MEASURED SAVINGS OF DC TO AC DRIVE RETROFIT IN PLASTIC EXTRUSSION

Ricardo A. Sfeir, P.E. Senior Electrical Engineer BASE Energy, Inc. San Francisco, CA

ABSTRACT

This paper presents the potential electrical energy efficiency improvements for utilizing alternating current (AC) motors controlled by variable frequency drives (VFD) in place of direct current (DC) motors to drive plastic extrusion machines. A brief background on the extrusion process is presented along with typical extrusion machine electrical drive performance requirements. Motor performance characteristics and control strategies are described for both AC and DC machines. A case study is presented, where detailed electrical measurements were performed on two similar extrusion machines driven by a DC motor and an AC motor respectively. Electrical energy, demand, and cost savings are analyzed.

INTRODUCTION

In the plastic extrusion process, extruders continuously feed resin into a heated barrel, where a screw conveys, compresses, melts the resin, and expels the melt through a die. After exiting the die, the melt is cooled (through air, chilled water baths, etc,) and solidified to the shape of the die. Although the extruder barrel is electrically heated, the resin melts mostly due to friction and compression forces of the screw acting on the resin (approximately 85% of the heat required to melt the resin is delivered through friction [1]). The only moving part in an extrusion machine is the screw.

Melt quality is mostly controlled by heat that is delivered to the resin (through friction by the screw); therefore it is important to have a consistent and reliable screw drive system. If constant and sufficient heat is not delivered to the resin, the melt will be uneven; conversely if too much heat is delivered to the melt it would result in significant energy waste due to: 1) excess heat delivered to the melt and 2) added cooling load when the melt exits the die and is ready to be solidified.

Traditionally DC motors have been used as screw drives due to their:

- Relatively constant torque throughout the speed range, and
- Simple design of motor drive system compared to an AC motor drive system

However, with advances in AC motor drives (vector flux variable frequency drives) their dynamic response has improved dramatically, making them an attractive alternative to DC drive systems. Due to improved dynamic response and better motor efficiency of AC drives (compared to DC drives), extrusion machines using AC drives can run faster than extrusion machines using DC drives, resulting in improved productivity and significant electrical energy savings.

DC DRIVES

Traditionally DC motors have been the preferred drive system for extrusion machines due to their relatively "flat" speed vs. torque profile. A typical speed/torque profile for a DC motor is shown in Figure 1 [3].

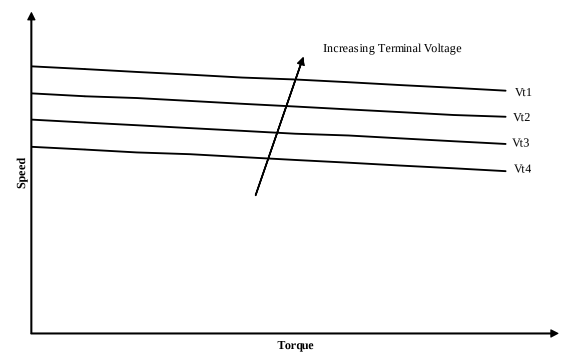

Figure 1 Typical Speed/Torque Characteristics for a DC Motor

Four curves are shown in Figure 1, each representing shaft speed with constant terminal voltage (at four different terminal voltages, V_{t1}, V_{t2}, V_{t3}, and V_{t4}. Increasing the motor's terminal voltage will increase the motor's shaft speed. Ideally the speed curves should be completely flat; however due to armature resistance, a change in torque will result in a slight change in speed (the curve slopes are exaggerated in this graph).

These almost "flat" curves, which characterize DC motors, is one of the main reasons DC drive systems have been the preferred technology to drive extruder screws. DC motors are able to maintain a relatively