Magnetic-particle clutch ends paper chase

Bills of lading, personal checks, the 2000 Census-keyboards and touchscreens haven't replaced pen and paper as a data source for the electronic realm. In fact, the document-imaging market is projected to grow from $3.3 billion in 1998 to $6.9 billion by 2002. The increasing pace of commerce requires ever-faster and more reliable scanners to move mountains of data from the physical to the digital world.

The obvious weak link in any scanning system is paper transport. Paper is an abrasive material, pages often stick together, and human beings have never settled on a uniform size and thickness for the things they write on.

To keep its lead in the imaging business, engineers at Kodak Digital Science (Rochester, NY) paid special attention to the automatic document feeder when designing their new Document Scanner 7500/9500 series machines. With a promised throughput of as many as 30,000 varied pages per day, the transport mechanism had to work reliably.

Kodak introduced the product in Germany recently, and it is now available worldwide. The high throughput required a system capable of moving paper as fast as 24 inches per second. For that reason, Kodak abandoned the gravity-feed approach of previous designs. Instead, the new automatic document feeder uses a powered roller to "urge" the top sheet off an infeed stack toward the interface between a second pair of rollers just beyond the urging mechanism (see diagram). The upper roller of the second pair is powered. The bottom, unpowered roller is spring-loaded against the upper, and rides on a shaft linked to the scanner chassis through a pair of permanent magnet, magnetic particle slip clutches from Ogura Industrial (Somerset, NJ).

The lower, or separation roller is the key to the design. With no paper in the feeder mechanism, the clutches slip, allowing the lower separation roller to be driven by the upper feed roller. When a single page is drawn between the rollers, friction between the separation rollers and the paper remains high enough to maintain slippage, and the paper passes through the mechanism normally. But if two or more pages are drawn in, the coefficient of friction between the pages is not high enough to drive the separation roller, the slip clutch now acts as a drag brake holding back the lower roller. The roller stalls, preventing all but the top page from continuing through the feed device.

According to Eric Bruening, Eastman Kodak's product manager for high-volume scanners, "Making sure you get a reliable separation of the documents [was] one of the things that was required to make the whole thing work."

The Ogura OPL magnetic slip clutch chosen for the application uses a sealed, steel outer housing and a series of permanent magnets with north and south poles arranged alternately around a central hub. The space between the housing and the magnets is filled with a proprietary ferromagnetic compound the company simply calls "hysteresis particles."

As Dave Kane, Ogura's regional sales manager, explains, "Looking down the end of a shaft place through the hub of the slip clutch, the lines of flux between the magnetic poles curve together, producing a pattern similar to a daisy." The particles align themselves along the flux pattern between the steel housing and the magnets, creating a magnetic coupling between them. Depending on the number of particles added during assembly, the strength of this coupling determines the clutch's torque rating. (In the Kodak application, the clutches have a slip torque of 12 to 13 oz-inch; Ogura manufactures the clutches in values from 4 to 56 oz-in.)

Because the coupling is magnetic, not mechanical, the OPL clutch's torque value remains very stable over time and temperature. These qualities were important in the Kodak scanner application. "We needed a nice, steady, and even drag in that separation roller," says Steve Horstman, a mechanical design and manufacturing engineer on the project. "[Operating] life is one of the big issues-a friction clutch with spring-loaded washers ends up wearing a lot so the torque changes over time."

The final issue, says Horstman, is cost. The clutches are durable, but the elastomeric roller they control wears over time and needs to be replaced after handling every 300,000 documents or so. For simplicity, Kodak wanted to make the roller/clutch assembly a simple field-replaceable unit. The low cost of the clutches made that possible, and made a lot of customers happy.