ARTICLE

# Shaping the Solenoid Force Curve

*An Element to Consider for Custom Solenoid Design*

**DESIGNING THE PROPER SOLENOID ACTUATOR** to meet a specific application involves more than just gathering information on required force, stroke, and voltage. While these characteristics are certainly the most important, information such as ambient temperatures, environmental conditions, and required mechanical life are also necessary for determining suitable performance parameters.

A critical factor to consider when designing a reliable solenoid actuator is the force vs. stroke performance of the solenoid. Force generation is a function of power input. However, the length of the stroke also plays a critical role. The solenoids shown in Figure 1 have the same ending hold force once completely energized. The larger solenoid's stroke is 25mm vs. 3mm for the smaller unit. To achieve the same pull force across the longer stroke, the solenoid's size must be increased to compensate. It may be possible, within certain limits, to maintain the size of the solenoid by increasing the power input to get the same force over the longer stroke. However, this can lead to excessive heat generation and increased cost due to the need for higher power electronic controls.

**Figure 1: Latching Solenoid (top); Linear Proportional Solenoid (bottom)**

When designing the force and stroke characteristics of a solenoid, it is important to understand the point in the stroke where the maximum force will be needed. Just as compact cars and SUVs can both carry loads, each has a limit that is tied to a corresponding cost (use of fuel). Solenoids are somewhat the same. Many times a solenoid with the highest force and longest stroke is specified for an application. This leads to using a larger solenoid than is necessary, resulting in increased cost and a significant amount of wasted energy.

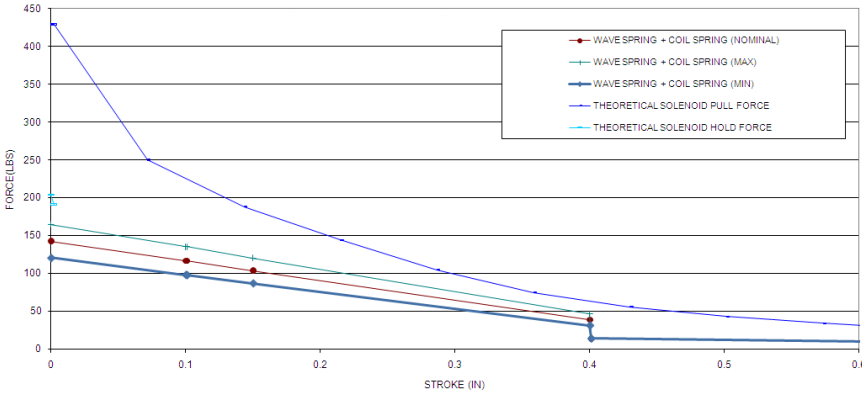


**Figure 2: Typical Solenoid Force Curve**

Mapping of the load force curve for a given application will provide the critical data needed for a more precise design of the solenoid force curve to meet the required load force at any point along the stroke (Figure 2). This is commonly referred to as shaping the curve. Utilizing magnetic analysis software

*continued to other side*

TLX Technologies

Written by Wayne Groth | Sales Manager | sales@tlxtech.com

(Figure 3), the design engineer can analyze multiple configurations of magnetic components, non-magnetic components, and air gaps in a relatively short time. Design consideration is given to permeability of materials, physical size and configuration of the magnetic and non-magnetic components, and reduction of air gaps in the flux path. The final design goal is to provide the maximum flux density at strategic points along the stroke length, shaping the force curve to meet the requirements of the application force. Shaping to the most efficient combination of force vs. stroke provides the best optimized solenoid design for size, power consumption, and cost.

Focusing on shaping the force vs. stroke performance of the solenoid is just one important factor to consider when custom designing a reliable solenoid actuator. Environmental factors, mechanical life requirements, and performance issues pertinent to the specific application must all be considered in the solenoid design. Often, features designed to accommodate mechanical life or environmental requirements, such as seals and bushings, can adversely affect the optimized force vs. stroke performance. Care must be taken when incorporating these features into the solenoid design so that the performance will not be adversely affected.

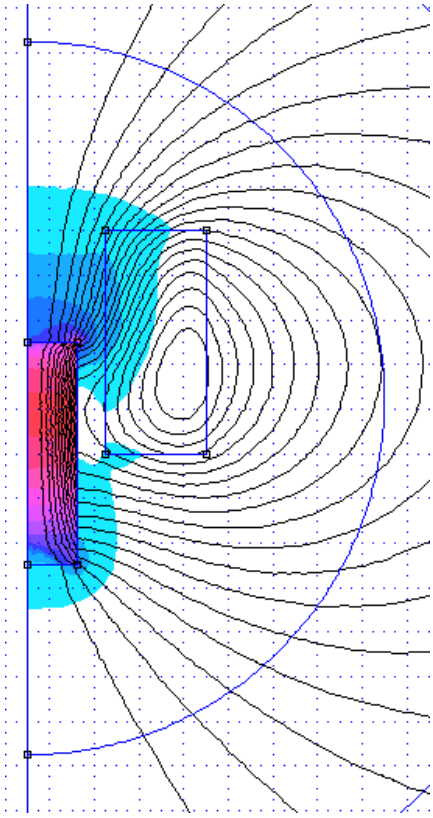

**Figure 3: Magnetic Field Simulation**



TLX Technologies

Written by Wayne Groth | Sales Manager | sales@tlxtech.com