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SNOWBLOWER FAILURE ANALYSIS CASE STUDY

By Dennis B. Brickman*

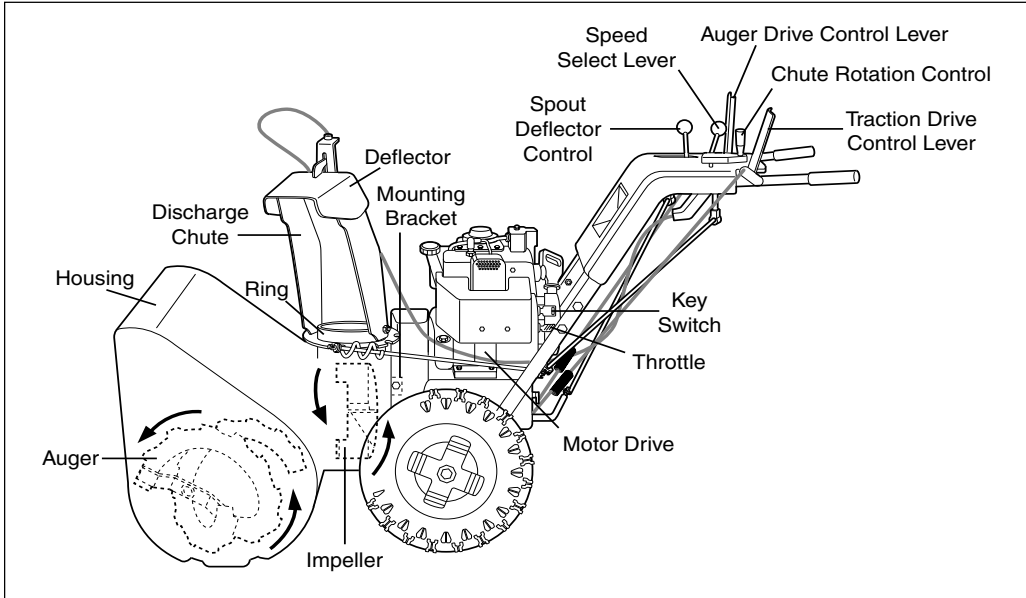


Figure 1 - Snowblower

ABSTRACT

A failure modes and effects analysis was conducted to analyze the cause of a snowblower accident in which the operator's hand came in contact with the rotating impeller. Systematic analysis showed that the accident was caused by multiple failures of the snowblower and improper snowblower service. Results of the analysis indicate that there are available design alternatives and countermeasures which would have prevented the accident.

I. INTRODUCTION

Snowblower Description

The subject professional 10 horsepower two-stage snowblower depicted in Fig. 1 utilizes an auger to collect the snow and an impeller to blow the snow out of the discharge chute. The auger is belt driven by the crankshaft pulley (A) off the engine crankshaft as shown in Fig. 2. The auger is engaged by moving the auger engagement lever (D) to the handle, which tensions cable (H) into spring (I). Upward force on the tension spring rotates cross shaft assembly (J) which moves idler pulley (C) into contact with the auger drive belt (K). Releasing the control lever allows the cross shaft (J) to rotate, moving the idler pulley out of contact with the drive belt. Adjuster (G) sets the auger drive belt tension. The adjustment is made by changing the position of a nut on the lower threaded end of the cable positioned inside the tension spring (I).

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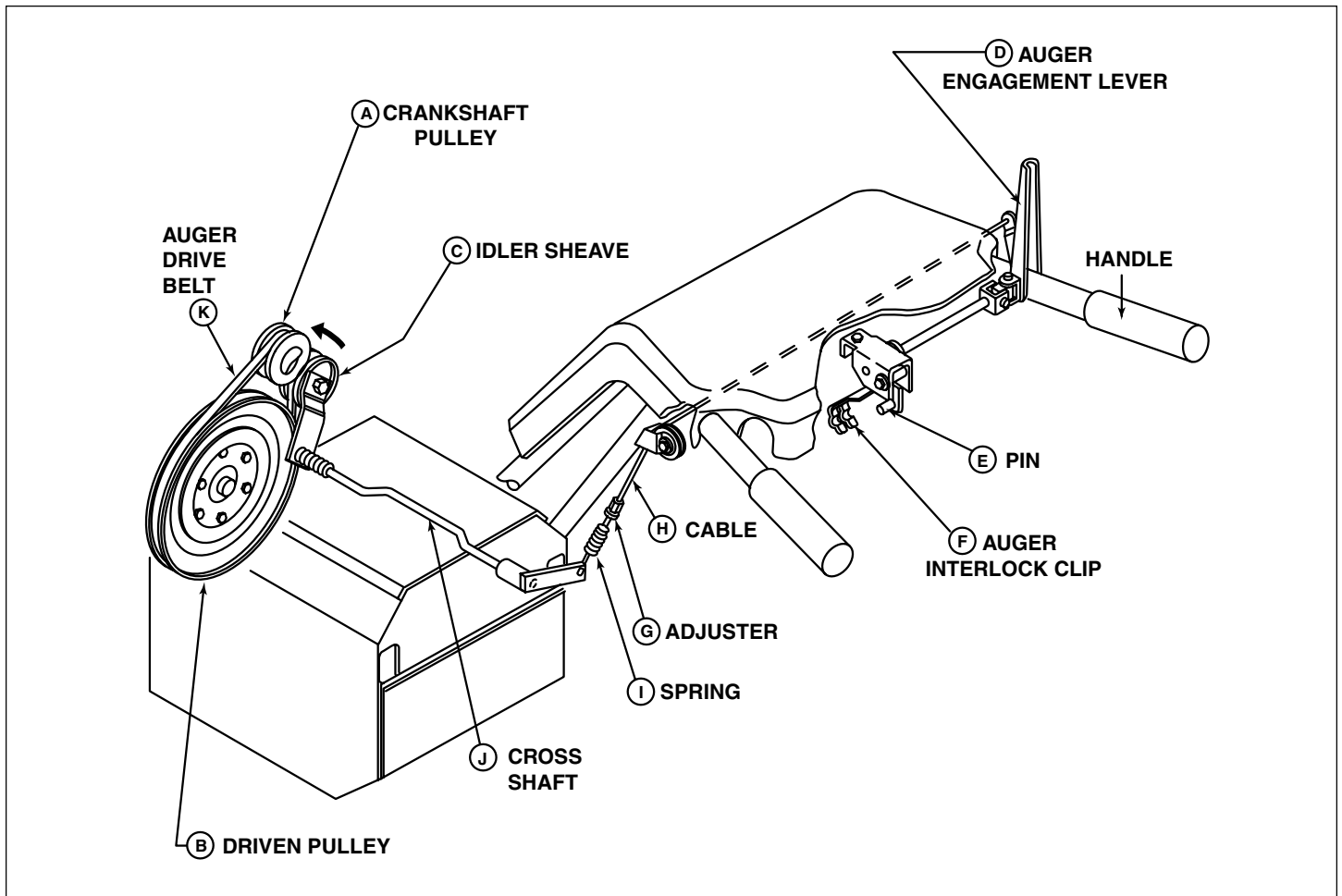


Figure 2 - Auger Control System

The auger drive and traction drive have an interlock system which allows the machine to be operated from either handle, while keeping both functions engaged. Whenever the auger engagement lever is held down, pin (E) engages in clip (F). The clip holds both auger and drive controls, but releases when hands are removed from the controls.

Accident Description

At the time of the accident, the snowblower operator was clearing 15.2 - 30.5 cm (6 - 12 in.) of snow from the sidewalks at a condominium. The discharge chute was pointed to the operator's right. All of a sudden, the discharge chute disconnected from the auger/impeller housing and was projected up and to the right, creating a vertical stream of snow. It should be noted that the discharge opening was not clogged. The operator released both the left traction drive control lever and the right auger drive control lever while the engine remained running and proceeded to walk around the right side of the machine. Then the operator attempted to grab the disconnected discharge chute which remained attached to the machine only by a cable which controls the discharge deflector. As the operator reached for the detached discharge chute, he slipped and his hand went through the discharge opening and contacted the rotating impeller. Approximately 10 - 13 seconds elapsed from the

time the operator released the operator presence controls for the traction drive and auger/impeller drive until his hand contacted the rotating impeller.

Snowblower History

Approximately two weeks after the snowblower was first put into use, the auger/impeller housing separated from the motor drive. Consequently, the snowblower was taken to a repair shop where the two groups of parts were reassembled. The service invoice for this repair has the following description of work performed:

1. Mounting brackets broke out of fan housing.
2. Grind them to fill back in holes.
3. Weld brackets back into place.
4. Weld extra support bracket on.
5. Paint brackets.
6. Install blower assembly back to motor drive.
7. Test to bolt up correctly.
8. Fix pull cord handle.

It is a policy of the repair shop to make sure the snowblower is properly adjusted and working properly when it leaves the shop. However, after the repair to the subject snowblower was completed, the snowblower was never

started, operated or tested. Furthermore, even if the personnel at the repair shop had checked the operation of the snowblower after the repair was completed, they did not know what the proper auger/impeller stopping time should be after the auger drive control is released.

Shortly after the accident, a welder repaired the discharge chute by brazing externally all the way around the lower collar and reattaching the flange to the machine. Following the welder's repair of the discharge chute and approximately two weeks after the accident, the snowblower was taken back to the repair shop because the drive shaft broke and bearings needed replacing.

ACCIDENT INVESTIGATION

Warranty Claims

A total of 940 warranty claims have been reported for the subject model snowblower. The majority of these warranty claims cover problems associated with the auger/impeller housing including 164 claims of the auger/impeller housing separating from the motor drive due to failed mounting brackets. In addition, there are a plethora of warranty claims associated with discharge chute assembly problems including 26 claims of the discharge chute falling off the machine. Other relevant warranty claims include the following in random order:

1. Ring that holds chute broke off.
2. Welds broke at discharge chute mounting ring.
3. Material too thin that holds spout.
4. Auger would not stop. Brake was broken.
5. Brake shoe was improperly assembled at factory, causing it to break.
6. Brake broke off arm.
7. Brake arm and spacer were installed wrong on idler.
8. Brake pad material gone off arm.
9. Auger brake pad bonding let loose.
10. Mounting tab interferes with brake arm.
11. Arm was bent such that it interfaced with belt.
12. Arm broke.
13. Welded pivot for auger brake broke off letting brake fall into belt and tear belt up.
14. Spring broke making arm fall down.
15. Brake spring broken.
16. Spring broke when auger engaged.
17. Defective belt.
18. Housing did not come with decals.

Several warranty claims stated that the snowblower was adjusted, run and tested after the repairs were completed.

Auger/Impeller Stopping Time

According to paragraph 4.2.4.1 of the American National Standard for Snow Throwers - Safety Specifications, ANSI B71.3-1984 (1), "A means shall be provided that will automatically stop the impeller in 5 seconds when the operator

leaves the operator position." According to the appendix of ANSI B71.3-1984, a five second stopping time is generally below the normal time it takes an operator to leave the operator's position and to reach the hazard area of the rotating impeller. Figure 3 illustrates the auger/impeller system for the subject snowblower. When the auger engagement lever is moved to the handle, the idler pulley moves into contact with the auger drive belt and the brake arm pivots, releasing the brake from the driven pulley. This allows the auger and impeller to rotate under power. Releasing the auger engagement lever moves the idler pulley out of contact with the drive belt and the brake makes contact with the driven pulley. This causes the auger and impeller to come to rest in less than two seconds when the snowblower is properly adjusted. At the time of the accident, the auger and impeller continued to rotate for at least 10 - 13 seconds after the operator released the operator presence controls for the auger/impeller drive and the traction drive. Although the operator's manual and the technical manual for the snowblower provide instructions for adjusting the auger/impeller system, no instructions are given for the required stopping time of the auger/impeller.

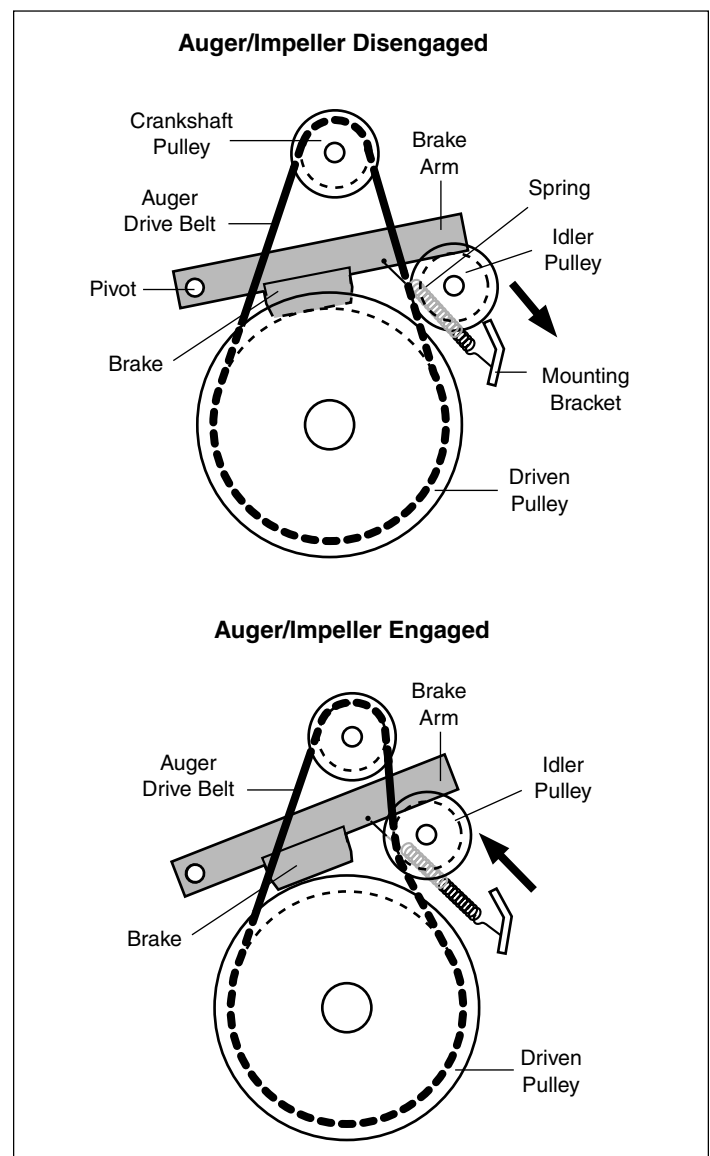


Figure 3 - Snowblower Auger/Impeller System

Potential causes for extended auger/impeller stopping time include the following:

1. Broken/disconnected spring.
2. Broken mounting bracket.
3. Improper auger drive cable adjustment.
4. Improper auger drive belt adjustment.
5. Tight auger drive belt.
6. Brake arm/mounting tab interference.
7. Broken/missing/worn brake pad.

Snowblower Repairs

In order to perform the repairs made prior to the accident to separate and reassemble the auger/impeller housing and the motor drive as listed in the snowblower history section, the auger drive belt had to be removed and reassembled. After completing repairs it was the standard procedure of the repair shop to start machines and ensure that belts were functioning properly and that machines stopped within a reasonable time. When interviewed, the repairman stated that an auger/impeller stopping time of 30 to 60 seconds after the auger engagement lever is released is reasonable. However, in this instance the snowblower was never started, operated or tested before it was returned to the customer. Therefore, the auger/impeller stopping time after the repair shop completed the repairs before the accident is unknown.

Auger Housing Retrofit Kit

After the date of manufacture and before the sale of the subject snowblower, a service information bulletin was published regarding auger and housing changes for the snowblower. The bulletin contains the following complaints:

1. Auger flighting bends.
2. Housing side plates bend or separate at lower weld seams.
3. Chute ring fails.
4. Water freezes in the housing.
5. Have to remove impeller shaft to replace bushing.

The bulletin states the following problems:

1. Auger flighting bends from contact with rocks or other debris.
2. Housing sides bend from contact with curbing or other solid objects. This also puts a high stress load on welded seams at the lower corners.
3. Chute ring welds fail and destroy ring. Chute ring is not a service part.
4. Water does not drain from housing and freezes.
5. Cannot reach impeller bushing hardware without removing impeller.

The bulletin specifies the following solution: Install new auger and/or housing which has the following improvements:

1. Auger thickness increased from 12 gauge (0.264 cm/0.104 in.) to 10 gauge (0.330 cm/0.130 in.) to strengthen flighting.
2. Side plates are embossed to strengthen the leading edge. Also the bottom edges have a tab added that bends around and connects to outside bolts of the scrapper bar to increase strength to each lower housing seam.
3. Housing-to-frame mounting tabs are changed to increase the weld area to secure tabs better.
4. Chute ring welds increased from 4 to 8. Also chute ring is now a service part.
5. A 0.794 cm (0.312 in.) drain hole in bottom of housing allows water to drain out to help prevent freezing.
6. Drive bolts with a serrated shoulder are used to hold the impeller bushing in place. This will reduce labor time if bushing has to be replaced.

Figure 4 illustrates the auger housing design for the subject snowblower. Examining Fig. 4, a set of four clips are utilized to attach the discharge chute assembly to the chute ring. Figure 5 demonstrates the auger housing retrofit design. Here, bolts are utilized with a retainer, bushing, and ring gear to secure the discharge chute to the auger housing.

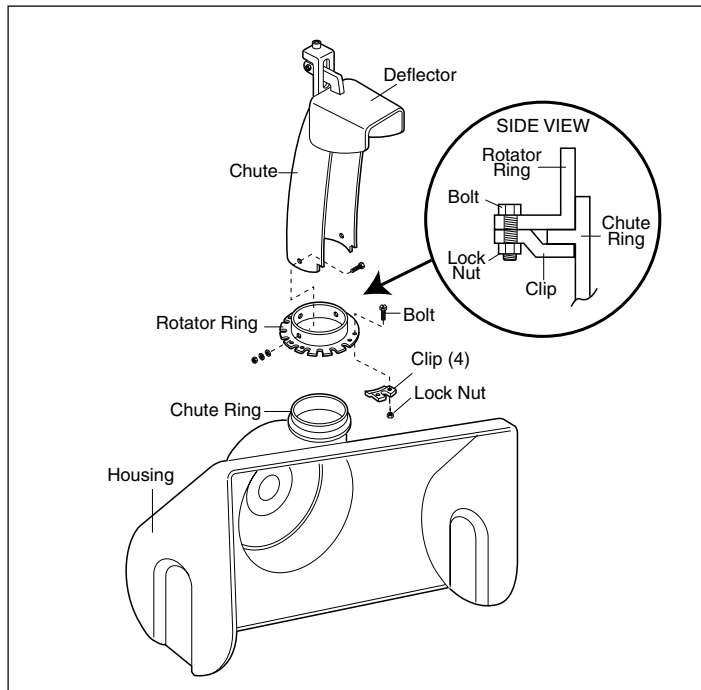


Figure 4- Auger Housing Design

The auger housing retrofit kit became available for the subject snowblower before the accident, but no attempt was made to notify the machine owner. Machine owners were made aware of the auger housing retrofit kit after they complained about the problems experienced with their snowblowers. The new auger housing was incorporated as standard equipment into the subsequent model year snowblower design.

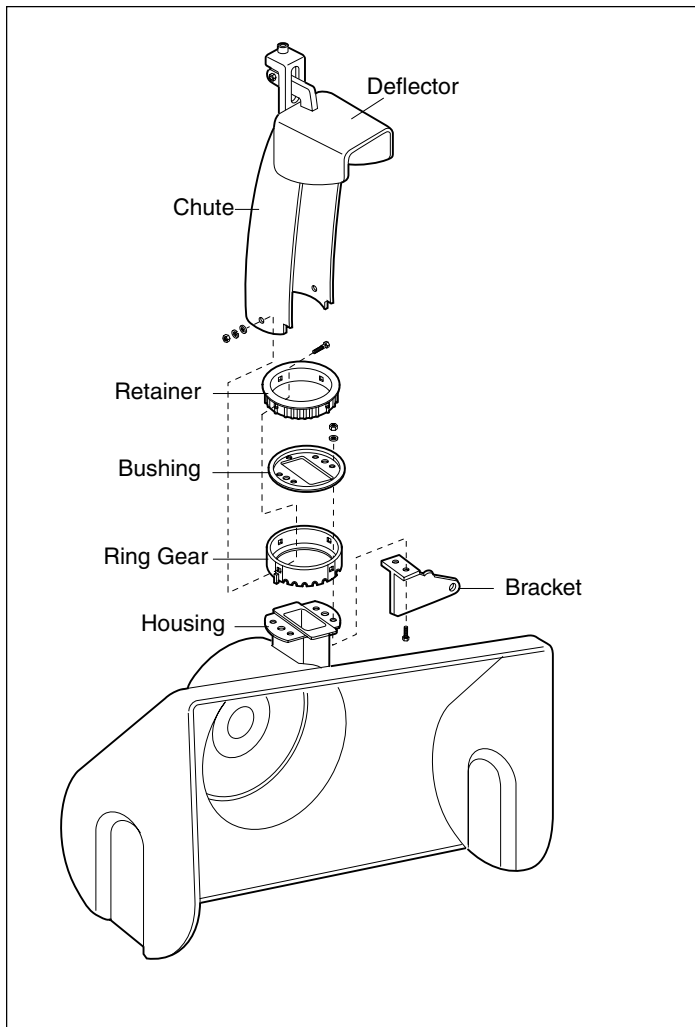


Figure 5- Auger Housing Retrofit Design

CONCLUSIONS

The following design alternatives can be utilized to prevent the subject accident.

1. The snowblower producer can incorporate an auger housing/discharge chute design that is not susceptible to the discharge chute falling off the auger housing. Alternative design features include increasing the number of chute ring welds, increasing the thickness of the material that holds the discharge chute, and incorporating a different method of attaching the discharge chute to the housing.
2. The snowblower producer can provide a snowblower design which is not susceptible to failures of the auger/impeller drive assembly components which could lead to an extended auger/impeller stopping time. The ANSI B71.3-1984 snow thrower safety specifications state that a means shall be provided that will automatically stop the impeller in 5 seconds when the operator leaves the operator position. This can be accomplished by improv-

ing the reliability of the brake, brake arm, pivot, spring, mounting bracket, and auger drive belt.

3. The snowblower producer can provide a snowblower design which is not susceptible to failures resulting in the auger/impeller housing separating from the motor drive. Increasing the weld area to better secure the mounting tabs and adding support brackets are methods to accomplish the desired result.
4. Instructions can be provided in the technical manuals regarding maintenance actions needed to fulfill the ANSI B71.3-1984 five second auger/impeller stopping time requirement when the operator leaves the operator position.

The following accident prevention countermeasures can be utilized to prevent the subject accident.

1. Notify the subject snowblower owner of the availability of the auger housing retrofit kit and install the retrofit kit on the machine.
2. The repair shop can start, operate, and test the snowblower after the auger/impeller housing is reassembled to the motor drive before the accident to ensure that the auger/impeller stopping time is five seconds or less when the operator releases the operator presence controls for the auger/impeller drive and traction drive.

REFERENCES

1. "American National Standard for Snow Throwers - Safety Specifications," ANSI B71.3-1984, American National Standards Institute, New York, July 19, 1984.

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SAFETY BRIEF

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