What to do with 135,000 pebbles: Generate a lot of C02-free safe nuclear power, says South African startup

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Posted by Mark Halper

Trevor Blench surveys the Steenkampskraal monazite mine, which will provide thorium for STL's pebble bed reactor. Blench is chairman of STL and of RARECO, the rare earth company developing the mine.

You wouldn't think a pile of pebbles would be much more than, well, a pile of pebbles.

Unless you were looking at the stack that Trevor Blench and his crew are assembling in South Africa.

Blench is chairman of Steenkampskraal Thorium Ltd. (STL), a company that is developing a "pebble bed" nuclear reactor (PBR) that he says will outperform conventional reactors in all important aspects, including that key post-Fukushima way: it's meltdown proof.

"Nuclear power in its present configuration has three big problems – meltdown risk, nuclear waste, and proliferation risk," says Blench, referring to the light water (LWR) designs used in almost all of the world's commercial nuclear power plants. "These three problems account for most anti-nuclear sentiment. If nuclear power is to be successful in the future, there must be a big improvement in nuclear technology that addresses these three issues."

Blench, whom I interviewed along with chief technical officer Martin van Staden last week when they were in London, believes that STL's reactor answers all those concerns by deploying several alternative designs.

Chief among them: Pebbles replace fuel rods; thorium fuel replaces uranium; and gas – helium – replaces water as the coolant and heat exchange medium.

The company's "Th-100" reactor stacks 135,000 6-centimetre spherical pebbles – "bigger than a golf ball and smaller than a tennis ball," says van Staden – inside a 16-meter tall industrial cylinder.

WON'T MELT

Each pebble houses thorium nuclear fuel and harbours a reaction that emits heat. Helium gas enters at 260 degrees C, runs through the cylinder and acquires the heat before exiting at 750 degrees C and relinquishing the heat to water, through an exchanger. The water turns to steam that drives a turbine, and the helium returns to the cylinder to do it all over again.

So how is that meltdown proof?

The short answer: The reaction simply stops if the temperature rises to a certain level,

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says van Staden. So if the coolant – the helium – fails, the reactions cease, unlike in LWRs, where reactions continue in a coolant failure and require the immediate intervention of control rods. A bit more detail for those you who can stomach it: The Th-100 shuts down because it works by the principle of "negative temperature coefficient." By the time the reactor hits 1550 degrees C, atoms move so fast that neutrons cannot find them to split.

Some more safety features: STL's PBR has a much lower heat density than a conventional reactor, which allows it to dissipate its heat naturally, without extra safety engineering.

"They don't need active cooling to be safe," says van Staden, noting that the Th-100 operates at 3.8 megawatts of heat per cubic meter, compared to 100 megawatts per cm pebble bed reactor for LWRs.

"If the coolant stops (in a conventional reactor) and you have100 megawatts of heat per cubic meter, you've got a problem, because you can't dissipate naturally," he says. "Our reactor can dissipate the 3.8 megawatts to the graphite structure of the reactor and through to the environment."

NO EXPLOSIONS EITHER

The graphite to which van Staden refers provides yet another safety feature: Unlike the metal cladding in conventional reactors, it does not release explosive hydrogen in extreme conditions. And the system's helium is harmless, because helium is inert, he notes.

But helium is in short supply – so won't that crimp the pebble bed style? No, says van Staden, because a reactor continually recycles its helium. "It's not like steam or something that you use up," he says, adding that one Th-100 requires about 150 cubic meters of helium, which he says "is not a significant amount."

He and Blench rattle off a list of other safety advantages provided by their reactor. Among them: 99.99 percent of the reactors' fission products stay inside the meltdown proof pebbles, so they cannot accidentally leak to the environment. The helium coolant doesn't even stand a chance of transporting them around the reactor, as the coolant touches only the impenetrable outside of the pebbles.

One of STL's Th-100 reactors has a thermal capacity of 100 megawatts (that's the "100" in the name; the "Th" is thorium), and an electricity capacity of 35 megawatts.

Chairman Blench envisions commercializing the technology within 5-to-10 years, a pace that he and van Staden point out is much quicker than the outlook for other alternative reactors, such as liquid thorium molten salt reactors (MSR) under development in China and also by U.S. companies including Flibe Energy and Transatomic Power.

"The molten salt guys have an excellent idea in concept," notes van Staden. But he says that decades of PBR development have helped get the Th-100 closer to reality.

EXPERIENCE COUNTS

STL draws on experience that date backs to at least the 1960s, when Germany developed and ran its thorium-fuelled AVR (Atom Versuchs Reaktorand), a 15-megawatt test reactor that it closed in 1988 amid public anti-nuclear sentiment after the Chernobyl nuclear disaster. Germany also operated a larger, thorium-fuelled, 300-megawatt PBR, the THTR-300, from 1983 to 1989, which ran into cost overruns. Both German reactors incurred their share of mishaps. A crack in the AVR – probably related to high temperatures – led to radioactive contamination of soil and groundwater, for instance. The THTR released radioactive dust when a pebble lodged in a feed pipe.

The South African government also infamously tried to develop a modular, uranium-fuelled, pebble bed reactor before cancelling its PBMR project in 2010, after over a decade of work and about $1 billion in expenditures. One problem there: Engineers attempted to develop a helium-gas driven Brayton cycle turbine process, rather than use traditional steam-driven Rankine cycle turbines running off of steam, as STL is doing.

STL is drawing from lessons learned at all of these projects. Most of the nine people – soon to be twelve – working at STL also worked on the PBMR.

"We've been able to draw from experience there," says van Staden.

There's another key asset on STL's side: It has a ready source of thorium, the fuel that will drive the Th-100. It just so happens that a related company, Canada's Great Western Minerals Group, owns 20 percent of STL and also owns a South African monazite mine, a rock that contains both rare earths minerals and thorium. Great Western itself is interested in the rare earths. It will give the thorium to STL, which has the rights to it. STL chairman Blench is also chairman of Rare Earth Extraction Co. (RARECO), the Great Western Group that runs the mining operation.

That's one direct connection to thorium, the fuel hailed by some as superior to uranium

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because it burns more efficiently, leaves less dangerous waste, and is more difficult to fashion into a bomb. There's another link: STL owns 15 percent of Thor Energy, the Norwegian company that is developing thorium fuel. (Blench says that STL's wil make its own fuel, and that it could be thorium plutonium blend, or could use uranium as a trigger).

OWN A PIECE OF THE ROCK

STL's progress will rely on attracting investors, to fund the €500 million that Blench thinks he'll need to build a first reactor.

The company is trying to raise the money by inviting in potential customers as investors, in a profit and risk sharing arrangement it calls the "Th-100 Consortium." Late last month, it began reaching out to the many industries it believes could benefit form a 35-mw reactor as either a source of process heat or electricity. Among the applications it is targeting: heat for chemical and petrochemical plants, refineries, oil sands and mining operations, smelters, cement factories, paper mills and water desalination; and electricity for off grid locations.

"The project is structured to award participants the opportunity to evaluate the outcome of every phase and to assess their own level of participation accordingly," CEO Eben Mulder says in a press statement. "Since every participating member would ideally also be a potential customer they will be in a position to acquire the first reactors and without having to pay a royalty fee."

Mulder hopes the initiative attracts more interest than did a previous Centurion-based startup, called QPower, where he served as chief technology officer and which attempted to raise venture capital to develop a similar PBR. According to Blench, QPower was unable to raise the funds. Mulder left to join STL earlier this year as CEO. Blench says there are no intellectual property issues between QPower and STL, which incorporated in April, 2011.

OTHER KIDS IN THE PEBBLE PIT

There's no guarantee the new funding model will work either. And STL is likely to encounter competition, as other outfits are also developing PBRs. Notably, China is building a 210-mw (electric) demonstrator reactor at the Shidaowan plant in Shandong province, following about 12 years of development at Tsinghua University, according to the World Nuclear Association.

Whether STL can raise the money it needs, of course, remains to be seen. When I look at the industries it's trawling, it seems to me that the one most likely to have the cash would be the oil industry, a possibility laden with irony given that nuclear power is meant to reduce the CO2 emissions that come straight from fossil fuel that nuclear power would help extract.

Or maybe STL has other good prospects. They hope to say more about who's interested in a few months.

Besides, they'll have to start somewhere if their PBRs, like the pebbles inside them, are ever going to stack up.

Photo from RARECO.

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