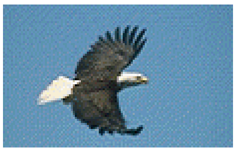





## Kodak cools cartridge cover with copper alloy cores

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**By: Jeff Sloan**

Every year Eastman Kodak Co. molds hundreds of millions of 35-mm film canister covers, gray LDPE lids well known to photographers. But a few years ago these covers were the cause of headaches. Chronically hot cores were causing pulled centers where the part failed to eject. The steel used for the cores was a 420 stainless. Kodak thought it could run cooler and faster with a copper alloy core, but before making the investment, decided to do some testing on the hypothesis.

The copper alloy Kodak tested is Ampcoloy 940, which according to specs, is nine times more conductive than 420 stainless steel. However, Ampcoloy is also softer, with a hardness of 92 to 94 Rockwell B, vs. 48 to 52 Rockwell C for the stainless steel. Because of this, Kodak decided also to test three surface treatments to protect the cores from gassing and plastic abrasion. Most 35-mm cover molds run for a year or more before preventive maintenance is performed, so corrosion resistance was a major concern.

### Thermal Conductivity

The project was headed up by senior technical personnel Gary Glozer and Brett Lebeau, who work at Kodak's Enterprise Process & Tooling Development Lab in Rochester, NY. They started by assessing the conductivity of the stainless steel and copper alloy. Using some relatively simple math, Glozer and Lebeau calculated the thermal conductivity of the steel and alloy, as well as the LDPE material used in the part itself.

What they discovered was that the heat transfer value of the LDPE cover was greater than the heat transfer value of the stainless steel mold core (Figure 1). This meant that the current 420 stainless steel core could not take heat away as fast as the plastic gave it up. On the other hand, the copper alloy showed its potential by removing heat one and a half times faster than the plastic gave it up.

### The Single-Cavity Test

A single-cavity 35-mm cover mold was built to production specifications and used for initial lab testing. A copper alloy core and a stainless steel core were also fabricated to production specs and interchanged within the single-cavity mold, run in a 125-ton Farrel.

To start, Glozer and Lebeau installed the copper alloy core and produced parts at seven different processing conditions. Process changes included mold water temperature, water flow rates to the core and cavity, plastic melt temperature, hot tip temperature, and part cooling time. Ten part temperatures at ejection were recorded for each processing condition.

The entire process was repeated with the 420 stainless steel core installed in the same tool. At all seven processing conditions the copper alloy core produced substantially cooler parts than did the 420 stainless steel.

Differences in part temperatures produced by the two cores ranged from a low of 14 deg F to a high of 24 deg F. On average, the copper alloy cores ran 18 deg F cooler than the 420 stainless steel cores. Encouraged by these results, Glozer and Lebeau decided to scale the testing up to a 48-cavity production stack mold.

### The 48-Cavity Test

As mentioned earlier, the Ampcoloy 940 copper alloy is significantly "softer" than the 420 stainless steel. As part of the 48-cavity production trial, Glozer and Lebeau also tested three different surface enhancements on the copper alloy cores: chrome, titanium nitride, and boron carbide (carbon black). Of the 48 copper alloy cores, three sets of 12 were treated with each coating. The fourth set of 12 was left untreated as a control. The cores were distributed evenly throughout both halves of the stack mold to test the effect of core location on each surface treatment.

To start the test, Glozer and Lebeau collected temperature data on the stainless steel cores. Their results show the stainless steel produced parts on 10.7-second cycles with an average part temperature of 110F. The mold was then removed from the machine--a 220-ton Husky--and the copper alloy cores were installed. The mold was reinstalled and run at the same process conditions. For the same 10.7-second cycle, average part temperature from the copper alloy cores was 83F.

Encouraged by such results, Glozer and Lebeau started reducing the cooling time on the process in .5-second intervals. The most that could be taken off was 2.7 seconds, which allowed for the fastest cycle of 8 seconds. This was dictated by the amount of time required for screw recovery. As cycle time decreased, part ejection temperatures increased. However, even at the fastest cycle of 8 seconds, the copper alloy cores produced parts that were cooler than those from the 420 stainless steel cores (Figure 2).

For production, Glozer and Lebeau settled on a midrange cycle time, which they calculated would provide substantial savings and eliminate the pulled core problem. This midrange cycle time also would most likely provide the greatest margin of processing error.

**Coating of Choice**

The mold was in production for more than 30 weeks, ran 1.12 million cycles, and produced more than 53 million parts, none of which was returned for pulled centers. Then the durability of the surface treatment was assessed. As expected, the uncoated copper alloy cores showed a visible change in appearance of the vapor-honed surface texture in the area directly across from the gate. There was little coating left on the cores protected with the boron carbide. It appeared the coating did not effectively adhere to the copper alloy substrate and eventually wore off. Texture changes were similar to those of the uncoated cores, but less severe. At $88 per core, the boron carbide was also the most expensive coating.

The chrome-coated cores showed a slight visible change in appearance, but there were no signs of adhesion problems. The chrome was the least expensive coating at $8 per core. The titanium nitrided cores revealed no visual change in appearance and outperformed even the chrome. At $26 per core, the titanium nitride was deemed the best performer for the money and chosen for production.

**The Bottom Line**

In the end, Kodak not only reduced average part ejection temperature and eliminated pulled centers, but decreased the cycle time as well. The 16 percent savings in cycle time and temperature allowed Kodak to produce 366,100 more 35-mm covers each week with a more durable and reliable core material.

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| **Copper alloy vs. stainless steel** | | |
|---|---|---|
| Core material | Average temp., deg F | Cycle time, seconds |
| 420 stainless steel | 110 | 10.7 |
| Ampcoloy 940 copper alloy | 83 | 10.7 |
| | 85 | 10.1 |
| | 89 | 9.5 |
| | 92 | 9.0 |
| | 98 | 8.5 |
| | 104 | 8.0 |

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