New hope for Africa's beleaguered stone breakers

The technological innovation behind the manually operated rock crusher is not one but many things: clever design, a combined use of high and low technologies, and all-important consultation with the target users.

MOKWETE, South Africa - As jobs go, stone breaking is surely one of the worst in Africa. Squatting in the hot sun and hammering away to smash large rocks into small ones, stone breakers expend joint-straining amounts of muscle power, face a constant risk of hand and eye injury, and breathe in huge quantities of harsh stone dust.

The task is also one of the lowest paid.

One group of women in this impoverished village some 300 kilometers northeast of Johannesburg recently found that, using hammers, iron bars and even other stones, they could produce about half a wheelbarrow of crushed stone per day - an amount for which they received about US$70 (70 cents). Still, it was better than nothing, enough income to buy the staple foods that their children need.

Members of the BaPedi people, the women had since the late 1980s collaborated with Hlatlolanang, a local non-governmental organization working for better nutrition. Hlatlolanang, which is funded in part by the Kaiser Family Foundation, had already helped the women to create vegetable gardens. And it helped them start stone breaking in 1992 as a means of income generation - a project the women themselves decided on.

But about two years ago, the BaPedi women began asking if there was not a better way to produce crushed stone, which is used in building construction and road paving. And so Roselyn Mazibuko, who was then director of Hlatlolanang, called a friend at New Dawn Engineering, a Swaziland-based appropriate technology company specializing in the development of small-scale production machinery, and raised the issue.

The result was the development of what is believed to be the first manually operated stone-crushing machine in the world - one which in its simplicity of design, low cost, and relatively high output could potentially revolutionize the lives of stone crushers throughout Africa and elsewhere.
"Today the women are really excited about this stone crusher," said Ms. Mazibuko. "They have bought one and are now rotating it amongst themselves, taking turns. There is a lot of demand for crushed stone, and the machine is working as expected."

Maria Mampule Nkadimeng, one of the women who now works with the machine, put it this way: "The machine is very easy to operate. Before, we spent much time using the hammer, but sometimes we got injured on the fingers. But the machine is very easy, it is very safe. No one is getting injured." Ms. Nkadimeng is more than 70 years old.

**Solid Market, Low Price**

Rock-crushing machinery is notoriously energy-intensive, heavy and technically sophisticated. Such machines require a skilled staff and continuously consume a large number of spare parts. They are also costly.

In many parts of the world, however, such capital, know-how, and fuel are not always readily available - although cheap labor is. Hence there is a ready market in many areas for hand-crushed stone.

Yet as the women in Mokwete discovered, the market price is barely enough to make such work worthwhile. A 2 August 1996 article in The New York Times found that a similar group of women in Zambia will work for a week to produce "a knee-high pile of gravel that can be sold for $8 to a contractor to pave a driveway or mix a concrete floor."

faced with the challenge of creating a machine that might increase the crushing power available to such workers without pricing itself out of the range for which microcredit is available, Crispin Pemberton-Pigott of New Dawn Engineering determined that a manually operated machine would have to straddle a delicate balance between brute force and low friction and between ease of operation and the harsh economic reality of mechanized competition.

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--Crispin Pemberton-Pigott, of New Dawn Engineering

"It was a classic example of the need for an appropriate technology - in this case appropriate to the needs of a group of women clinging to the edge of the economy," said Mr. Pemberton-Pigott, who is the founder and owner of New Dawn.

And after visiting the women in Mokwete and studying their needs, Mr. Pemberton-Pigott determined that he would have to create a machine that could be purchased for less than US$1,500, and that it would have to produce at least US$3.33 per day worth of crushed stone to be economically viable. What followed was two long years of site observation, computer modeling, bearing testing, and the building and dismantling of prototypes in a constant struggle to shave weight and cost. The project was also helped by a grant of
US$3,000 from an anonymous donor, money which was used to underwrite this sort of research and development.

The resulting crusher weighs in at 200 Kg and now sells for US$1,435. It was introduced to the Mokwete group in May 1996. Although designed to crush 10 wheelbarrows of stone per day, the women have reportedly produced up to 16 wheelbarrows full.

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At his shop in Manzini, Swaziland, Mr. Pemberton-Pigott experimented with various methods of crushing rock. He decided first to increase the mechanical leverage available to a stone crusher by using a flywheel on a hand crank.

"Because rock is very hard and very brittle, it became evident to me that if we could get all of the energy out of the flywheel over a short period of time, like a hammer strike, it would shatter the rock," said Mr. Pemberton-Pigott.

He accomplished this by connecting the flywheel to a "V"-shaped set of metal plates, which sit in the machine like enormous upright jaws, an arrangement commonly called "a crocodile." One plate is stationary; the other is attached to the flywheel by a short camshaft. The camshaft forces the moving plate towards the stationary plate once each revolution, opening and closing with each turn of the crank.

**Force of a Dump Truck**

"When the jaws move toward each other, they do not meet with resistance until they trap the rock that has been put inside the machine," said Mr. Pemberton-Pigott. "Then the pressure increases as the flywheel moves on around until, suddenly, the rock shatters. We use a 40 kilogram flywheel and we estimate that you end up with about 15,000 kilograms of pressure on the rock. It is the equivalent of putting a fully loaded, double-axled dump truck on that rock for a split-second. And that will break almost any rock."

The next challenge was to develop a machine that would hold up to the conditions in rural Africa. One problem, for example, was to find bearings that could support such loads on the flywheel and crankshaft - without lubrication. "We know that where these machines are going people are not going to lubricate them," said Mr. Pemberton-Pigott. "Even if you give them a grease gun, they will run out of grease and then just keep cranking."

The solution was to use a high technology sealed ball-bearing assembly designed for use in hydraulic machinery and earth-moving equipment. "These bearings cost about $45 a piece, but they can take tremendous loads and, because they are permanently lubricated inside with PTFE, a sophisticated plastic, they work in a very dusty environment."

The solution tells much about New Dawn's philosophy in developing appropriate technology. "Many organizations approach appropriate technology with the idea that their machines must be completely low-tech, that they should use only parts and technologies that are made in a given region," said Mr. Pemberton-Pigott. "But we don't accept the idea that a country or region has to be completely self-sufficient in everything, that you can only use the materials available around you. Rather, we are perfectly willing to use high technology solutions in combination with simple designs to create machines that solve the problem appropriately. If that means using a bearing made in Japan, okay. It is sort of a one-world argument."
"With the right tools and techniques, manual methods can effectively compete against even the largest capital-intensive crushing operations," said Mr. Pemberton-Pigott. "Every increase in output by the women's groups is a bite not out of each other's income, but out of the money now going to pay for the heavy, expensive and imported machinery of the centralized crushing operations."

Isaiah Jele, the income generating projects coordinator for Hlatlolanang, said the organization now hopes to find credit to purchase more machines. He said that they are working with some 300 women in eight villages who are crushing rock for income. "The machine is working well," he said. "It does not need electricity. It does not need fuel. And it does not break down or stop. And it crushes many different kinds of rock without any problem."

**The Needs of the Women**

An important element in the design process was consultation with the women in Mokwete. Mr. Pemberton-Pigott talked extensively with the women in Mokwete about their needs, discussing everything from rock type and size to grading and batching as well as the target income required to make the machine viable.

This sort of consultative process was very important to both Mr. Pemberton-Pigott and to Ms. Mazibuko. Both are members of the Bahá'í Faith, which promotes consultation at all levels as a key element of community reconstruction.

"The rural women for which the crusher was designed are illiterate, and they were not used to being consulted," said Ms. Mazibuko, who has moved on from Hlatlolanang to a government position as Chief Director for Districts, Primary Health Care, Northern Province. "The rural poor seldom get listened to by people who have know-how. Their self-esteem is now much greater. The people now feel they belong in society."