TG005: WEAR CHARACTERISTICS PIEZOELECTRIC DISC PUMPS

1. INTRODUCTION

1.1.Piezoelectric Disc Pump

Our piezoelectric disc pumps are silent, high-performance piezoelectric micropumps.

Owing to its operating mechanism, the disc pump can be controlled with unmatched precision, yet at the same time respond to full-scale set point changes in a matter of a few milliseconds. The compact form factor means it can be tightly integrated into products, increasing portability.

Figure 1. A Piezoelectric Disc Pump

1.2.About this Application Note

This Application Note sets out how the piezoelectric disc pump performance changes during use in response to operational wear. It is intended to aid customers' understanding of the technology to support an initial assessment of technical suitability for their application. There is no substitute for customers testing the pump under the drive regime and operating conditions expected in the product, however, and we strongly recommend that customers conduct their own life testing as early in the development process as practicable.

2. DISCLAIMER

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3. OPERATIONAL WEAR

3.1. Pump pressure capacity

The primary failure mode of the disc pumps is a gradual reduction in pressure capacity as the pump begins to wear. Flow capacity is largely unaffected.

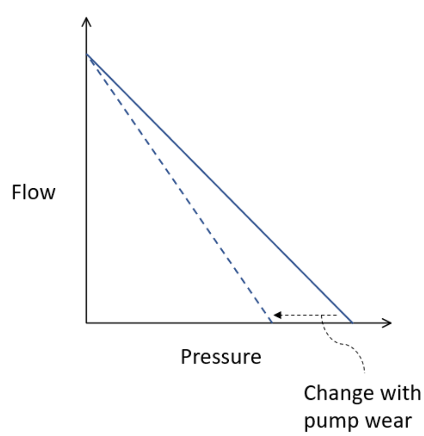

Figure 2. Change in pump head curve with operational wear

3.2. Performance degradation

There are distinct stages to the life of the pump:

- A period of operation before the wear process begins to affect performance at time = t_1
- A period during which the pressure capacity gradually reduces – this can be considered as a reduction in pump efficiency.
- A time after which the performance reduction typically plateaus, t_2

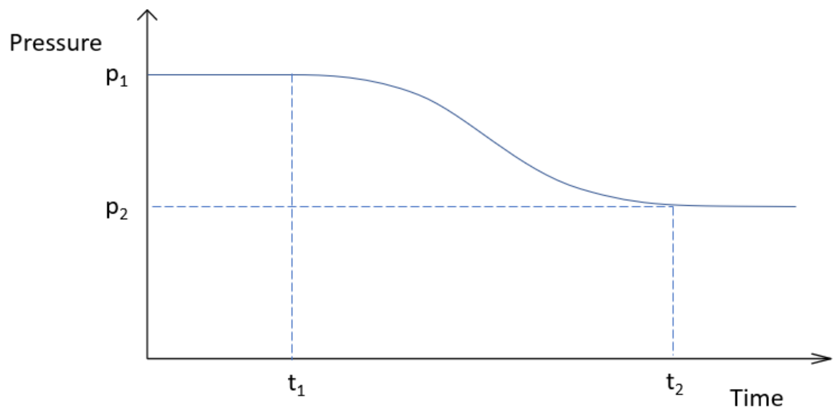

Figure 3. Pump performance change over time through operational wear

The exact values for p_1 and p_2 will vary part-to-part, although as a very approximate guide p_2 is typically around 50% of p_1. The exact values for t_1 and t_2 will vary by design (pump model), part-to-part and with operating condition (temperature, back pressure, etc). Most significantly, the values for t_1 and t_2 vary with pump drive power.

3.3.Relationship between drive power and operational wear

Figure 4 summarises general relationship between drive power and t_1, shown for the long-life LT Series Disc Pumps and for other models[1]. Again, it is important to note that t_1 is the time at which the operational wear process begins to impact the pressure/vacuum capacity of the pump, rather than the end of pump life. Appendix 1 presents the test data behind this summary.

[1] "Other Models" curve does not include HP Series pumps. At the time of writing, testing is underway to establish the characteristics of HP Series models.

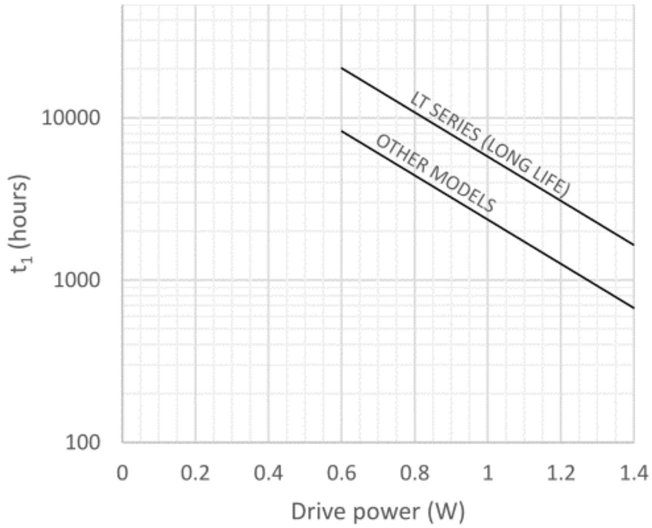

Figure 4. Relationship between drive power and t_1

Note that actual performance over life will vary pump-to-pump and with the specific operating conditions present in the final product. Customers should always validate the performance of the pump under test conditions representative of the final product.

3.4. Relationship between drive power and performance

Pump performance varies with power. For example, for the XP Series SDC configuration pump (UXPB5401200A), this relationship is broadly as follows; note that the exact pressure and flow values will vary part-to-part and by other factors such as temperature. The values shown are the *minimum* values expected for a pump under standard conditions at the start of its operational life.

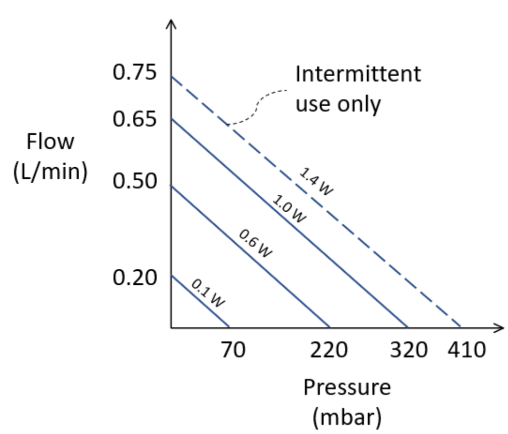

Figure 5. Relationship between drive power and performance

3.5.Impact of performance degradation in closed-loop control systems

In applications where some form of closed-loop control is used, it is possible to compensate for performance degradation by increasing the drive power. Figure 6 provides a schematic illustration. At the point that t_1 is reached and the wear process starts to impact performance, the power level is gradually increased to maintain constant output from the pump. At some much later point, the drive power limit is reached, and the power can no longer be increased to compensate for the performance reduction. This point, t_{end}, can be considered the end of life for the pump in this particular application. In many applications, t_{end} will be several times larger than t_1.

Note that the drive power limit will be the lower of:

- The maximum power the product is able to supply to the pump – this is pertinent for battery-powered products, where a certain minimum runtime is required between recharging or replacing the battery.
- The rated power limit for the pump in question.

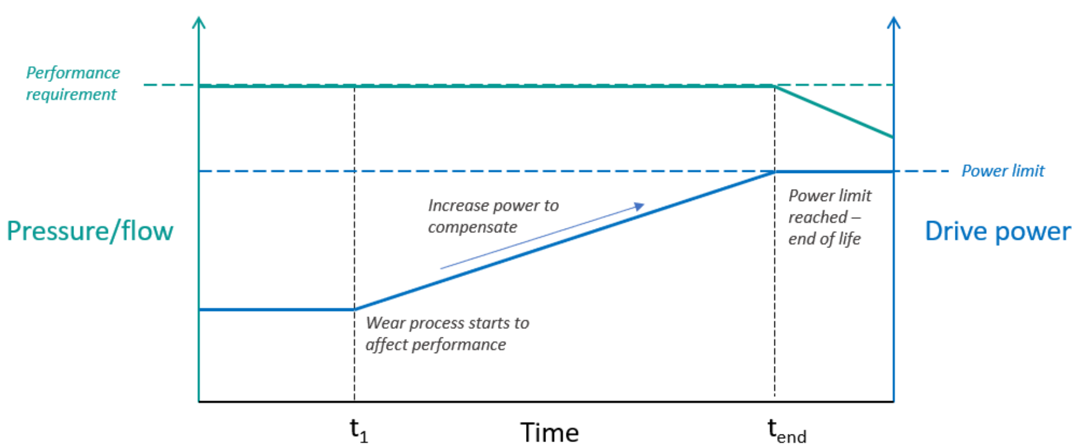

Figure 6: Increasing drive power to compensate for performance reduction in a closed-loop control system

3.5.1. Use of increasing drive power for predictive maintenance

In closed-loop control applications, the gradual increase in drive power following t_1 can be used to indicate the wear state of the pump, and to predict when system servicing may be required (for example, the replacement of the pump).

3.6.Impact of performance degradation in open-loop systems

Some applications do not use closed-loop feedback. In these applications, at the point that t_1 is reached, the pump output will begin to reduce gradually. At some later stage, the performance will fall below the minimum requirement. Once again, this point, t_{end}, can be considered the end of life for the pump in this particular application. Figure 7 provides a schematic illustration.

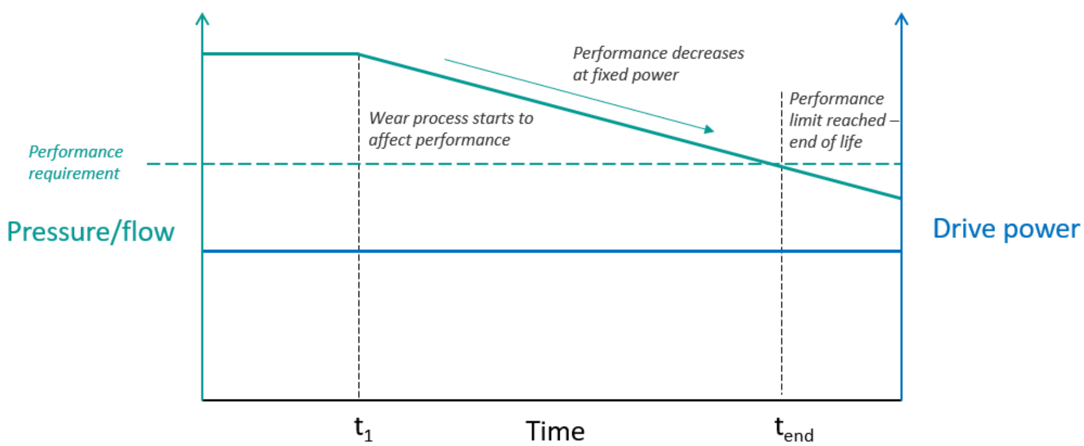

Figure 7: performance reduction in an open-loop system

3.7.Considering pump lifetime in your application

To assess how the pump might be expected to perform over time in your specific application, it is therefore important to:

- determine the application pressure and flow requirements;
- Estimate (or measure) the drive power required to deliver the required pressure and flow;
- consult data for drive power vs. t_1;

and, ultimately, to carry out life testing of the pump under representative conditions.

4. SUPPORT

The Lee Company is happy to discuss application requirements and expected pump lifetime with customers, and to provide guidance on pump selection. For further support, please contact you Lee Sales Engineer.

5. APPENDIX 1

Figure 8 presents engineering data from nominal units under life test[2]. All pumps were tested in a 40°C environment. Pumps tested above 1 W drive power were driven intermittently to maintain an average drive power of 1 W. Pumps tested below 1 W were driven continuously.

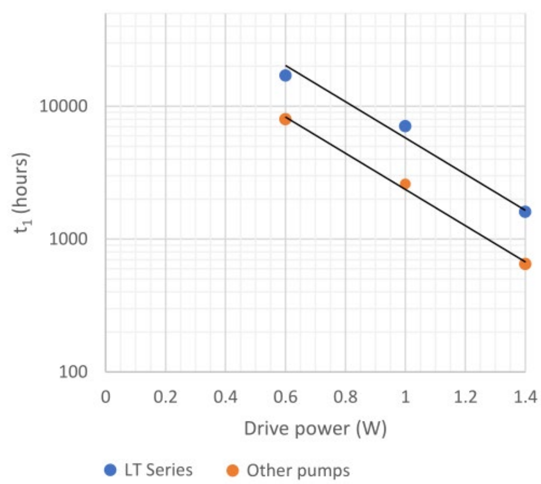

Figure 8: Engineering data for drive power vs t_1

[2] "Other pumps" curve does not include HP Series pumps. At the time of writing, testing is underway to establish the characteristics of HP Series models.

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6. REVISION HISTORY

Date	Revision	Change
June 2023		Rebranded
29 June 2022	r220629	Updated data set behind §3.3 and Appendix 1.
23 August 2021	r210823	Updated data set behind §3.3 and added Appendix 1. §3.5, 3.6, 3.7 added. Update to new document template.
25 September 2019	r190925	Initial release.