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Since 1922, the Falk Steelflex coupling has been one of the major types of mechanical devices for connecting the rotating shafts of two machines. The original grid crosssection for the Type F and earlier Steelflex coupling was rectangular. A tapered grid cross section was introduced in *1963* and grid shot peening, for improved fatigue life, was initiated in *1984*. This is the basis of the current Type 1000T line of Steelflex couplings.

Both T and F style couplings transmit torque without slip and are designed to accommodate shaft offset and angular misalignment, permit axial shaft movement and provide torsional flexibility.

The purpose of this paper is to review and identify the types and causes of field failures of the Steelflex coupling. Solutions to prevent failures are proposed.

GRID FAILURES

The grid is a serpentine alloy steel flexible member that connects two hubs which are mounted on separate machines. The types of grid failures experienced are:

1. Fatigue 2. Yield

Extensive laboratory and field tests have established the allowable grid fatigue and yield capacity for each coupling size. From this knowledge, it is often possible to determine the torque load in a drive system where a grid failure has occurred.

GRID FRACTURE – FATIGUE

A Steelflex grid when transmitting torque must flex an amount which varies with load. If there are cyclic type load changes such that the allowable bending fatigue stress of the grid has been exceeded, a fatigue type grid failure will occur. These cyclic load changes may consist of a complete or partial reversal of torque (+ to -) or may vary within the same load direction (0 to +).

The location of the grid fracture on the grid rung along with pertinent operating data such as number of load cycles before failure can often be a guide to the probable failure load. Load cycles could be the frequency of a vibratory load, the number of start-ups or speed changes, or when misalignment is a load factor, it could be the number of shaft revolutions. A grid failure occurring between the tooth contact point and loop or in the loop of the grid after one million load cycles indicates a load less than *130%* of grid fatigue capacity (see Figure 1).

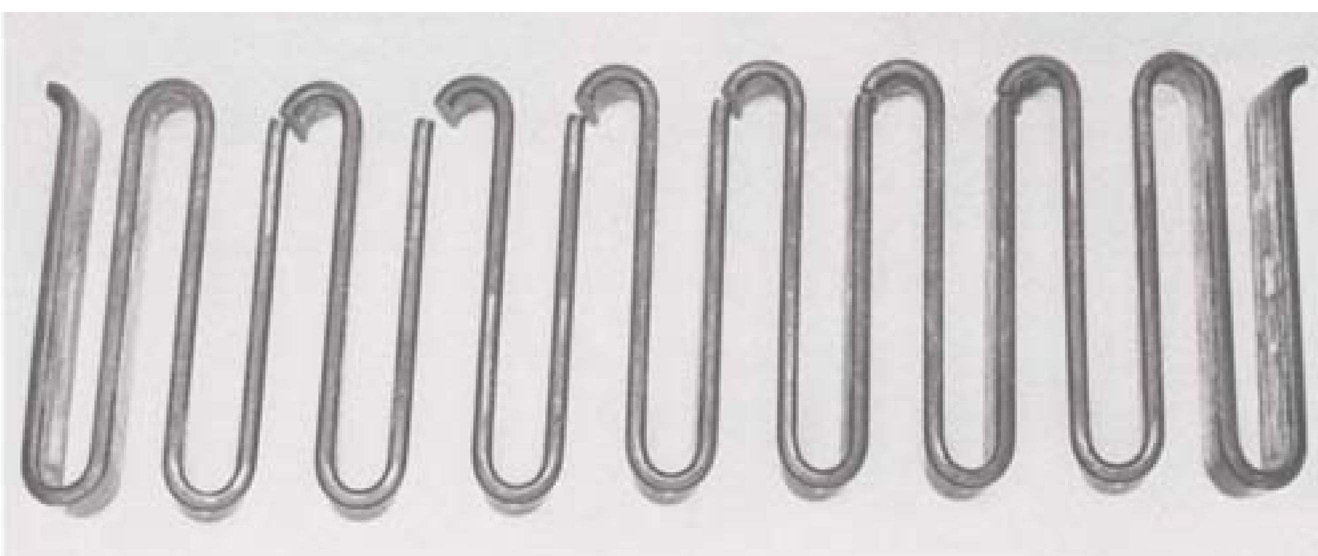

FIGURE 1

GRID FRACTURE – FATIGUE – continued

Loads higher than 130% of grid fatigue capacity are indicated when grid failure occurs between tooth contact point and the coupling hub gap before one million load contact cycles (see Figure 2).

FIGURE 2 (EG-44134)

FIGURE 3 (EG-43877)

Grid fatigue failures are a result of overloads due to torque of misalignment, or a combination of the two. Torque overloads in a system may result from starting high inertia mass, impact, and vibratory loads. Grid failures can be prevented by removing either the overload condition from the system or selecting a coupling size which has the capacity to handle the loads.

GRID FRACTURE-YIELD

Under high peak loads (over five times the coupling rating), which could be due partially to a misaligned operating condition, the grid section may fracture in the gap portion of the coupling. This infrequent type of grid failure is often a combination of grid yield and fatigue and is usually accompanied by broken and deformed hub teeth (see Figure 3). A grid yield failure without fracture can also occur in the gap area of grid (see Figure 4).

Grid fractures and yielding in the coupling gap area can be prevented by removing system overloads and realigning shafts to eliminate excess misalignment

FIGURE 4 (EG-46190)

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HUB TOOTH FAILURES

Steelflex coupling hub teeth are designed to have at least twice the fatigue strength of the grid. As a result, hub tooth fatigue failures are rare with Steelflex couplings. The yield capacity of the hub tooth is often less than that of the grid so under shock or high peak load conditions, the teeth may be permanently deformed or broken. As the result of overload and misalignment the hub teeth may break at the root diameter (see Figure 5).

The tooth yield capacity has been established for each coupling size. Where coupling teeth have yielded or broken off, it is often possible to determine the minimum overload that existed in the drive system when failure occurred.

Since tooth fractures will generally occur after grid failures, corrections made to the system in regard to torque load, and misalignment for grid capacity improvement will also prevent tooth fractures.

HUB SHANK FAILURES

Occasionally a Steelflex coupling hub shank failure is encountered. These failures generally consist of cracks extending through the hub shank at a keyway corner or through the set screw hole. Examples of hub failures are shown in Figures 6 and 7. Steelflex hub failures can usually be traced to poor installation practices, such as hubs forced onto shaft radii, keys oversize for hub or shaft keyways, setscrews being tightened on hot hubs used for interference fits, or excessive interference fit between shaft and hub.

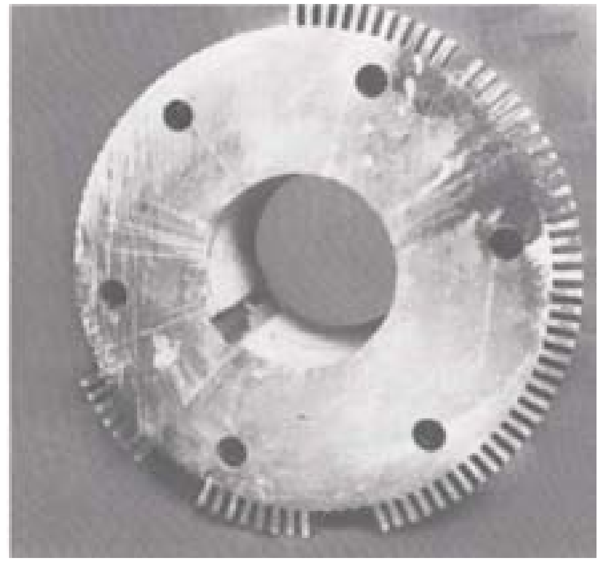

FIGURE 5

FIGURE 6

FIGURE 7

HUB SHANK FAILURES – continued

Sometimes a short length key is used or a key may project into the hub a short distance which may cause local yielding in the keyway (see Figure 8). The resulting loose fitted key condition may cause impact type loads on hub from system load variations and initiate hub failure. This local yielding condition is particularly critical on smaller size couplings where clearance fit hubs are preferred by most customers.

Another form of hub distress consists of wear and fretting corrosion in bore, Figure 9 (early stage). The cause of hub bore wear and fretting is usually radial clearance or light interference fit between hub bore and shaft which permits axial or planetary motion of hub on the shaft. Clearance fit hubs having loose setscrews may permit sliding or rocking of hubs, frequently with each shaft

Figure 8

Figure 9 (EG-46154)

revolution. The hub tooth flank and the contacting grid surface of a coupling whose hubs are loose on the shaft will also often show excess wear.

Frequently hub movements are related to external forces which may be the result of failed bearings, flexible supports, excess deflection of shaft, or improper installation of drive.

Hub failures can frequently be prevented by normal maintenance practices. The bore, key, and hub, and shaft keyway dimensions must be correct, setscrew tight and external parts such as bearings and supporting foundations must be in proper working order.

COVERS

On rare occasions, covers have broken apart, Figure 10. In this case, the coupling was subjected to repeated high loads that caused grid failures of every rung near the gap. This permitted the driving hub to turn independent of driven hub. The cover spun with driving hub until grid pieces became wedged between the stationary hub and rotating cover, resulting in destruction of one cover half. The coupling size was obviously improper for the particular system loadings.

Figure 10 (EG-43878)

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SEALS AND GASKETS

The grease lubricated Steelflex coupling uses contact type seals between the cover and the hub shank outside diameter. The T20 steel stamped cover uses a seal that fits over the inside diameter of the cover seal flange. If the hub shank outer surface is dry, rusted, or scratched, this seal may roll over in assembly of the cover, Figure 11, and cause the seal to come off the cover flange or become cut from the cover flange, Figure 12. The seal may also be cut due to excessive misalignment. To minimize seal roll over, lightly lubricate the hub shank to permit the seal to slide freely until the half cover is assembled in place.

The T10 seal used with the horizontal split covers, Sizes 1020-1140T10, is placed into position on the hub before the cover is placed on the coupling. The tapered side of the seal helps guide the seal into the seal cavity of the cover. Gaskets are used to seal the coupling cover splits on both T10 and T20 styles of couplings. Grease leakage through properly installed gaskets have not been a problem with Steelflex couplings.

Good installation practice is the key to correcting or avoiding gasket leakage problems. The fasteners holding the gasket joint must be properly tightened. Torn or used gaskets should be replaced, and the contacting cover surfaces should be free from burrs and scratches that would either damage the gasket or provide a path for the grease to escape. In a rotating coupling, grease is subjected to a centrifugal force that creates hydraulic pressure on the gasket or seal.

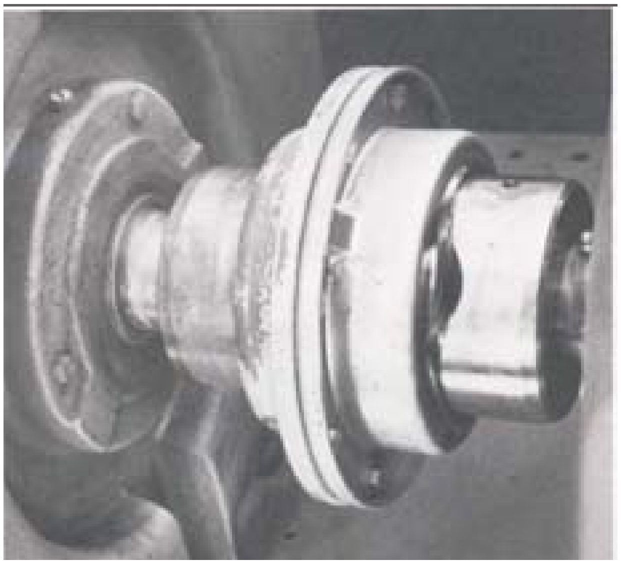

FIGURE 11 (EG-46155)

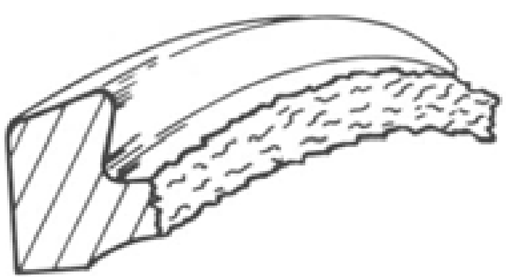

FIGURE 12

WEAR AND LUBRICATION RELATED FAILURES

GRID WEAR

A Steelflex coupling accommodates misalignment and axial movement of the connected shafts by the sliding and flexing of the grid in the hub tooth slots. This action, with proper lubrication, develops a polished surface on the grid contacting surfaces.

Installation and operating characteristics of the coupling can often be determined from the grid contact pattern. Such factors as gap setting, reversing load, axial movement, or parallel misalignment can be noted. Grid contact near the gap end of tooth denotes high torque loads. An example of normal grid contact patterns is shown in Figure 13.

With inadequate lubrication, wear will occur on the grid surfaces that are subjected to a sliding action. This wear occurs when there is reciprocating motion occurring between contacting surfaces, localized loading, and lubrication deficiency. In the early stages of lubrication deficiency, the contact area appears scuffed. If the coupling continues operating with a lubrication deficiency, worn grid surfaces will result. Sometimes fretting corrosion, as evidenced by the appearance of a red powder, can be noted. With continued grid wear, grid breakage will finally result when grid section is sufficiently reduced, (see Figure 14).

Combinations of torque load, misalignment, and rotational velocity produce forces that result in grid loop end and radial outer grid edge wear. Measurable grid end wear is an indication of frequent vibratory pulsations. A combination of grid end wear and wear on radially outer edge of grid where it strikes the inside of cover are indications of excess shaft misalignment (see Figure 15). Rotational speed affects the severity and frequency of occurrence of grid wear.

In general, excessive grid wear conditions can be minimized with adequate lubrication and correct alignment. Where vibratory type loads are expected, proper service factors should be used in coupling size selection to minimize the load effect on the grid.

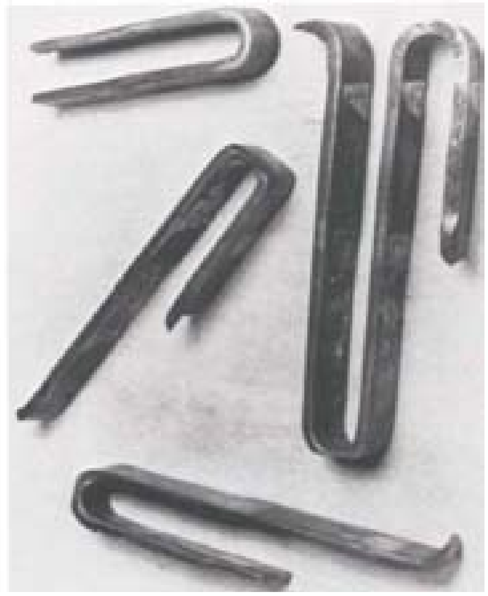

Figure 14

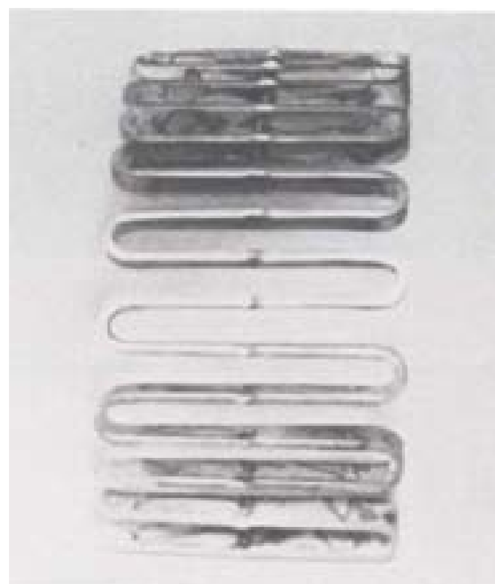

Figure 15

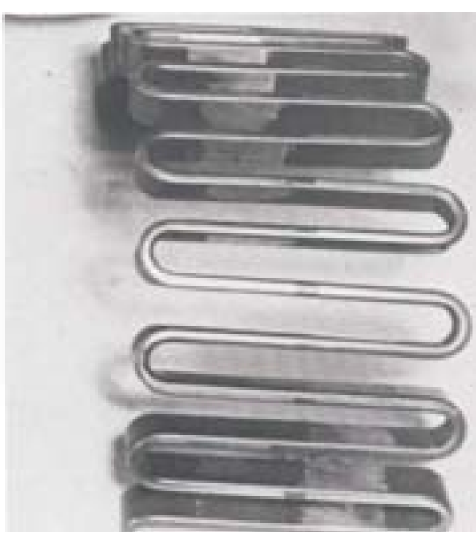

Figure 13

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HUB TOOTH WEAR

Hub teeth also become worn from lack of lubrication and the sliding of the grid from load variation, misalignment or axial shaft movements (see Figure 16).

Since tooth fractures and wear failures of hub teeth will generally occur after grid failures, corrections made to the system in regard to torque load, misalignment and lubrication for grid capacity improvement will also prevent the hub tooth-failure problems.

COVER WEAR

It is the function of the cover to contain the grid axially and radially and to retain the lubricant, which is normally grease. Two styles of covers are used with the Steel-flex coupling, an axial split and a vertical split cover. The axial split cover for the T line is generally made of aluminum while the vertical split cover is of steel.

Since the cover must retain the grid both axially and radially, it is normal to find markings or shallow grooves in the inside cover diameter. Deep grooves, Figure 17, indicate coupling is operating under parallel misalignment exceeding operating recommendations. Since the cover is not a load carrying component of the coupling, such markings on the cover inside diameter will not affect the torque load transmitting ability of the coupling.

The end flange of the covers may have indentations from the grid ends. These markings are also a normal result of coupling operation and are of concern only if their depth approaches one-half of the side wall thickness, Figure 18. Deep indents are an indication of high vibratory loads or high starting torque loads. Operating under excess misalignment will also produce deep cover indentations from the grid ends.

SEAL WEAR

Both T10 and T20 seals may experience wear on the surfaces contacting the hub shank. This wear primarily occurs where excessive misalignment causes considerable axial movement of the cover. Wear also occurs on drive systems with excess axial play and systems having frequent starts and stops.

The T10 covers have lugs cast into the cover to prevent relative rotation independent of hub, so that these cover seals are not affected by frequent start and stop applications.

"O" ring type seals are used on some larger couplings. These seals are totally enclosed by a seal cage to minimize any roll out. Any cuts or flat spots produced on the "0" ring seals are a defect that will promote lubricant leakage. Defective seals should be replaced. Where necessary to minimize maintenance labor, the replacement "0" ring may be cut in one place, wrapped around the hub and then cemented together with Eastman "910" or equivalent cement.

Figure 16 (EG-41776

Figure 17 (EG-41646)

Figure 18 (G-6187)

TEMPERATURE RELATED FAILURES

High and low temperatures can affect both the seals and the lubricant. When the temperature limits of the seal are exceeded, the seal material will become brittle and fracture. This will allow the grease to escape and/or allow external contaminants to enter the coupling. The result will be excessive wear on the mating grid, tooth and cover components.

Temperature effects on the lubricant cause the viscosity to change. High temperature results in a reduction of the viscosity and a loss in the lubricating quality of the grease and an increased rate of the separation of the grease. Low temperature results in a loss of mobility of the grease causing metal-to-metal contact between mating parts. Both conditions will result in increased wear between mating components.

Your Falk Representative can recommend extreme temperature lubricants or alternative seals to allow for operation under these conditions.

SLUDGE

Sludge is the result of the grease lubricant breaking down into soap (thickeners) and oil. Separation causes the soap portion to be centrifuged to the cover ID and tooth/grid area. This results in a loss of lubrication between the grid and tooth, and increased wear. This can be caused by high temperature, prolonged operation without regreasing or high speed operation. Falk LTG coupling grease has been specifically formulated to resist separation by utilizing a thickener with a specific gravity comparable with the base oil.

CONCLUSION

The most frequent Steelflex coupling failures involve grid fatigue failures. Grid fatigue type failures in a drive can be attributed to torque overload and/or excess misalignment in the drive system. Since the rating of Steelflex coupling is based on the grid fatigue capacity, grid fatigue failures can be related directly to the loads in the system, providing coupling alignment is within specified. operating limits. In this manner, the grid failure can indicate the magnitude of torque present in a given drive system. Grid failures can be prevented by proper size selection of coupling and proper installation, particularly alignment.

Slight grid and cover polishing or wear can be expected in most applications. The wear patterns and marking on grid and cover are indicators to the type of loading to which the coupling is subjected. Extensive grid and cover wear under adequate lube conditions indicate that torque loads and/or misalignment is excessive and should be brought into line with coupling capacity.

Hub failures as well as seal and gasket problems are generally associated with poor installation or maintenance practices.

Repeated failures of a coupling component indicates an improperly selected or applied coupling. This paper is designed to assist you in recognizing problems that may be related to the drive train. The proper analysis of the failure of a coupling component will frequently allow you to correct these abusive conditions and extend the life not only of the coupling but also the connected equipment.

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