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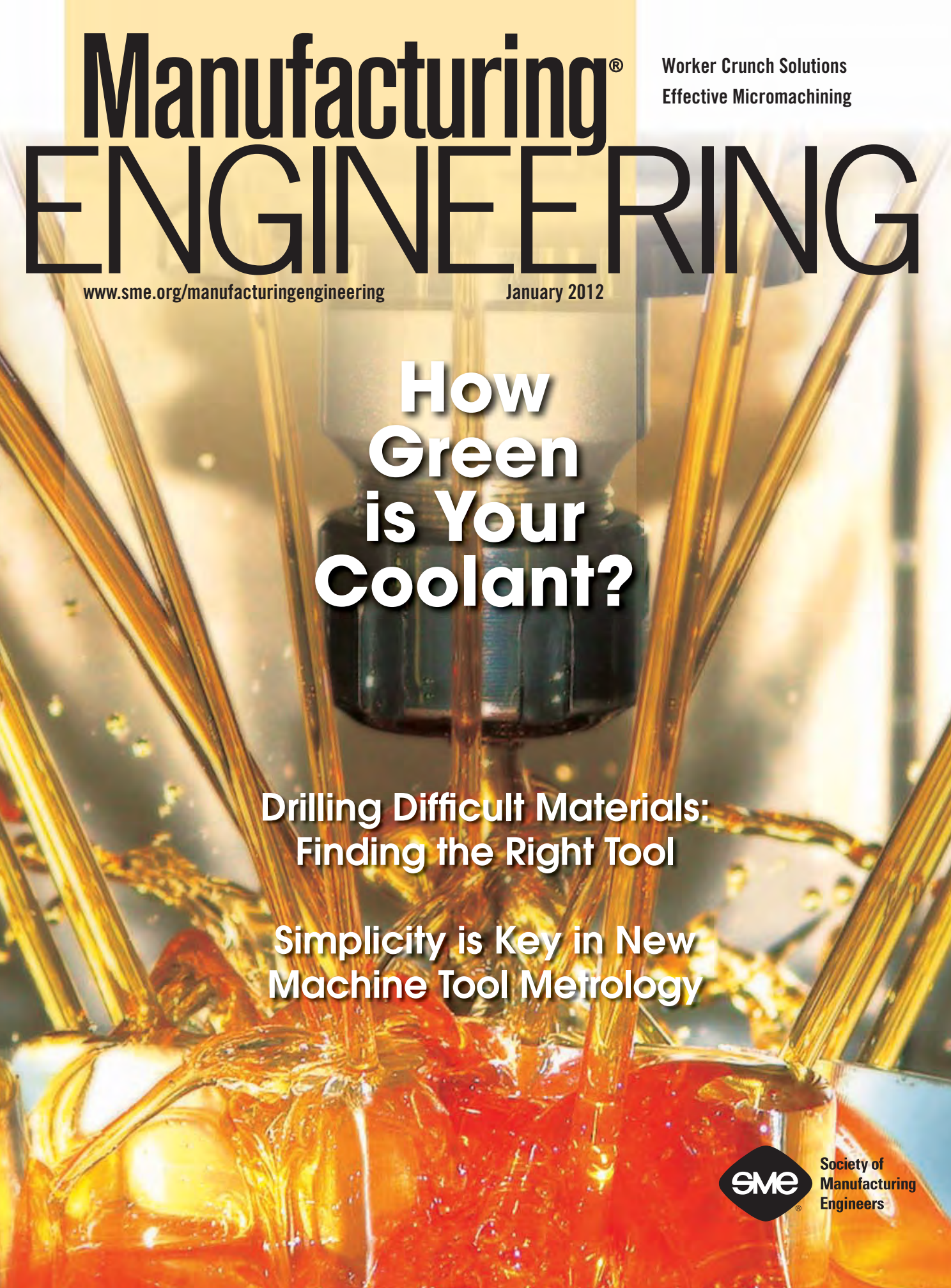
Worker Crunch Solutions

Effective Micromachining



How Green is Your Coolant?

Drilling Difficult Materials: Finding the Right Tool

Simplicity is Key in New Machine Tool Metrology

Society of Manufacturing Engineers

Precision Machining Hydro Impellers

Canyon Hydro (Deming, WA) is the country's leading supplier of large hydropower generating systems, located west of the Mississippi right in the heart of the hydropower market. The company builds hydroelectric systems to the rigid specifications of public and independent power producers. Using state-of-the-art CNC machining technology, Canyon Hydro manufactures Pelton, Francis, and Crossflow-type hydroelectric turbines in a highly automated CNC machining facility it has built specifically for that purpose.

Machining the buckets of these 11' (3.35-m) runners at Canyon Hydro requires 500 hr of long-reach contour milling with some undercuts and is done largely with standard tooling from Ingersoll Cutting Tools.

Turbine rotors, called "runners" in the hydropower industry, convert water flow to the rotary motion that drives the generators. The principal machining challenge is to contour-mill the runner buckets, which are essentially paddles on a sophisticated paddle wheel where every machined surface has a hydrodynamically correct curvature. A typical runner, made from a stainless casting, weighs 10 tons (9.07 t) measures 11' (3.35 m) across, and has 22 carefully contoured double buckets. Runners can take months of continuous five-axis, long-reach milling to complete, removing a ton and half of stainless chips in the process. Although virtually all milling involves long 19" (482-mm) shank lengths, as-machined surfaces must be smoother than 32 µm and geometrically correct within 0.010" (0.25 mm), in order to prevent turbulent flow while in service.

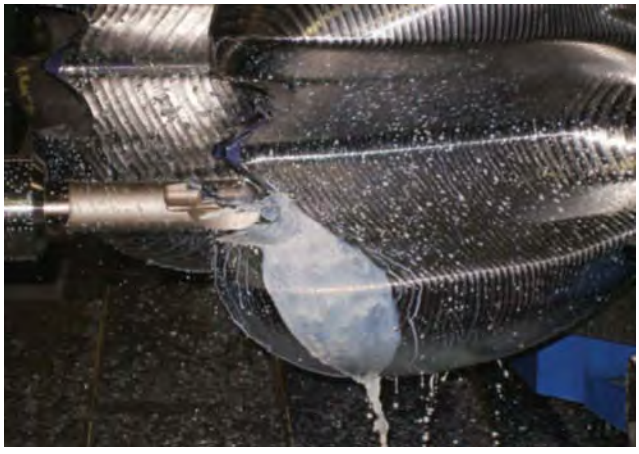
Advanced tooling and customer support from Ingersoll Cutting Tools (Rockford, IL) have helped Canyon Hydro complete the runners in one-third the time with accuracy and surface finish required for higher efficiency over the runners' projected 30–40 year service life. "It's like a large-scale cavity milling job," says Ingersoll's Chris Murray, who devised the tooling solution.

Previously, Canyon Hydro finished the buckets by manual grinding, using CAD/CAM templates to check dimensions and contours. Typical cycle time for an 11' diam runner was six months, involving 100% attendance by skilled operators. Typical tolerances were 0.035–0.040" (0.89–1 mm).

Anticipating greater demand for alternate energy sources including hydropower, the company made the strategic decision in 2009 to change its process by automating runner machining. The company built a CNC facility in nearby Sumas, WA, with the centerpiece machine, a FPT five-axis CNC floor-type horizontal mill from FPT North America Inc. (Livonia, MI). The mill is equipped with a two-axis rotary table, 80-station ATC, and two interchangeable heads: a 360° universal 3 + 2 bi-rotational head and a 29" (736.6-mm) extension head. A skeleton crew of two to four CNC machinists works 8-hr shifts to handle support functions as the machine runs largely untended, sometimes overnight as needed to maintain delivery schedules. "Chipmaking itself is essentially hands-off," says Mike Hansen, Canyon Hydro manufacturing engineer.

To find the needed tooling solutions, the company invited proposals from all mainline vendors. "Cycle-time savings were really secondary to repeatable accuracy and smooth finish," says Hansen. "We knew the business would become more efficiency-competitive, and standard tooling was essential to eliminate all the uncertainties and expenses inherent in special tooling."

Only Ingersoll offered full application support free of charge, and found a standard tool able to do most of the job and a modified-standard to handle the rest. "It was their

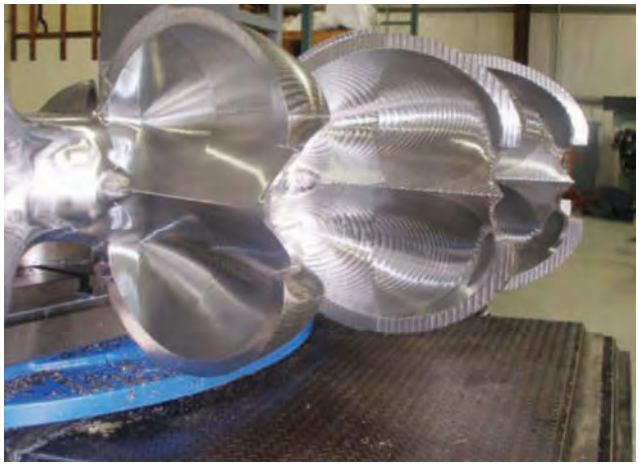


Most of the contour, roughing and finishing, is done with the large standard Ingersoll ProBall indexable ball mill.

up-front helpful attitude that led to our choice," Hansen says. "Sure we would test each of Chris Murray's ideas in trials later on, but only to verify recommendations and optimize parameters, not to pick a vendor. We were looking for a marriage, not just a first date."

The company started up by automating the smaller runners, diameters down to 4 ½' (1.37 m), gradually working up to the larger parts. The smaller runners were handled by a standard 1" (25.4-mm) Ingersoll FormMaster Pro specially suited for long-reach roughing and finishing. To defeat harmonic vibration, the three-flute tool features circular, serrated inserts in a timed array. Each insert is turned 5 min from the other, so its edges engage a different area of the cut, and the whole toolpath is covered progressively with every full cutter revolution. Close mating between the seat pocket and corners keep the insert in exact position.

The operation ran smoothly with no chatter, reducing cycle time on average by 50% vs. manual grinding. Tool life was more than enough for lights-out operation when needed. It wasn't until February 2011 that Mike Hansen converted the larger runners over to the automated process and had to scale



Finished buckets in the foreground (left center) have a 32-µm surface finish, achieved despite extremely long reaches throughout the seven-axis contour- milling operation. Standard 2" (51-mm) Ingersoll ProBall ball mill with side-cutting inserts handles both roughing and finishing.

up the tool sizes. Principal model in this class is 11' (3.35-m) diam with an average annual volume of 12 pieces.

Geometry of the runner buckets includes six-axis contours, mostly long reaches, and some undercuts, calling for use of ball mills for the most part. Sheer size of the workpieces called out for a tool much larger than most standard models. "To do a 3' [0.9-m] contoured cavity with a 1" [25.4-mm] ball mill or FormMaster would take forever," Hansen says. "Besides, in stainless steel the insert would wear out too quickly for secure lights-out operation."

Chris Murray recommended a 2" (51-mm) Ingersoll ProBall indexable ballnose for the bulk of the work, and a modified standard Form Master button cutter to handle the undercuts. "The button cutter works like a standard contour mill for most of the pass, then like a T-slotter when it reaches the undercut portion along the outer edge of the bucket," Murray explains.

Hansen and Murray worked together, right at machine-side, to establish machining parameters for the 10 ton (9.07-t)

410 NM stainless casting. The undercut portions required the modified button cutter and involved the longest reaches: 20.5" (520.7 mm) from spindle to face. Hansen uses these parameters during the day when the machine is tended, backing down the feed rate about 10% as a precaution for lights-out operations. In all cases, the inserts last long enough for absolute process security over 12 to 15 hr; some last 45 hr per edge.

The big two-flute ProBall ball mill features serrated inserts at the ball end plus heavy-duty side cutting inserts farther up the active length for larger diameters and deeper cuts. "Visitors to our shop floor are amazed that such a large ball mill is available as a standard," Hansen adds. A screw-on style coupling enables in-spindle tip-shuttling to 0.005" (0.13-mm) repeatability so there's virtually no dead time for tool servicing.

"It's as much a matter of listening as anything else."

More a modified standard than a special, the button cutter is needed to access one portion of the cut which involves undercutting much like slotting. The backside of the tool must be effective upon withdrawal to create the top of the slot. The tool uses standard inserts with the cutter shank extended and insert seats repositioned to present cutting edges on both the front and backsides. Mike Hansen gave Chris Murray the CAD file on the starting and finishing geometry of the outer lip of the bucket, which was handed off to Ingersoll product specialist Mark Teno and his team back at Rockford.

Working together on the shop floor, Hansen, Murray, and lead CNC machinist Ken Neal have bumped up the parameters about 15% overall since February, always paying attention to accuracy, surface quality, and process security in a chatter-prone operation. "It's as much a matter of listening as anything else," says Murray.

Not surprisingly, all Canyon Hydro's runners are completed much faster and with much less operator attention as a result of the company's strategic move to CNC automation and advanced tooling. Cycle time averages are down by 50%, and labor costs are virtually nil. The mainstream eleven footer runs even better: 500 vs. 1500 hr previously, and tool life is reliably long enough to enable lights-out operation as needed.

"What's most important is the improvement in repeatable accuracy and surface finish quality, which will pay off for hydropower developers whose bottom line hinges on efficiency of these runners. Holding 0.005–0.010" [0.13–0.25 mm] on geometry and near-mirror 32-µm finishes at our end will make a measurable difference at theirs," Hansen concludes. **ME**

For more information on Ingersoll Cutting Tools, go to www.ingeroll-ims.com, or telephone 815-387-6600.

CNC Monitors Aerospace Turning

Monogram Aerospace Fasteners (MAF; Commerce, CA) is a leading producer of high-strength blind bolts for aircraft assembly, temporary fasteners for fixturing and alignment, as well as installation, finishing, and removal tools. With manufacturing expertise of more than 120 years, the company has pioneered a number

> "By utilizing ePS remote viewing, we minimized time spent on the diagnosis of a failure."

of fastener innovations. Its Visu-Lok, Composi-Lok, Radial-Lok, and OSI-Bolt brands are well known throughout aerospace manufacturing. Likewise, the company's fastener designs have evolved with the times and technology to incorporate various features required for semi-automatic or totally automated assembly