



## Nano and cool

Call it serendipity if you will, but a chance observation in a lab has led to the invention of a new coolant technology that applies cutting-edge chemistry to everyday engineering. The new cooling solution is a nanofluid — not only is it faster, it uses less water and its use reduces greenhouse gas emissions to boot. The icing on the cake, the nanofluid can find applications in industries across the board — from automobile engines, to power plants, to steel industries — wherever there is a call for cooling hot materials and machinery in as short a time as possible.

The nanofluid, appropriately named CoolFast, and the technology was created by a team of six innovators from Tata Steel, Sumitesh Das, Shantanu Chakrabarti, Jayabrata Bhaduri, Deb Roy, Subhrakanti Chakraborty and Vijay Kumar Nirala, who comprise a mixed bag of competencies featuring mechanical engineers, an applied physicist and a metallurgist.

The need for a quicker-acting industrial coolant comes from the fact that in any heavy industry, vast amounts of energy are dissipated in heating and cooling materials. The cooling process is just as energy intensive, resulting in CO<sub>2</sub> emissions and requiring the consumption of water, a fast-disappearing resource.

A couple of years back, R&D laboratory tests at Tata Steel showed that a nanofluid could cool a red-hot surface much faster than water. Tata Steel's nanofluid CoolFast is basically an aqueous medium containing a small

quantity of nanoparticles of different metals such as aluminium, copper and titanium. It cools more quickly than pure water because heat transfer depends upon the total surface area, and the small particles dispersed in the fluid significantly increase the total surface area for absorbing heat. Another reason is that the particles of metals have 500 times the heat conduction ability of water.

In October 2008, a regular project review meeting sparked off a unique idea: To use nanofluids to expedite the cooling of steel coils at the annealing stage.

In an integrated steel plant, hot molten steel is cast into slabs, rolled hot into thick strip coils, and then further cold-rolled and annealed into formable steel, the kind of steel used to make automobiles, refrigerators, washing machines, etc. In annealing, the steel is first heated, and then cooled, in a chamber through which hydrogen gas is circulated. This treatment adds \$40 / tonne to the value of the steel, a significant value addition.

However, during annealing, the steel takes a long time — as much as 16 hours — to cool. The steel strips are cooled by a flow of hydrogen gas, which in turn is cooled in a heat exchanger where flowing water cools the gas before it re-enters the steel chamber. This cooling stage is a bottleneck area. A more efficient coolant can cut down the time taken to cool the steel and increase the overall productivity of the unit. This was the area where the team decided to employ the nanofluid technology.



### PROMISING INNOVATION

An enterprising team from Tata Steel has used nanoparticles to create a new coolant and a heat dissipation technology that can increase productivity and save on valuable resources.

## Innovation

Most industries need to tackle the issue of cooling or heat dissipation in one form or another. Faster, more efficient heat distribution can increase yields and reduce energy use, cycle time and water consumption. The two most common methods of improving cooling are: 1) To increase the surface area that has to be cooled, and 2) To increase the rate of fluid flow. Unfortunately both of these require significant changes in equipment, design of processes, scale and so on. Some industries have used non-water coolants, but these are more expensive. CoolFast is an ideal solution, as it works by increasing the heat-dissipating ability of the water already being used.

The CoolFast technology is innovative in several aspects — the team had to work out the right formulation; a way of delivering the nanoparticles to water to form the nanofluid had to be devised; and a method of mixing the particles, so that they would remain suspended in solution, was also necessary. The team's innovation addressed all of this in making the process viable and useful.

Using the new solution brought down cooling time by as much as 1-2 hours per cycle. A one-hour reduction in cycle time translates into additional revenue of over \$1 million every year just in increased annealed steel production. The R&D investment in CoolFast was just \$0.5 million.

What makes CoolFast a valuable breakthrough is that the technology can be adapted and used in several industries. Already Tata Steel is taking it places — the wire rod mill and the hot strip mill. There have been queries from Tata Motors and Jaguar Land Rover about applications as car coolants, and Tata Power has expressed interest in the technology.

In creating the CoolFast technology, the Tata Steel team have not just pioneered an invention with several potential applications, they have also broken several speed records on designing, developing, testing and implementing the project. From idea to pilot to full scale model in just four months is a remarkable effort in itself.



The Tata Steel team received the 'Promising innovation' award from Mr Tata at the JRD QV Award 2009 function in Mumbai

The team worked day and night and completed the major part of the job in 18 days. The motivation came from the power of the idea, the passion for success, and the fear that they would be pre-empted by other researchers in the field.

## Hurdles

In order to achieve deadlines, the team worked at top speed. But assembling equipment and machinery meant involving new vendors. To expedite the new vendor registration process, the team took the support of senior managers. Another snag was the designing of the equipment, for which a company was hired to fabricate the machinery. However, in the interests of keeping the intellectual property secure, the company wasn't told what the machines would be used for.

At the end, what the Tata Steel team did was to create the first ever mass application of nanotechnology by generating 20,000 litres of nanofluid that used 20kg of nanoparticles. Though this in itself was a ground-breaking event, the team had to come up with innovative solutions to resolve three critical issues: Safety, stability and scalability.

The safety issue was crucial; nanoparticles are so minute that they can be inhaled and cause health problems. The team addressed that problem by creating tablets of nanoparticles (much like a dispirin pill) that dissolve in water to form the nanofluid. The nanotablet,

an innovation in itself, makes it safe for workers to handle the nanofluids.

The stability of the nanofluid was optimised by testing combinations of nanoparticles that remained dispersed in the medium for the longest possible time. Scalability was handled by another innovation — using a mechanical mixer to generate the huge volumes of fluid necessary.

## Success

The CoolFast technology is protected by several Indian and international patents. The next step is to scale it up to cover the entire mill. Tata Steel has 46 bases where strips are cooled constantly. By increasing production at all bases, the company can save on capital costs of investing in new bases. Here, with existing equipment, the potential increase in steel production is worth \$1.2 million.

Even more attractive is the fact that this technology opens up opportunities to make new steel grades with potential revenues running into hundreds of crores every year. Equally important is the environmental aspect. The new technology offers savings in electrical energy, hydrogen gas, water consumption and reduction of CO<sub>2</sub> emissions.

The nanoparticle frontier is still a new one, and Tata Steel's path-breaking success with the new application can only herald many more such innovations in the future. ●

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