Fuser Roller Core and Drive Collar Assembly Design for High Speed Printer

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Abstract

Very high speed electrophotographic printers often use a fusing system consisting of a fuser roller and associated drive mechanisms which employ a coupled drive hub assembly. The fuser roller typically includes a metal core onto or into which a mating drive hub and collar assembly are connected. Rotating at high rotational speed, and at high temperature, with extremely fast start/stop conditions, instabilities create issues between the contacting surfaces causing micro machining issues which eventually develop failure modes of the apparatus. Such is the case in the drive system employed in printers using a drive key and drive slot configuration. The thermal expansion of the aluminum core differs significantly from the thermal expansion of the steel drive hub causing loss of contact between the mating surfaces. Micro machining occurring between the steel drive key and the aluminum core slot, widens and weakens the drive slot causing eventual failure of the roller and drive hub, sometimes catastrophic.

The design of the fuser core and the drive collar assembly has undergone development that takes into account the differing thermal expansion of the aluminum fuser core and the steel drive hub. The development has been furthered by a unique design which incorporates a self locking and self centering drive mechanism, along with a rubber interface design, again taking into account for the thermal expansion of aluminum and elimination of the drive key and slot, to address the failure mechanism of the previous designs. This mechanism absorbs the shock energy of the fast start – stop motion, dissipating the energy over the full surface diameter of the drive hub. This paper describes the design history, the associated failure modes, and the new and novel solution.

Introduction

High speed electrophotographic digital laser printers utilize a fuser roller and a mating pressure roller, rotating at high speed, to fuse the toner to a substrate. As the media passes between the fuser roller and the pressure roller, the toner is fused to the media through a process using pressure and heat exceeding 180° C. The interference area between the fuser roller and the pressure roller, referred to as the nip, is desirable to maintain a substantially uniform pressure. Non-uniform pressure, due to wobble and chatter may result in degraded print quality and wrinkled print media. Non-uniform contact in the drive mechanism of the rollers may result in destructive consequences during high speed, start stop operating conditions. As a result, the various fusing assembly components should preferably be mated to close tolerances at room temperature and remain close at operating temperatures of 200°C, with the expansion of different components.

The fuser roller typically includes a metal core made of aluminum and a polymer coating applied to the surface. The mating fusing assembly of the printer includes hub and collar coupled to the drive mechanism. The fusing drive assembly components are commonly fabricated of a steel alloy and may also include drive members such as a steel key. In the original design a plastic collar is placed between the steel drive hub and the aluminum fuser roller. As the fuser components heat from ambient temperature to operating temperatures exceeding 180° C, the components of the fusing assembly expand in relation to their respective coefficients of thermal expansion. The thermal expansion of the aluminum roller core is significantly larger than the thermal expansion of the steel hub components. The thermal expansion of the plastic collar is significantly less than the thermal expansion of both the aluminum roller core and the steel hub components and therefore provides no mating compliance at operating temperatures. Over the life of the product, destructive micro machining and cracking occurs in the fuser roller and in the steel drive keys. Therefore, a system and method for addressing these design issues and problems is needed.

Discussion and Results

The objective of design and development of a new fuser and drive hub system is to provide an apparatus that will reduce the fuser roll and hub/collar assembly wear and breakage over the life of the fuser roller at operating temperatures. The design criteria of the system is to compensate for the differences in the thermal expansion between different materials from which the fusing members are composed, thus reducing the micro machining wear and cracking due to the high speed start-stop operating conditions.

Figure 1 shows the destructive micro machining of the drive slot of the aluminum core and the steel drive key of the original drive system design. The constant wear caused by high speed starts and stops and the small vibrations of the components during steady printing produce a failure mode of the fuser roller before the actual printing surface the fuser roller has reached its life expectancy.

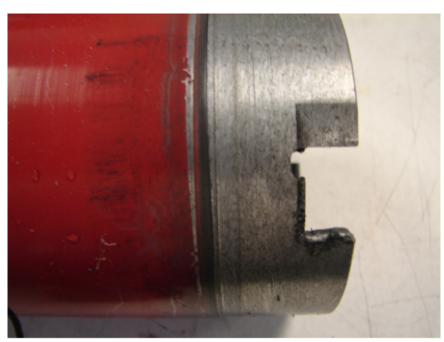

Figure 1. *Excessive drive slot wear of fuser roller core.*

The new designs and development of the fuser roller and drive assembly were evolved over a period of several years. The initial design incorporated modified components based upon the original design. The latest design broke from the original drive design to a unique mechanism incorporating the drive dynamics with the temperature expansion compensation of the initial hub design.

The original OEM design [1] of the fuser and drive hub assembly, mounts the stainless steel hub into the inner diameter of the aluminum core. A single drive key on the front and rear hubs mate with drive key slots machined into the front and rear of the fuser core. A plastic ring is placed between the two mating surfaces of the hub and core. At operating temperature of 200 ºC the aluminum core increased in diameter about 200 microns, while the stainless steel drive hub expands less than 10 microns, and the plastic ring not at all. To compensate for the expansion differences between the aluminum core at 200ºC and the stainless steel hub, a fluoropolymer rubber (FKM), with expansion conditions similar to the aluminum, is molded onto the steel hubs that mate with each side of the fuser roller. The rubber then expands with the fuser core as it heats, thus forming a full contact mating surface between the core and the hub, [2]. Thermal mechanical analysis (TMA), performed under ASTM E 831-05 conditions using Perkin Elmer Series 7 DMA/TMA instrumentation, showed a 3.6% increase in thickness at 200 ºC from 25ºC. The plastic collar is eliminated from the system.

The drive key and drive slot wear, due to micro machining at operating speeds, and the impact of sudden stop and starts, also needed to be considered in the evolution of the system. To help compensate a second drive key was added to the rear hub and the rear of the fuser roller core. All the drive slots on the fuser roller were then reinforced with steel brackets. Figure 2 shows the hub fuser system.

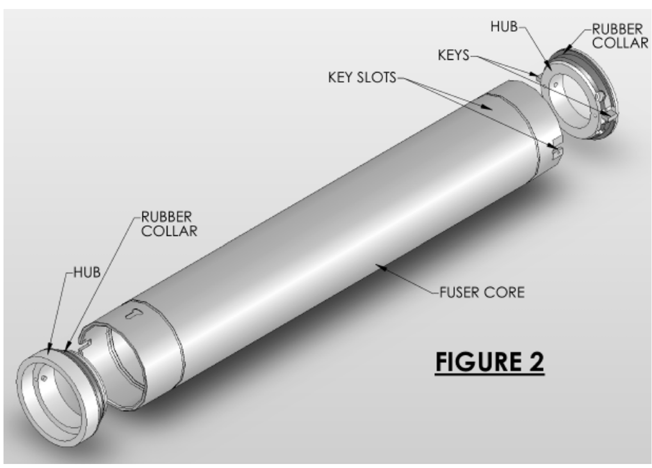

Figure 2. FKM rubber Hub and fuser core assembly.

The results of the rubber hub and fuser assembly with two drive keys were that the cracking of the fuser roller core, causing life failure, was eliminated, and the overall life of the fuser roller was increased by 20%. The life of the hub more than doubled because the steel drive keys do not wear as quickly. Still though, micro machining issues between the drive slots in the fuser roller and the steel drive key on the hub persisted. Though reduced in severity, and improved life of the drive hub over the original system, it remained the item to improve the life of the products even further. The next iteration deviated dramatically in design, by eliminating the drive key and drive slot all together.

Keyless Hub and Fuser

The concept of eliminating the drive key and drive slot design was accomplished by employing a “ratchet type” design geometry surface profile on the outside diameter of the hub and a mating geometry on the inside diameter of the fuser core. The geometry is defined by at least two opposite circular arcs, 180 degrees apart. Each opposing arc is a portion of a circle whereby the center of the circle is offset an equal but opposite distance from the center of the minor circle. The distance from the center of the minor circle defines the height or depth of the arc, depending upon if the arcs are inscribed on an exterior or interior surface, [3]. Figure 3 shows the defining arc concept. The center of circle A is a distance x from the center of circle C and circle B, an equal distance x from the center of circle C. The centers of A and B and C align along a straight line. The Arcs a and b, formed by portions of the opposing circles, define the geometric profile of the system and the height or depth of the surface profile.

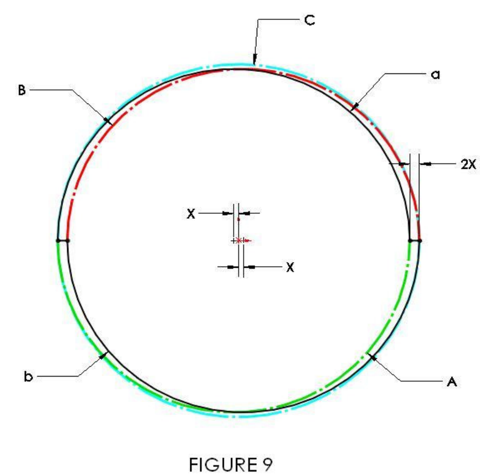

Figure 3. Arcs formed by offset circles, defining the geometric shape of the keyless hub and mating fuser core.

Figure 4 shows the surface geometry of the hub exterior profile. The exterior of the hub mates with the equal but opposite interior geometry of the fuser core. The system self locks as the two surfaces rotate into each other. As the printer drive starts, the drive side (rear) locks to a point where it will not move. The idle side of the roller, front side with a bearing, has a surface profile which is in the opposite direction of the rear hub and core to compensate for momentum. The rear motor drive of the system stops suddenly but the rotational momentum of the fuser core with the front bearing wants to keep rotating. In the original OEM drive key system this sudden stop of the fuser roller momentum is the major cause of core cracking and key/slot failure. In the “ratchet” concept, that forward momentum further locks the fuser roller to the front hub while keeping the rear hub locked in place, thus eliminating issues seen with the key/slot design. The high forces exerted at start and stop are compensated for in this design and lock the fuser roller into place with the hubs. The opposing forces of start and stop on the front and rear of the fuser core are not sufficient to unlock the mechanism, thus allowing for a hub core system which does not chatter and does not crack or wear surfaces.

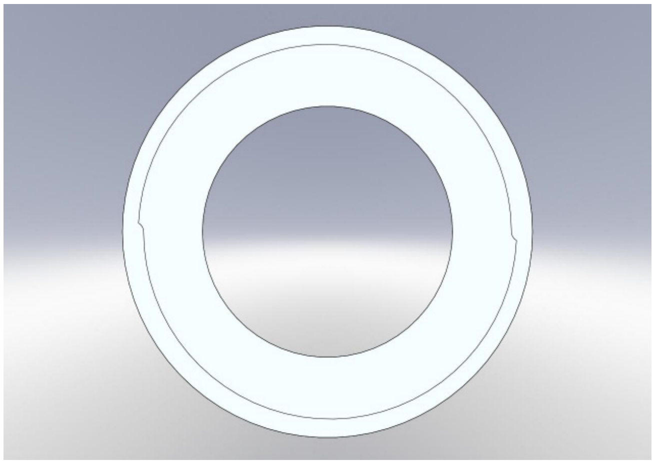

Figure 4. *Surface profile of outer diameter of the hub.*

To compensate for the expansion differences between the aluminum core and the steel hubs, a fluoropolymer rubber is molded to the steel hub, as in the keyed hubs described. The rubber is precisely molded to the geometry necessary to mate with the fuser roller. As the temperature of the fuser roller increases to operating temperature, the rubber expands in similar fashion, thus maintaining contact between the two surfaces, [1,2]. Figure 5 shows the mating surfaces of the keyless hub and core system with FKM rubber (dark colored portion) molded onto the outer diameter of the hub.

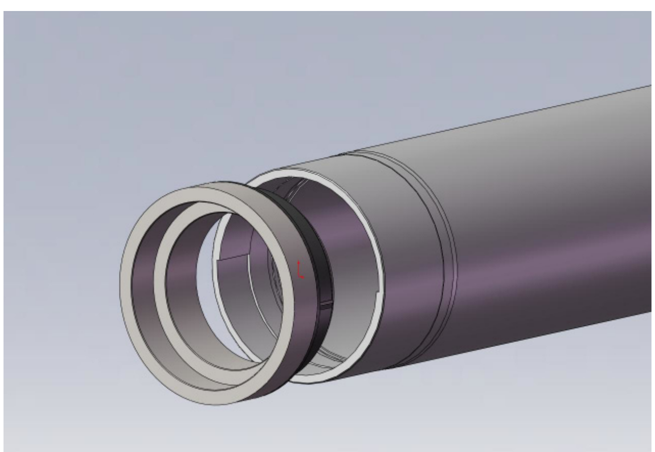

Figure 5. Mating Surfaces of keyless hub and fuser core.

The life of the fuser roller is then left to the effects of interaction between the surface of the roller, the toner and the paper. The fuser failures due to slot wear are eliminated as are the machining wear of the keys on the hubs. The removal of the locked hubs from the fuser core is simply achieved by a screw driver that is placed in a slot between the hub and the core. Applying a downward pressure on the screw driver lifts the hub away from the core and is easily separated from the core.

Conclusion

The original design of the fuser roller drive system employed a single key on the rear drive hub and a single key on the idle front hub with corresponding drive slots on the fuser roller. The issues with high speed start and stop forces and micro machining of the drive key and drive slots caused early failure of the fuser roller and the hubs. The addition of two keys on the rear drive hub, and two drive slots on fuser core, were to distribute the drive forces. The addition of the rubber to compensate for the differences in thermal expansion of two different materials, significantly increased life of both the fuser roller and the hubs. Though the cracking of the fuser core was eliminated in this design, the micro machining, though much reduced, of the steel drive key and the fuser core drive slots, still remained an issue to overcome. The elimination of the drive keys and drive slots was the resultant design. Designing and employing a geometry that utilizes the rotational momentum forces of the drive system, locks the two mating surfaces of the hubs and the fuser roller into place. The rotational momentum which caused cracking of the core and and the micro machining of the drive slot and drive key is then eliminated. The fluoropolymer, FKM, rubber interface expands with temperature to keep a tight surface contact between the aluminum fuser roller and the steel hubs, eliminating the gap between the two surfaces at 200 ºC and the resultant destructive failure issues associated with non mating parts at high temperature.

References

[1] Syuho Yokokawa, et al. "Fixing Unit for Electrophotographic Device." U.S. Patent 4952782, August 28, 1990.

[2] Wade R Eichhorn, et al. "Collar Assembly for Printer Fusing System." U.S. Patent 7242899, July 10, 2007.

[3] Richard Duda, et al. "Fuser Core and Drive Collar Assembly." U.S. Patent 7941085, May 10, 2011.

Author Biography

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