

# How to catch torque

**Quick response magnetic particle brake automatically controls torque** | Greg Vrana, Contributing Editor

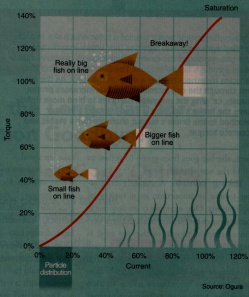
**Y**ou've been sitting patiently as the morning sun gently climbs overhead. You're almost hypnotized as you stare at the end of your fishing line disappearing into the deep waters of the Gulf of Mexico. Suddenly, the rod lunges toward the water's surface as your reel unwinds countless yards of 200-lb test line. Then, just as suddenly, a pause. You cautiously begin reeling in the line wondering what is on the other end. It isn't long before your question is answered as a 900-lb blue marlin leaps from the water and hovers for a second several feet in the air. The line grows taut as you fight against the increasing torque on the reel's handle. Suddenly, all tension in the line vanishes as you realize you've exceeded its strength.

Don't feel bad. You can always buy more tokens and have another chance at that trophy marlin lurking behind the CRT of the *Angler King* video game.

Namco, the maker of *Angler King*, faced several engineering challenges trying to simulate the experience of fishing for some of the world's great game fish. One of those challenges was figuring out how to accurately vary the torque on the arcade game's reel to give players the sensation that a large fish is fighting to get away. When the fish jumps out of the water the torque on the reel's handle should drop to near zero, but when the fish fights hardest the torque should increase to some maximum value giving

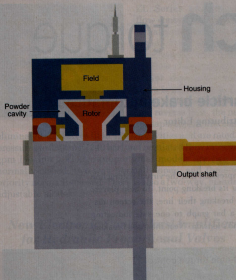
the impression that the virtual fishing line is near its breaking point. To help players avoid breaking their line, the screen displays a bar graph to one side indicating the line's tension. Near the line's breaking

**Reel-time torque control**



The near-linear relationship between input current and torque makes a magnetic particle brake a solution for applications that require torque be varied automatically. In an arcade game, it simulates torque on a fishing line.

## Anatomy of a particle brake



A magnetic particle brake houses a rotor which sits in a cavity filled with magnetic particles (not unlike iron filings). A field coil surrounds the cavity, which creates magnetic flux when a voltage is applied to it. The flux tends to bind the particles together creating a drag on the rotor. As the current through the coil increases, the flux increases proportionally, causing the magnetic particles to bind more tightly. Since the brake's housing is fixed in place, the rotor attached to the brake's output shaft creates a stable and accurate torque.

point, the bar goes from green to yellow to red to the one that got away.

**Taking control.** Accurately controlling torque is important in a variety of applications. One example is an automatic bottling machine, which must apply a certain amount of torque to the cap as it is screwed onto the bottle. Too much torque and the cap will be difficult to remove. Too little torque and the bottle may leak. Bottling machines oftentimes use a friction clutch or hysteresis permanent-magnet clutch, which can be preset to a particular torque value.

The challenge then becomes more interesting when the torque value depends

take-up spool.

The Namco engineers considered different options for controlling the fishing reel's torque. Using a low-cost motor and controller would have been the most economical alternative, although size and heat dissipation given the desired form factor were concerns. More importantly, they felt that the cogging effect of the motor would have felt unnatural to anyone familiar with a fishing reel.

The second option they evaluated was a magnetic particle brake. It offered the smallest form factor, plus the torque can be accurately controlled due to the near linear relationship between input

on real-time (or "reel"-time, in this case) feedback. Torque on the hand crank changes according to the fish's actions.

There are many other situations in which engineers may need to figure out a way to vary torque automatically. A sign printer that uses spools of colored foils needs to apply a constant tension on the unwinding spools to ensure proper registration. The printer uses different tension values based on the foil's thickness, the amount of foil remaining on the spool, temperature, and spool speed. Wire coating machines need to apply the proper amount of tension to the wire as it unwinds from a feed spool and winds onto a

current and torque. Because there is no lag associated with mechanical parts, the magnetic particle brake also has a quick response time—somewhere on the order of 30 ms.

A limitation of a magnetic particle brake is that it exhibits a minimum (non-zero) amount of drag—even when no power is applied to the coil. Also, the low end of the torque range is not linear with respect to current, a problem when the application calls for accurate torque control across the brake's entire range. (In this case, engineers often opt for an electromagnetic hysteresis brake, which exhibits finer control in the lower end of the torque range.)

Magnetic particle brakes are best suited to horizontal-shaft applications. When the shaft is mounted vertically, the magnetic particles tend to settle around the lower portion of shaft due to gravity. If the particles become compacted they can create a "false" torque when no current is flowing through the field coil.

Once Namco engineers decided to go with a magnetic particle brake, it was a simple matter of selecting the brake that met the fishing reel's torque requirements. Namco chose Ogura Industrial Corp.'s model OPB5, which has a rated torque of 4.4 lbs-inch at 24V and weighs only 1.5 lbs—not so attractive a weight for a fish on the line, but perfect for the virtual world of deep-sea fishing! **DN**

## For more information

Go to [www.designnews.com](http://www.designnews.com) and click on Request Product Info in the navigation bar, or enter the number on the Reader Service Card:

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