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PORTABLE ROCK CRUSHER FOR TRAILS

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BACKGROUND

One of the earliest machine-driven rock crushers was built in the 1960s. It was tricycle mounted, its jaws were too small to be effective, and it had a tendency to jam. (See figure 1.)

Figure 1—This machine was resurrected in 2000 and used briefly on the Lassen National Forest.

In 2003, Dick Dufourd from the Deschutes National Forest in U.S. Department of Agriculture Forest Service Region 6 requested, through the Recreation Steering Committee, that the San Dimas Technology and Development Center (SDTDC) develop a mobile trail rock crusher with 6- to 8-inch adjustable jaws that would operate from a trail dozer's hydraulic system.

THE BICO CRUSHER

SDTDC's product search located the Braun Instrument Corporation (BICO) electric Badger Jaw Crusher (a laboratory crusher) that could crush a 6-inch rock. This crusher was chosen for further evaluation because of its lighter weight and its hopper that shields workers from flying rock fragments.

The BICO jaw crusher produced pulverized to ¾-inch material. SDTDC personnel worked with designers at BICO to enlarge the space between the jaws to effectively crush a 7-inch rock. Now the jaw space on the BICO crusher can be adjusted to produce 2- to ¾-inch crushed rock. (See figure 2.)

Figure 2—Crusher with crushed aggregate on the Pacific Crest Trail.

The original electric motor on the BICO crusher was replaced with a hydraulic motor. A quick-coupling hose mechanism attaches the crusher to the dozer's hydraulic system. A mount was manufactured to attach the crusher to a standard 3-point hitch. SDTDC used a Sweco Trail Dozer

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for this project. The crusher is mounted on the rear of the dozer. Also, a stand was designed and built that allows the crusher to stand alone and operate when hooked to an alternate hydraulic source. Care must be taken when using the crusher in the stand-alone mode because it may move (see electric motor test).

HOW TO USE THE BICO CRUSHER ON TRAILS

Mount the crusher in a level position to the back of the Sweco dozer. The hopper must be in place before use.

Operate one auxiliary hookup at a time when the crusher is attached to the Sweco. All auxiliary hookups share the same hydraulic circuit. For example, the crusher jaw will slow while the blade is being raised. This can cause a rock jam. For best performance, no rocks should be in the hopper or being crushed while the blade is in motion. The crusher jaw does not slow while the dozer is moving because the dozer uses its own hydraulic circuit.

The Sweco model 450 has 65 horsepower and the model 480 has 84 horsepower, which accounts for the longer time required for the model 450 to crush the same type and amount of rock. The shape and hardness of rock affects crushing time, as does the timing and rhythm of the “feeders” (persons putting the rocks into the hopper). If the rocks are fed too quickly, the crusher will jam. The back inside panel of the hopper prevents rocks from lodging behind the jaw.

The crusher can be adjusted to crush rock to a 2- to ¾-inch size. Turning the adjusting screw changes the jaw opening; the tensioner rods also need to be tightened or loosened. If the crushed rock needs to be smaller than ¾ inch, a 12-inch shim can be inserted behind the moveable jaw that brings the jaws closer together, resulting in an aggregate size of ¾ inches to sand. (See figure 3.)

This crusher has one moving jaw and one fixed jaw. Most of the crushing occurs in the lower portions of the jaws. When the jaws begin to lose their efficiency, they can be detached and turned around (bringing the bottom to the top, same surface faces in) and used again until the entire jaw surface is worn.

Figure 3—Tightening tensioner rods after adjustment of jaw.

Ensure that the moveable jaw is rotating in the correct direction or rocks will be thrown out of the hopper. The movable jaw must move up, in, and down. If it is moving in the other direction, reverse the hoses.

SAFETY

Do not run the crusher without the hopper secured. The jaws will forcefully throw rock bits 25 feet and higher into the air. Always wear safety gear: a hardhat; gloves; and ear, eye, and respiratory protection are mandatory. (See figure 4.) Dick Dufourd of the Deshutes National Forest has experimented with a number of earplugs and found that the Howard Leight Max with a noise reduction rating of –33 decibels is effective.

Figure 4—Safety equipment.

The following additions to the Sweco are recommended:

- A rearview mirror and hand signals for communication.
- A mud flap between the dozer fan and the crusher to prevent those persons feeding the rocks into the hopper from becoming covered with and blinded by dust. (See figure 5.)

Figure 5—Notice the mud flap attached to the back of the Sweco.

Use a piece of bent rebar to dislodge jammed rocks. Turn the crusher off before removing stuck rocks.

RESEARCH

A thorough search of the rock crushing industry revealed that rock crushers generally are either large enough for freeway construction or small enough for use in a materials testing laboratory. Jaw crushers, however, are appropriate for the rock size usually crushed on a trail. All crushers researched, except for the BICO, were too heavy or too large for use on trails, or too expensive. They are all considered portable. The BICO and Morse models are materials-laboratory models. A comparison of the rock crushers is shown in table 1.

Table 1—Rock crusher comparison.

Crusher Name	Rock Size (inches)	Weight (pounds)	Cost ($)
BICO Badger Jaw Crusher	7	800	8,250
Morse 5- by 6-inch Jaw Crusher	4	1,220	12,900
Morse 8- by 8-inch Jaw Crusher	8	3,200	28,600
Lippman 10- by 24-inch Jaw Crusher	9	9,000	8,500
SDTDC-modified BICO Badger Jaw Crusher (with hydraulics)	7	900	12,188

PERFORMANCE TESTING

Sutter Equipment Company Tests

Two tests using the BICO crusher were run at the Sutter Equipment Company plant where the Sweco trail dozer is manufactured. The first test used the electric motor; the second test used a hydraulic motor. The electric motor test was performed to establish a baseline of performance. The goal was to ensure that the hydraulic motor selected would crush as well as the electric motor on the BICO equipment.

Electric Motor Test

A 1-cubic-yard sample from a commercial quarry was used. It consisted of fractured and solid granite, sandstone, and medium-to-hard structure rock. Rocks were 3 to 8 inches in diameter.

Consistently sized rock was placed in the container by hand. Crushing took 27 minutes to complete. The crusher performed well. All rock in the container was crushed. The average size of the crushed rock was ¾ by 1½ inches to 1 by 2 inches. The percentage of rock, 90 percent, versus fines, 10 percent, was verified using a sizing screen.

The crusher jammed four times during testing. The vibration from the crushing operation caused the freestanding unit to move approximately 3 feet from its original location.

Hydraulic Motor Test

A Sweco 480 trail dozer was hooked to the BICO rock crusher. Rock from the same quarry was used in the same amounts. The test began at 1,500 revolutions per minute. This speed proved too slow and was increased to 2,100 revolutions per minute to better match the revolutions of the electric motor. The crusher performed well. All of the rock was crushed in 24 minutes. The average size of the crushed rock was ¾ by 1½ inches to 1 by 2 inches. The percentage of rock, 90 percent, versus fines, 10 percent, was verified using a sizing screen. Three rock jams occurred during the test; they took a total of 4 minutes to clear.

Field Tests

Dick Dufourd tested the crusher on the Deshutes National Forest, Trails Unlimited tested the crusher on the Cleveland National Forest, and SDTDC staff tested the crusher at their San Dimas, CA, facility.

Deshutes National Forest

Dufourd used the crusher on lava rock. He was able to crush rock on 0.8 miles of heavily cobbled trail in 2 days. The Sweco 450 trail dozer was run at 1,500 to 1,800 revolutions per minute. It jammed frequently. The original stand would not hold the crusher in a level position when lifted off the ground. A new base was fabricated to hold the stand level and the crusher jammed less frequently. Dufourd also reported that the pump and hoses on the crusher got very hot to the touch and hydraulic pressure was lost in the afternoon.

Cleveland National Forest

The Region 5 Trails Unlimited Enterprise Unit tested the rock crusher on the hard rock of the Cleveland National Forest's Pacific Crest Trail. The field test was conducted over a 3-day period. Weather was rainy with cool to cold temperatures. The two-person crew alternated as operator and crusher feeder. Existing rocks from the trail—fractured and solid granite rock and sandstone—having a medium to hard structure were crushed. (See figure 6.)

Figure 6—Feeding rocks into the crusher; dozer is stationary.

The crusher was attached to a SWECO 480 trail dozer fitted with an extra-capacity positive-displacement gear drive accessory pump that pumps 18 to 22 gallons of hydraulic fluid at 2,100 pounds per square inch. The extra capacity was sufficient to run the crusher efficiently at 1,000 to 1,200 revolutions per minute. The speed was increased to 2,100 revolutions per minute to see whether increased speed was beneficial; it was not. The increased speed created more heat and

less fuel efficiency, and it increased wear on the crusher jaws. Crushing began at 9 a.m. and ended at 5 p.m. each day. Six hundred to 1,000 feet of trail was worked per day. The crusher performed very well. All rock of the correct size was crushed. The average size of the crushed rock was ¾ by 1½ inches to 1 by 2 inches. The percentage of rock, 90 percent, versus fines, 10 percent, was verified by visual inspection.

San Dimas Technology and Development Center

The third test was conducted at SDTDC using the same SWECO 480 trail dozer. The stationary crusher test was conducted under normal operating conditions. Three 1-cubic-yard containers of rock were purchased from a local rock company. Three different hardnesses of rock were tested at two different crush sizes, 1½ and ¾ inch. The test was conducted under continuous operation to evaluate long-term durability. The tests took an average of 44 minutes per cubic yard of crushed material. Two difficulties were encountered during the test. First, there were several rock jams that took less than 2 minutes each to clear; second, the tensioner rods came loose when the size of the jaw opening was changed.

TO ORDER A CRUSHER

The SDTDC-modified BICO Badger Jaw Crusher is the only rock crusher designed specifically as trail equipment. This crusher can be ordered with the original electric motor. A stand can also be ordered. Orders for trail use include the crusher with hydraulics and quick couplings, hopper, 3-point hitch, adjustable top link, shim, extra tensioner rods, lightweight base, and users manual.

The SDTDC-modified BICO Badger Jaw Crusher has a 1-year warranty. Specific operating and maintenance instructions are provided. The jaws and the bearings do wear out; the jaw is worn when it becomes cupped. The machine can be returned to BICO for maintenance. Routine maintenance takes 8 to10 hours at a cost of $40 per hour, plus parts and shipping.

For further information on the SDTDC-modified BICO Badger Jaw Crusher, contact Ellen Eubanks, project leader, by phone at 909–599–1267 ext 225 or by e-mail at eeubanks@fs.fed.us.

You can order a copy of this document using the order form on the FHWA's Recreational Trails Program website at:

http://www.fhwa.dot.gov/environment/rectrails/trailpub.htm

Fill out the order form and fax it to the distributor listed on the form. You can send a fax request to 301–577–1421, e-mail it to report.center@fhwa.dot.gov, or request by mail from:

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