REELL
Innovative Torque Solutions

REELL Long Life Clutch Development and Testing

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Project Introduction

Reell entered the wrap-spring clutch market in the 1970's to help a customer improve the quality of its copiers by providing clutch technology with a significantly longer life. Reell's on-going research and design in this area led to a patent in 1975; multiple patents followed in the 80's and 90's. Although Reell's original patented design is still in use today, the office copier/printer market's expectations for speed, durability and reliability continue to increase.

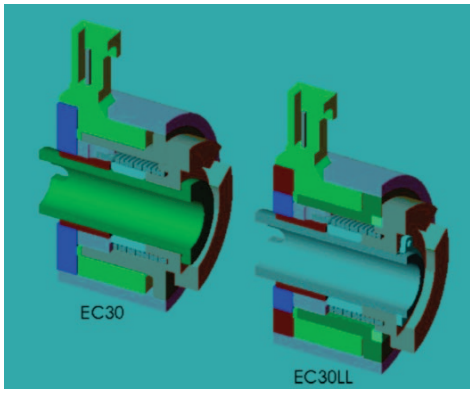
By the mid-90's, customer performance requirements were growing beyond the standard set by Reell's clutch technology. Manufacturers needed to extend clutch life to cut service costs and improve customer satisfaction. Performance concerns focused primarily on timing changes: late time-to-disengage and late time-to-speed during cold start-up and thermal transient times later in clutch life. In response, Reell's engineering team committed substantial resources to address the technical needs of the market.

Approach

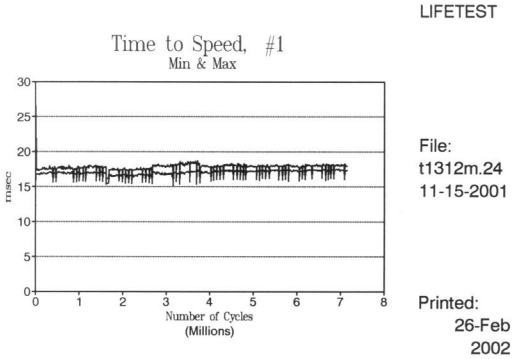
Tests revealed that both intermittent and catastrophic failures are driven by wear debris and oil contamination. Reell approached the problem on two fronts: First, one team focused on wear debris reduction. A second team designed a more sophisticated testing system to better predict field performance. The combined efforts resulted in the creation of Long Life (LL) clutch technology and a new level of reliability in Reell's wrap spring technology.

Wear Debris Reduction and EC30LL Launch

The wear-debris team evaluated every wear pair in the clutch, and the level of debris shed by the surfaces to contaminate the oil. Digital pictures of wear surfaces in alternate designs provided clear records of debris generation at regular intervals during the tests. Several designs of each wear set were tested to best meet the target of 100 million input bearing revolutions.



The test findings and the application of wear theory led to the use of harder surfaces. Lubrication design prompted the team to test PFPE oils to reduce the thermal and shear breakdown of the oil. The bearings were made to run cleaner and longer by separating functions and optimizing parts. Three new parts and several secondary process and material changes resulted in a cleaner appearance and longer reliable function in a wider temperature range. The design changes from EC30 to EC30LL provided significant wear reduction.

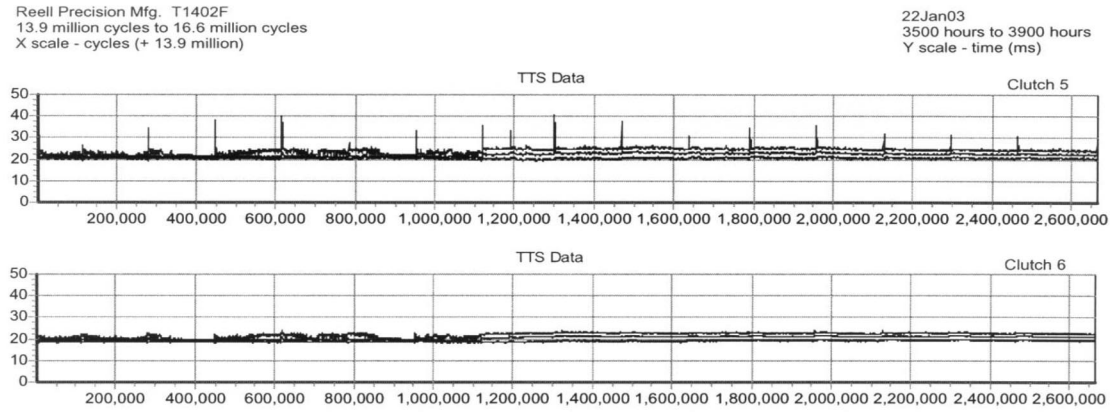


Initially, Reell tested these changes on a system that typically measures 30 cycles on each clutch every 20 minutes. Cool down evaluations requires manual intervention and could not evaluate performance on the first cycle or during the warm-up thermal transient. In spite of these limitations, the debris reduction effort was successful and resulted in a long-life design capable of surviving between two and ten times more hours and bearing revolutions than earlier designs. Customers accepted the new EC30LL, EC25LL and custom LL clutches for production use. These customers confirmed that the design change successfully reduced field replacement rates.

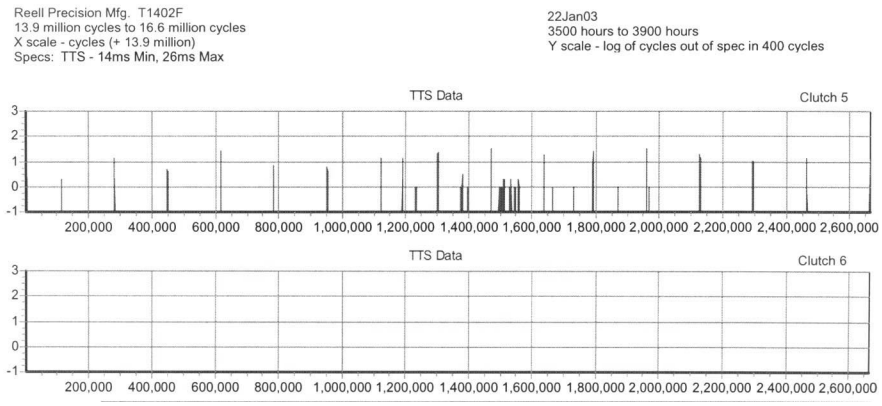
100% Data Collection Testing

In conjunction with the wear debris reduction project and the effort to develop a very high level of cycle-to-cycle reliability, Reell developed a 100% data collection test system. This new standard of testing measures every cycle of six clutches on a typical life test of millions of cycles. New software and hardware measures and stores time to engage (TTE), time to speed (TTS), time to disengage (TTD) and time to zero (TTZ.) The actuation voltage can be set to automatically sequence through power supply max, min and below min to simulate higher ambient conditions. Also, clutch thermal cool downs to room temperature, with the input turning or off, can be automatically executed by the test computer on a regular schedule.

The test performance summary below shows low-avg-high results for 3.5-minute test segments. To evaluate test segments with the high or low response out of the expected range, quality graphs were developed. These show the logarithm of the number of out-of-spec cycles in each test segment. These TTS examples have 400 cycles per test segment. Clutch 5 below is responding up to 20 milliseconds late after cool down times. Clutch 6 has no cycles with variation from normal performance at cool downs. From the quality graph for clutch 5 the maximum number for cycles between the spec of 26 ms and max timing results of 40 ms is about 30.

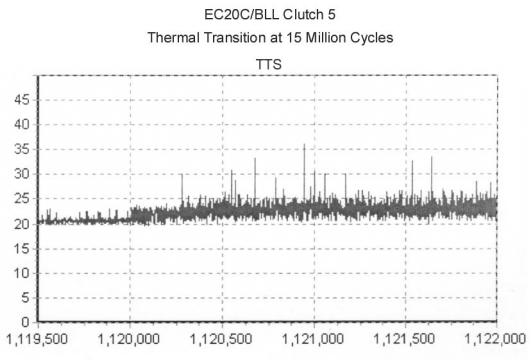


High, Avg & Low Timing per Test Segment vs Cycles



Log of Number of Cycles Out of Limits per Test Segment vs Cycles

The actual cycle data can be plotted on screen and any area expanded to evaluate the extent of cycle-to-cycle variation at any place in the test. This chart shows the TTS results on clutch 5 with over 3000 hours and 15 million cycles as the fixture and clutch warm up after a long shut down.

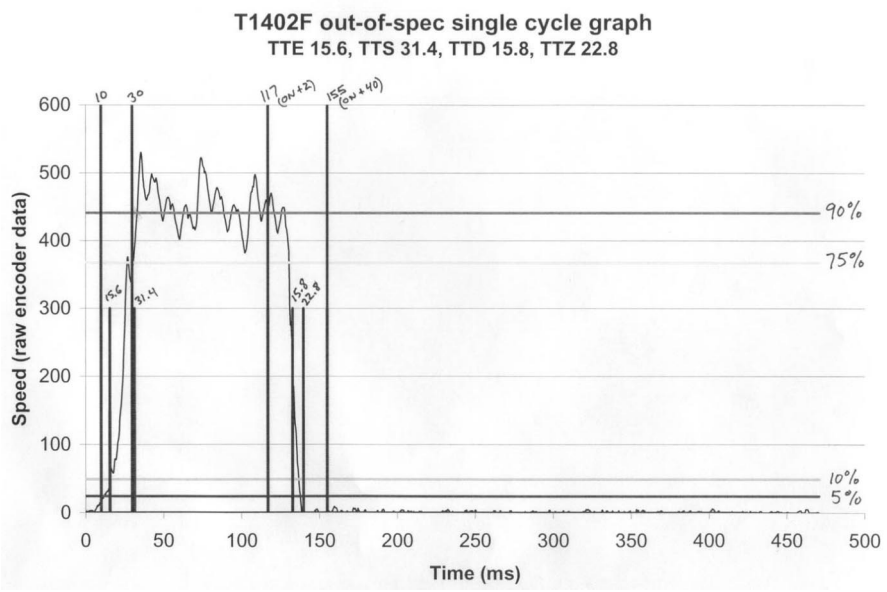


The 100% data collection test system has become the new standard of evaluating high performance wrap spring products. Identifying exact cycles in tests up to 30 million cycle lasting 1000 to 5000 hours is invaluable both for extending customer confidence and for evaluating further design improvements.

Current Improvements:

The LL wear technology set is under evaluation for oil content and fretting wear debris caused by loss of lubricant. The latest test results suggest that additional oil content extends life. Magnetic flux levels and spring energy storage design may also be modified to decrease cycle-to-cycle performance variability late in life. In addition, a new model, the EC75LL, is currently available for testing and will be available in production quantities in April 2003.

The new test system has been upgraded to accept timing specifications for detection and storage of out-of-spec cycles. The first out-of-spec cycle in each test segment for each clutch can be automatically sent by email to the test technician. This email contains not only the timing response but also the tachometer trace that led to the out-of-spec data.



This detailed information on outlier cycles can be used for engineering design reaction. It can also be integrated to determine the position error caused by the timing shift. An example of the benefit is evaluating high TTS cycles: if the timing slip were to happen at 80% of full speed, the position error would be only 20% of that calculated by typical time-position clutch calculations.

Next Steps

Reell is committed to continually improving the LL design and test systems. We are looking for opportunities to source higher performance and lower cost components to provide customers with reliability and value. To better serve the market for long life wrap spring devices; we are seeking additional custom applications of this technology.

The test system improvements are in both quantity and application simulation. Reell has three operating 100% data collection systems, one in process, and four older systems to upgrade at a rate of two per year. Our European plant in the Netherlands plans to begin design and quality testing with this system in late 2003. An application simulation improvement will allow extended thermal cycle range. We are expanding a single station thermal housing system that can both heat and cool a clutch case in a range of 15C to 90C. Our current typical case temperature test range is 25C to 60C on all test systems. This forced heating and cooling will allow us to simulate 1000 days of 5000 cycles per day in 100 calendar days. Currently we do one or two two-hour cool down cycles to test room ambient per day. This system will allow 8 to 12 15-minute cool downs to 15C each day.

Conclusion

The Long Life technology and the 100% data collection testing system are competitive extensions of wrap spring technology that have confirmed Reell's reputation as the leading innovator in the electric wrap spring market.
If you'd like to contact me regarding our long-life products or testing, please email me at gdl@reell.com.