lock washer and bolt preload are insufficient to retain the fastener in position. The helical spring lock washer/bolt combination is a widely used fastener. In some applications, like that shown above, the fastener has its limitations. Analysis of the design using computational methods (FEM) or physical testing will improve the chances of a viable design.

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Fig. 2 — Close-up of the remains of a bracket attached to a baffle after failure.

Fig. 3 — Stainless steel lock washer removed from the assembly (left) compared to a new lock washer (right).

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