

Bags to slags: Recycling plastics to make steel

A researcher in Australia seeks ways to use alternative resources.

Veena Sahajwalla is making a dent in landfills. The materials engineer has found that certain waste products can be substituted for some of the coke—a form of coal—used in the conventional electric-arc-furnace process for making steel. The process she and her team at the University of New South Wales in Sydney (UNSW), Australia, have developed and continue to work on is doubly good environmentally: It not only recycles but is more energy efficient to boot.

“Steel is the backbone of a lot of society,” says Sahajwalla, “and plastics and rubber tires are plentiful in terms of the quantity that any society produces. So the more we can marry the two together, the greater the potential to divert a lot of these types of materials away from landfills.” The process she developed is in use by the Australian steel manufacturer OneSteel.

Sahajwalla’s engineering studies took her from India, where she did her bachelor’s degree, to Canada for her master’s and the US for her PhD, before she moved to Australia. She now directs the Centre for Sustainable Materials Research and Technology at UNSW. Her roots are in research related to conventional steel making, but she is increasingly branching out into other areas involving alternative resources. On work that has not yet been published and patented, she remains mum, saying only that “the idea is to see how to achieve similar goals in other areas.”

PHYSICS TODAY spoke with Sahajwalla by telephone in February.

PT: What was your “aha” moment?

SAHAJWALLA: We have a camera that looks in at the carbon material reacting with slag, so we are in a dynamic sense

monitoring how this foam is forming. Imagine a cappuccino which has a layer of froth on top. The slag foam literally looks like a foam in which you have gas bubbles trapped inside a liquid layer of metal. It’s like a nice insulating blanket that’s sitting on top of liquid steel. Carbon is introduced into the furnace to carry out slag-foaming reactions. The slag layer has got iron oxide in it. When carbon is introduced, the iron oxide layer is reduced by the carbon to produce iron. That is the role of carbon and the reason why the slag-foaming reaction is so important: It minimizes heat losses and allows you to make the process more efficient.

When we did visual observations of these types of plastics for the first time, we could see the foam, and we could actually compare that to conventional coke. We could say, Oh my goodness, this is actually working.

Obviously, we had to get down into the science and understand what was going on, but the visual observations were pretty clear that this was going to work.

PT: Describe briefly how steel is made and what you did.

SAHAJWALLA: Your starting raw material is just recycled steel, scrap steel. You melt that, and you produce new steel. The scrap from one place might go to another steel plant that produces steel that requires higher levels of carbon, and you lose some carbon in the chemical reaction in the furnace. It’s never going to be that perfect match to produce the exact same quality or grade of steel.

You need to have carbon for a host of different reasons. The simplest one is that there is some amount of carbon that is always dissolved in iron and steel. It gives you desirable properties. Iron without carbon does not have strength. But if

When Veena Sahajwalla saw a slag foam form from a plastic-coke blend, she knew her recycling method for steel making would work. Here, she loads a sample into a high-temperature electric-arc furnace.



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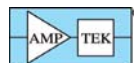
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you keep increasing the amount of carbon, the material becomes brittle.

What we then did was say, Okay, can we replace some of the coke by mixtures of coke with different polymer materials, such as rubber or plastic?

We knew there is enough carbon in plastics. What we didn't know is whether plastics would actually carry out the kinds of chemical reactions and ultimately give you the outcome that is desired. The goal was to simulate the high temperatures where the chemical reactions take place and then ascertain how efficient those reactions are. Are you still getting the slag foam that you would expect under normal practices? For us it was about using the standard raw materials as a benchmark. In some cases we actually found that the plastics were better than the coke. The foam itself was better, which means it allows you better efficiencies.

PT: How did you get into recycling waste materials for steel making?

SAHAJWALLA: When I was doing my PhD at the University of Michigan in Ann Arbor, I was very much looking at conventional resources [for making steel]. Here [in Australia] I started to look at alternative resources. The logic from my point of view went that if there are alternative resources that can still do the job of producing metals, then let's do that.

Plastics have been introduced into blast furnaces for iron making for a long time in Japan. Also in some places in Europe. It's not a new thing. But the blast furnaces for iron making are completely different from the electric-arc furnaces in steel making.

PT: What waste materials did you try?

SAHAJWALLA: The ones we recommended for use in the actual plant were the ones that showed the best potential in the lab. The plastic that we ultimately ran with is HDPE, high-density polyethylene. And rubber tires. HDPE is a widely used material. Here in Australia [it's in] things like milk bottles. Plastics can be recycled, but there is a limit, and that is exactly the reason a lot of it ends up in landfills. So for a particular plastic, if there is no other home for it, then steel making really just offers another opportunity.

Whether it's plastics or rubber tires or what have you, you have to crush it down to a certain size, and that is then introduced to the furnace.

There are a whole lot of processing questions prior to getting it into the furnace that one needs to consider. It's not just about the chemistry of the material but also the physical aspects. You have to go with what can be collected and

processed in the most cost-effective manner.

PT: Why do you use a blend of plastics or tires with coke rather than replacing coke?

SAHAJWALLA: You don't want to end up in a situation where you have got enormous foam the first minute and then it all dies out the next minute. Or the foam can't maintain itself. Those are the kinds of considerations that have to be looked at when you are reflecting on what blends work and why. The idea ultimately would be to develop an understanding of why a particular blend might work better than another. We are in the process of publishing some of our work on this.

PT: It sounds like you are motivated both by curiosity about the science and by the potential to make a difference for society.

SAHAJWALLA: Yes, but as a scientist, my role is to develop the science. The focus here is on the process. Yes, it's got bigger implications. But we have to be practical about things. I leave the commercial side of it to the manufacturing industries.

Toni Feder

news notes

Enrollment data. The fall of 2008 saw some 14 500 students enrolled in US graduate physics programs, the highest number since 1991. A rise in the number of US

citizens entering graduate programs over the past decade has bumped them back to a majority; in recent years first-year enrollment by noncitizens has held in numbers but dropped from more than half to about 44%, according to the latest *Physics Enrollments* report by the American Institute of Physics' Statistical Research Center.

Some 763 departments offered physics degrees in 2008, about the same number as a decade earlier. Over that decade, 32 colleges and universities suspended or discontinued a physics program, and 33 added or reinstated one.

The number of students taking an introductory physics course in degree-granting physics departments increased by 28% between 1999 and 2008. The greatest gain (34%) was seen in algebra-based courses, followed by conceptual physics (27%). Calculus-based physics, which has the highest total enrollment, went up by 23%.

Departments that offer a master's as the highest degree have a larger proportion of entering women than do PhD-granting departments. But the overall proportion of women among first-year physics graduate students has hovered around 20% in recent years.

The report with these and other data can be downloaded free of charge from <http://www.aip.org/statistics/trends/undergradtrends.html>. **TF ■**

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