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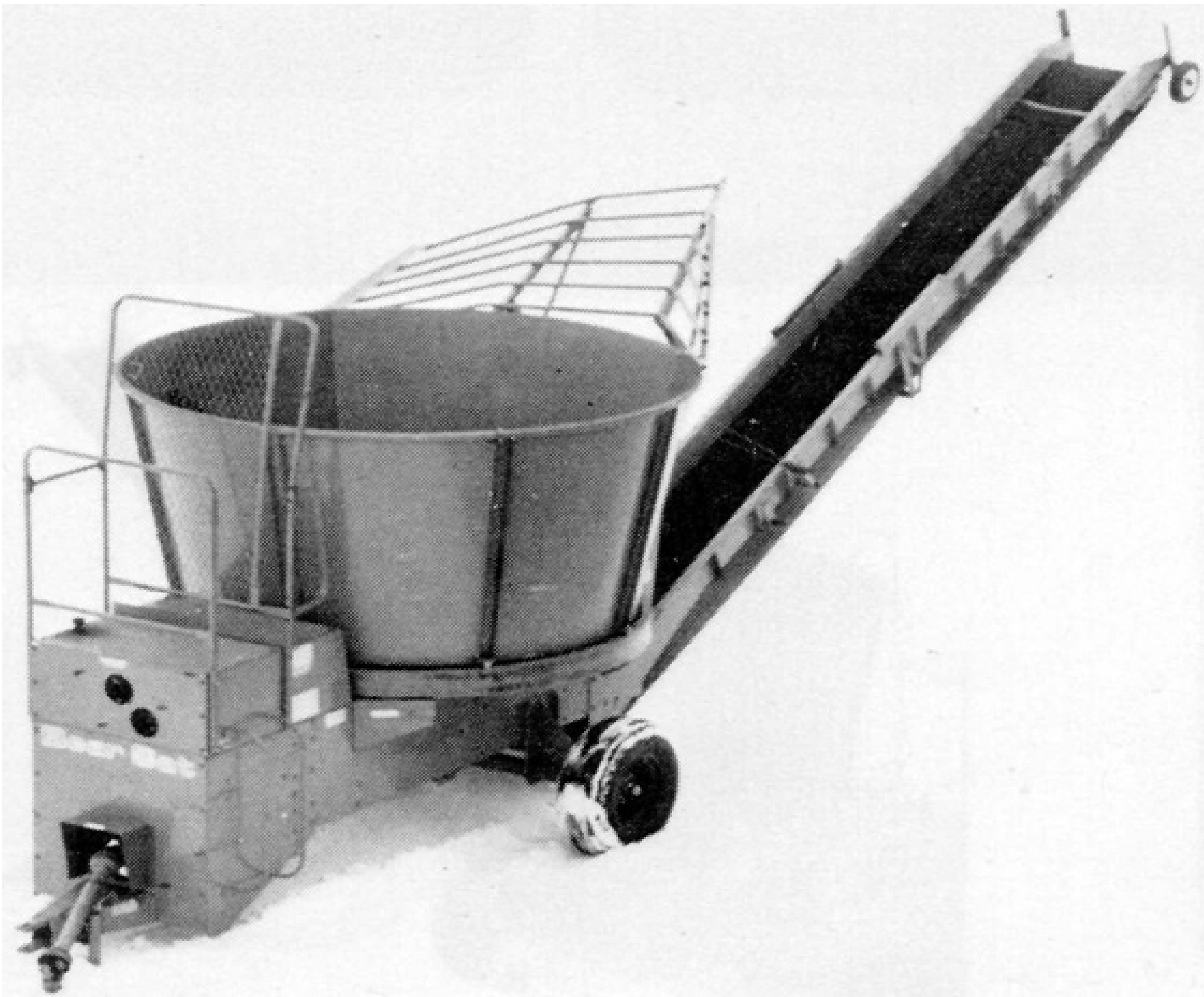
Evaluation Report 14



Bearcat Model 4200 Tub-Master Feed Grinder

A Co-operative Program Between
ALBERTA FARM MACHINERY RESEARCH CENTRE
PAMI
PRAIRIE AGRICULTURAL MACHINERY INSTITUTE

BEARCAT MODEL 4200 TUB-MASTER FEED GRINDER

MANUFACTURER:

Western Land Roller Company
Hastings, Nebraska
U.S.A. 68901

DISTRIBUTOR:

Dumarr Equipment Limited
140 - 4th Avenue East
Regina, Saskatchewan
S4N 4Z4

FIGURE 1. Bearcat Model 4200 Tub-Master Feed Grinder.

SUMMARY AND CONCLUSIONS

Overall functional performance of the Bearcat 4200 was *good* in both baled and stacked hay and straw. Ease of operation was *good.*

Maximum grinding rates with a 51 mm (2 in) screen were about 11.0 t/h (12.1 ton/h) in baled alfalfa, 3.4 t/h (3.7 ton/h) in stacked alfalfa, 7.8 t/h (8.6 ton/h) in stacked barley straw and 7.5 t/h (8.3 ton/h) in baled barley straw. Maximum grinding rates with a 25 mm (1 in) screen were about one-half as large as those with a 51 mm (2 in) screen. With most tractors, grindIng rates were usually limited by tractor power rather than by feeding characteristics.

As with most tub grinders, power consumption was high and specific capacity was low. Specific capacity varied from 0.16 t/kW.h (0.13 ton/hp.h) in stacked alfalfa hay to 0.08 t/kW.h (0.06 ton/hp.h) in round barley straw bales, when using a 51 mm (2 in) screen. Specific capacities were reduced by about 50% when using a 25 mm (1 in) screen.

As with most tub grinders, the method of feeding the hammer mill imposed heavy shock loads on the power train and resulted in wide power fluctuations. For example, at the maximum feedrate of 7.5 t/h (8.3 ton/h), with a 51 mm (2 in) screen in round barley straw bales, the average power input was 100 kW (134 hp), however, a tractor with a maximum power take-off output of at least 151 kW (202 hp) was needed to prevent tractor stalling due to the wide power fluctuations. By adjusting the tub governor, smaller tractors could be used at reduced grinding rates.

The Bearcat 4200 was safe to operate if the manufacturer's recommendations were closely followed. The location of the tub speed control above the pto shaft required additional caution when making adjustments to tub speed.

RETAIL PRICE:

$13,280.00 (December 1, 1977, f.o.b. Regina, with 51 mm (2 in) and 102 mm (4 in) screens)

RECOMMENDATIONS

tt is recommended that the manufacturer consider:

1. Providing adjustable drive fins on tub side wall.
2. Providing a heavier winch for raising the rear elevating conveyor.
3. Providing a shorter pto shaft to improve ease of connecting to tractor.
4. Investigating the possibility of installing a suitable flywheel on the hammer milt to reduce drive train shock loads.

Chief Engineer - E. O. Nyborg
Senior Engineer - L. G. Smith

THE MANUFACTURER STATES THAT

With regard to recommendation number:

1. Two drive fins (baffles) are provided which are mounted on opposite side walls. There is also a guide mounted on the tub floor. The floor mounted guide must be removed when grinding round bales. It is also recommended that some loose hay be placed in the tub prior to dropping in the first bale. The side walls and the drive fins are structurally compatible and any extension of the fins could result in tub side failure.
2. The winch handle and mounting have been redesigned.
3. Our field experience has not verified the need for a shorter pto shaft. A special length can be provided upon request.
4. Various types of dampening devices are under consideration.

GENERAL DESCRIPTION

The Bearcat Model 4200 Tub-Master Feed Grinder (FIGURE 1) is a portable power take-off driven hammer mill with rotary feed tub, designed to grind loose, stacked or baled straw and hay.

The manufacturer recommends use with tractors up to 112 kW (150 hp) at 1000 rpm power take-off speed.

The Bearcat 4200 is designed to be batch fed with a suitably equipped front end loader. The hydraulically driven, variable speed tub regulates feed to a belt driven hammer mill. A hydraulic governor automatically controls the tub speed and stops tub rotation when the tractor speed drops below a preset level.

Fineness of grind is determined by the size of screen used below the hammer mill. Ground material falls through the screen onto a continuous chain with drag bars which delivers it to an adjustable roughtop rubber belt conveyor.

Detailed specifications are given in APPENDIX I.

SCOPE OF TEST

The Bearcat 4200 was operated for 41 hours while processing about 273 t (300 tons) of hay and straw. It was used to process small square bales, large round bales, and stacked hay.

It was evaluated for ease of operation, rate of work, power consumption, quality of work, operator safety and suitability of the operator's manual.

RESULTS AND DISCUSSION

EASE OF OPERATION

Hitching: The Bearcat 4200 hitch pin hole would accommodate a 19 mm (0.75 in) draw pin, which is considerably smaller than draw pins used on tractors of 75 kW (100 hp) and larger. A larger hitch pin hole would improve transport safety.

The excessive length of the 1000 rpm power take-off shaft caused difficulty in connecting if the tractor was parked in a depression. A shorter power take-off shaft is recommended. The power take-off shaft was attached with a spring loaded spring.

Tub Control: The reversible hydraulic tub drive was equipped with a proportioning valve to control the tub speed and consequently the feedrate. The valve had to be set to obtain steady tub rotation while utilizing the available tractor power. The valve had to be adjusted to suit both the type of material being ground and the tractor size. It was quite easy to determine the proper setting by opening the valve until the tractor was suitably loaded.

The hydraulic governor reduced hammer mill slugging if the proportioning valve was properly set. As engine speed dropped under Icad, the governor stopped tub rotation if the power take-off speed fell below 810 rpm. As with most tub grinders, slugging and high drive train loads occurred if excessive feedrates were attempted.

Loading the Tub: The Bearcat 4200 has a large tapered tub (FIGURE 2) with a rear guide rack to facilitate loading large round bales. Height to the top of the tub was 2820 mm (9.25 ft). When loading loose material with grapple forks, large loads tend to wedge as the material drops into the narrower section of the tub. Most effective feeding was obtained by taking small loads which would easily drop to the bottom of the tub.

FIGURE 2. Tub and Guide Rack.

Occasionally, a large round bale placed in the centre of the tub would not contact the tub fins and no grinding would occur. Loading a second bale on top would force the first bale against the tub wall and initiate grinding. It is recommended that an adjustable fin be placed on the side of the tub to correct this problem.

Screen Removal: Eleven screen sizes from 6 to 102 mm (0.25 to 4 in) were available for the Bearcat 4200. Changing the screens (FIGURE 3) required removal of five bolts to remove the feed regulating plate. With the use of a bar, the screens could be pried up and around the mill. Screens could be removed and replaced by one man in about 10 minutes.

Hammer Mill: The hammer mill contained four rows of swinging hammers, with two rows of 12 and two rows of 14. When worn, the hammers could be reversed to present new wear surfaces. This could be accomplished from within the tub by removing each pivot shaft through a hole in the cylinder housing to a man outside the tub. Hammers must be replaced in sets of two opposite hammers to maintain rotor balance.

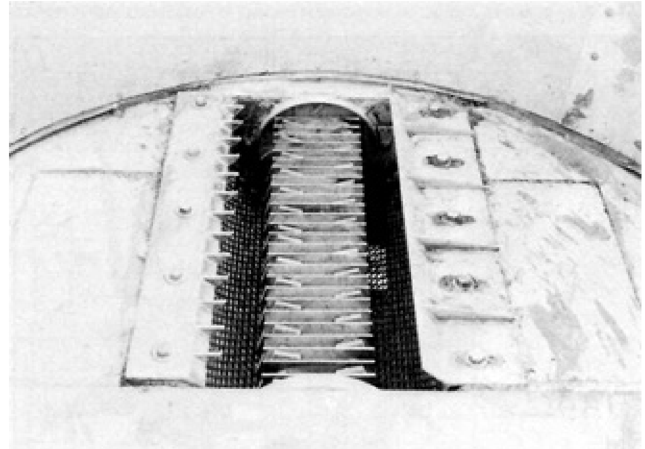


FIGURE 3. Hammer Mill and Screen.

Discharge Chamber: The hammer mill discharged ground material onto a continuous chain with drag bars (FIGURE 4) beneath the screen. The conveyor was well shielded and effectively delivered ground material to the elevating conveyor without losses and blockage. The chamber did not have any clean out doors, but the wide conveyor opening gave suitable access for unplugging.

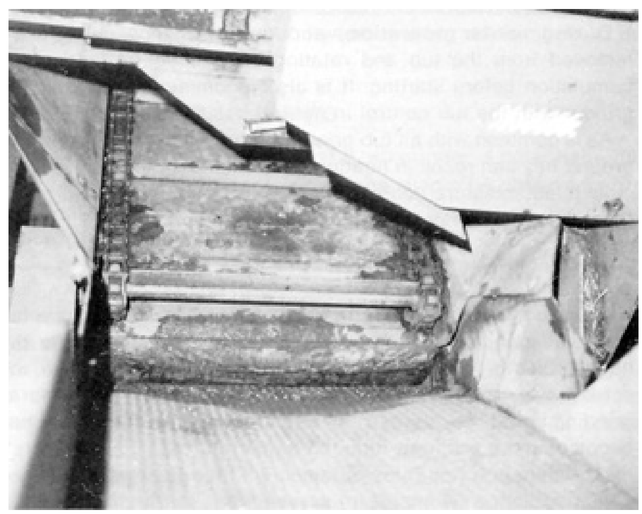


FIGURE 4. Apron Conveyor.

Elevating Conveyor: The rough top rubber conveyor had ample conveying capacity at lift angles up to 25°. In most materials, at lift angles greater than 25°, the material slipped and tumbled on the belt. At a 25° angle, the conveyor had a discharge height of 3050 mm (10 ft) and a corresponding reach of 6353 mm (20.8 ft).

The self cleaning drive pulley effectively reduced the buildup of fines between the conveyor belt and the belt trough, but is mounted so low that it scrapes the ground when transporting over uneven surfaces. The sides at the conveyor trough reduced the blowing of fines in moderate winds.

The conveyor folded for a reduced length during transport (FIGURE 5), but was awkward for one person to unfold.

The conveyor was equipped with a friction drag winch ensuring safe adjustment of conveyor height and also conveyor folding, but appeared to be inadequate for the Icad applied, since the handle broke and the winch tore free of its mounting during use. A heavier winch is recommended.

FIGURE 5. Conveyor in Transport Position

Transporting: The Bearcat 4200 had a fixed single axle with no spring suspension. As a result, it was not suited for high speed transport.

Safety straps were provided for locking the folded conveyor in position during transport.

Winter Operation: All evaluation was conducted in winter conditions, typical of most tub grinder use in the prairie provinces. All components, including the hydraulic tub control, worked well, even at temperatures of -30° C.

During winter operation, accumulated snow should be removed from the tub and rotating parts checked force accumulation before starting. It is also recommended to start the grinder with the tub control in neutral position.

As is common with all tub grinders, excessive snow mixed with ground hay can result in heating problems. If ground hay is to be stockpiled, moisture content must be low enough to ensure that the stockpile will not heat and spoil.

RATE OF WORK

Maximum Grinding Rate: The maximum grinding rate for a tub grinder depends on the type of hay being ground, whether the hay is baled or loose, its moisture content and temperature, the screen size used, and the available tractor power. In general, grinding rates are higher at very low temperatures as hay becomes more brittle at reduced temperatures.

Maximum grinding rates obtained with the Bearcat 4200 when equipped with a 51 mm (2 in) screen were 11 t/h (12.1 ton/h) in baled alfalfa, 3.4 t/h (3.7 ton/h) in stacked alfalfa, 7.8 t/h (8.6 ton/h) in stacked barley straw and 7.5 t/h (8.3 ton/h) in baled barley straw. In general, capacity was directly related to the screen size used and reducing the screen size by 50% also reduced the capacity by about 50%. For example, the maximum capacities to be expected when using a 25 mm (1 in) screen would be about from 1.7 to 5.5 t/h (1.9 to 6.1 ton/h) in alfalfa and from 3.8 to 3.9 t/h (4.2 to 4.3 ton/h) in barley straw.

POWER CONSUMPTION

Power Take-off Requirements: FIGURE 6 shows the average power take-off input for the Bearcat 4200 in alfalfa and barley straw. The power input is plotted against grinding rate up to the maximum rate reached for each test. The average power input, at maximum grinding rate, with a 51 mm (2 in) screen varied from 20 kW (27 hp) in stacked alfalfa hay to 100 kW (134 hp) in round barley straw bales.

The power consumption at reduced grinding rates, corresponding to smaller tractors, may be read from FIGURE 6. As mentioned previously, capacity was directly related to screen size for a certain power input. For example, a power input to 100 kW (134 hp) in round barley straw bales corresponds to a maximum capacity of 7.5 t/h (8.3 ton/h) with a 51 mm (2 in) screen and a maximum capacity of only 3.8 t/h (4.2 ton/h) with a 25 mm (1 in) screen.

Specific Capacity: Specific capacity is a measure of how efficiently a machine performs a task. A high specific capacity indicates efficient energy use while a low specific capacity indicates inefficient operation. Tub grinders, in general, are inefficient machines.

The specific capacity of the Bearcat 4200, with a 51 mm (2 in) screen, varied from 0.16 t/kW.h (0.13 ton/hp.h) in stacked alfalfa hay to 0.08 t/kW.h (0.06 ton/hp.h) in round barley straw bales. These values represent average operating values and not peak outputs. These values would be reduced to about 0.08 t/kW.h (0.07 ton/hp.h) in alfalfa and 0.04 t/kW.h (0.03 ton/hp.h) in straw, when equipped with 25 mm (1 in) screen.

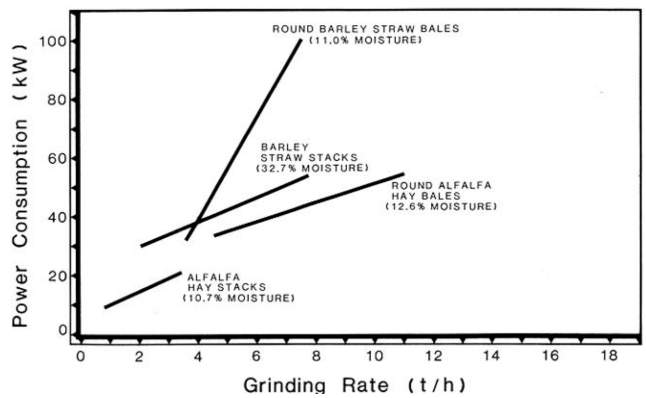


FIGURE 6. Power Consumption of the Bearcat 4200 at Various Grinding Rates, when Equipped with a 51 mm (2 in) Screen.

Instantaneous Power Requirements: FIGURE 6 shows the average power consumption at various feedrates. Instantaneous power input fluctuates rapidly due to non-uniform feeding to the hammer mill and governor sensitivity. Peak power requirements are much greater than those shown in FIGURE 6. A typical one minute long instantaneous record of power input while grinding baled alfalfa hay is shown in FIGURE 7. As can be seen, input power fluctuated rapidly during one minute of operation at a fixed governor setting. These wide power fluctuations represent shock loads to the tractor and grinder drive train and indicate the amount of reserve power needed to prevent tractor stalling.

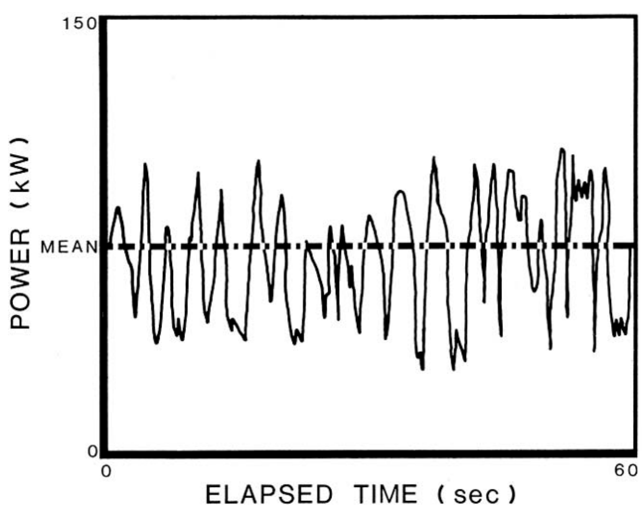


FIGURE 7. Typical Instantaneous Power Requirements for a Tub Grinder.

The coefficient of variation[1] (TABLE 1) may be used to compare the power train shock loads and to show the possibility of tractor stalling when grinding various materials. The larger the coefficient of variation, the higher are the shock loads and the greater is the possibility of tractor stalling. Large variations in power requirements may be partially controlled with the tub governor. Most of the variation, which is beyond operator control, is due to the erratic nature of feeding in most tub grinders. In general, smaller variations in power requirement occurred with loose hay or straw than with bales, due to more uniform feeding. It is recommended that the manufacturer investigate the possibility of installing a suitable flywheel on the hammer mill to reduce drive train shock loads.

TABLE 1. Coefficients of Variation of Input Power for the Bearcat 4200 with 51 mm (2 in) Screen.

STRAW BALES	STRAW STACKS	ALFALFA STACKS
25.3%	28.3%	9.4%

Determining an Expected Grinding Rate for a Certain Tractor Size: FIGURE 8[2] may be used to estimate the average grinding rate which may be expected for a certain tractor size in a certain type of material when using a 51 mm (2 in) screen. FIGURE 8 presents the same data as given in FIGURE 6, but has been corrected to include the peak power fluctuations shown in TABLE 1. For example, a tractor with maximum power take-off output of 70 kW (94 hp), at 1000 rpm expected maximum grinding rates without tractor stalling are 4.3 t/h (4.7 ton/h) in round straw bales, and 5.5 t/h (6.1 ton/h) in stacked straw. As previously discussed, changing to a 25 mm (1 in) screen would reduce the expected grinding rates to about one-half of those shown in FIGURE 8, for the same power input.

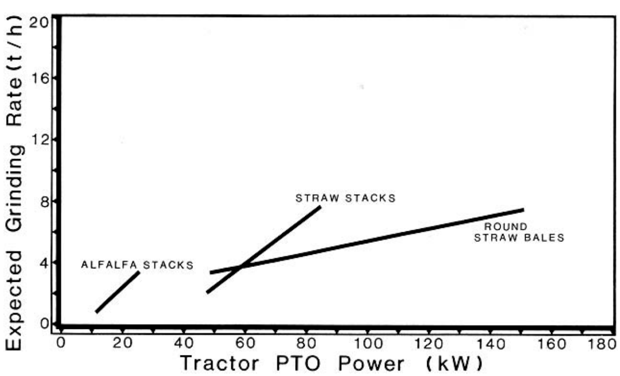


FIGURE 8. Determining Expected Average Grinding Rates With the Bearcat 4200 for Various Tractor Sizes when Using a 51 mm (2 in) Screen.

QUALITY OF WORK

Length of Cut: For a certain screen size, tub grinders produce chopped hay of varying particle lengths. FIGURE 9 shows a typical particle size distribution for the Bearcat 4200 when grinding stacked alfalfa hay with a 51 mm (2 in) screen. TABLE 2 shows the percent by weight of each of the particle sizes given in FIGURE 9, when grinding various materials with a 51 mm (2 in) screen.

[1] The coefficient of variation is the standard deviation of the power fluctuation expressed as a percent of the mean power at one feedrate setting. The coefficients of variation given in TABLE I are the average of the coefficient of variation for at least five different feedrates in each material.

[2] FIGURE 8 is a plot of the mean power requirements plus twice the standard deviation of the power fluctuations. Instantaneous power requirements should fall below the line 98% of the time.

TABLE 2. Size Distribution of Ground Materials when Using a 51 mm (2 in) Screen.

LENGTH OF PARTICLE	PERCENT OF TOTAL SAMPLE WEIGHT				
	STACKED BARLEY	ROUND BARLEY	STACKED ALFALFA	ROUND ALFALFA	STACKED SWEET CLOVER
Less than 3 mm long (FIG. 9a)	10.5	22.5	17.2	17.2	31.6
3 to 10 mm (FIG. 9b)	34.0	40.2	39.5	46.2	39.9
10 to 18 mm (FIG. 9c)	20.4	15.9	13.1	12.6	11.4
18 to 25 mm (FIG. 9d)	14.4	10.4	13.3	13.7	9.5
25 to 38 mm (FIG. 9e)	17.3	9.5	14.1	9.0	5.5
Greater than 38 mm (FIG. 9f)	3.4	1.5	2.8	1.3	2.1

OPERATOR SAFETY

The Bearcat 4200 was generally safe to operate and service as long as common sense was used and the manufacturer's safety recommendations were followed. Rotating parts were well shielded, the unloading conveyor could be fixed in position for transport and the cable winch had a friction drag for safety in lowering the conveyor.

The cable winch appeared to be inadequate for the Icad applied, since the handle broke and the winch tore free of its mounting during use. A heavier winch is recommended.

The location of the tub speed control (FIGURE 10) adjacent to the pto shaft required caution when making adjustments to the tub speed.

GENERAL SAFETY COMMENTS

The operator is cautioned that a tub grinder is potentially very dangerous. The following precautions should be observed when operating any tub grinder:

Never stand on the inspection platform or look into the tub while the grinder is in operation as dangerous objects may be thrown out of the tub by the hammer mill.

Never grasp loose baler twine that is hanging over the tub wall as it may be instantaneously reeled into the hammer mill causing injury.

Periodically remove twine buildup from the hammer mill rotor to reduce fire hazard and carry a fire extinguisher on the grinder at all times.

Tow the grinder behind a tractor or suitably sized truck at low speed. A light pickup truck is not suitable. Be especially careful of conveyor height and overhang when turning corners or passing under power lines.

Disengage the power take-off and stop the tractor to clear blockages or to make adjustments. The manufacturer can only go to certain limits in providing shielding and safety devices and must rely on the operator's common sense in following established safety procedures.

As is common with all tub grinders, great care must be taken to ensure that the hay is free of foreign material such as barbed wire or baling wire. This is especially true when processing large round bales. Although wire presents no problem to the tub grinder, the short pieces formed after grinding are a potential source of "hardware disease" in cattle.

OPERATOR'S MANUAL

The operator's manual was clear, well written and contained much useful information on operation, servicing adjustments and safety precautions.

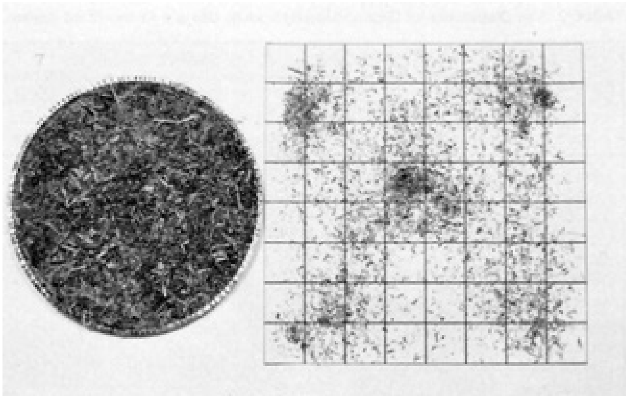


FIGURE 9a. Less than 3 mm long.

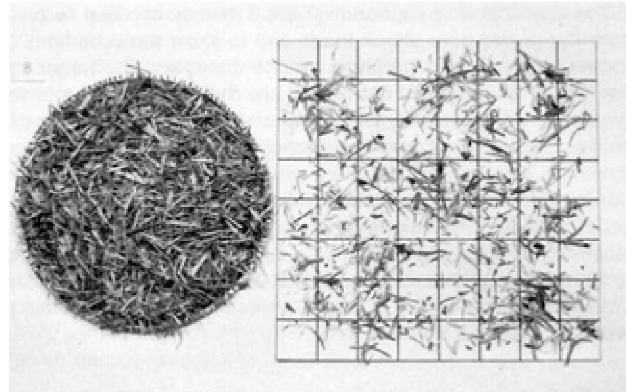


FIGURE 9b. 3 to 10 mm.

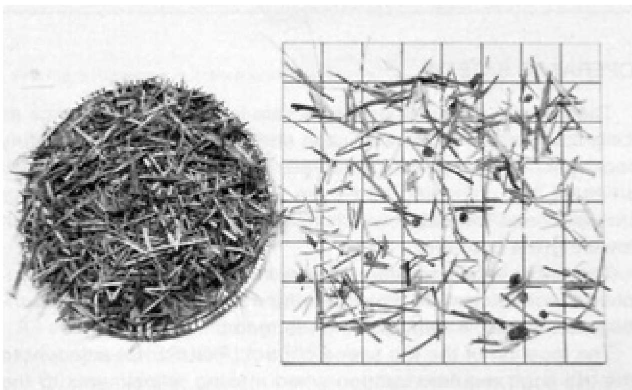


FIGURE 9c. 10 to 18 mm.

FIGURE 9d. 18 to 25 mm.

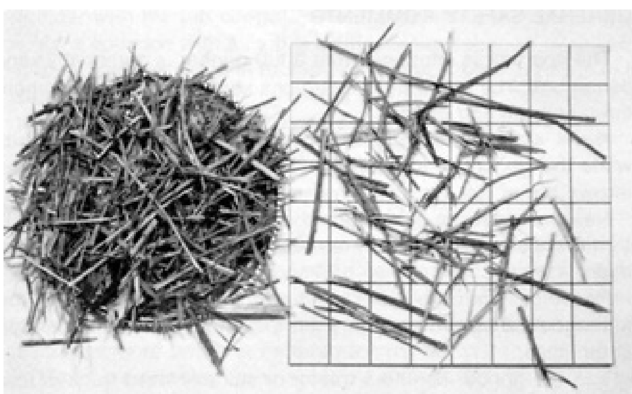


FIGURE 9e. 25 to 38 mm.

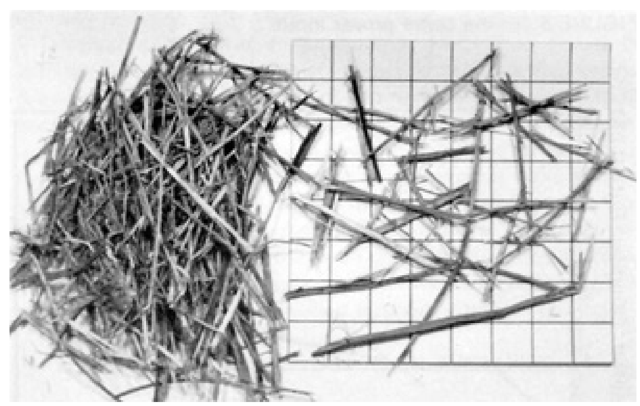


FIGURE 9f. Greater than 38 mm.

FIGURE 9. Distribution of Particle Lengths when Grinding Stacked Alfalfa Hay with a 51 mm (2 in) Screen. (Pictures taken on a 2 cm grid.)

DURABILITY RESULTS

The Bearcat 4200 was operated for 41 hours while processing about 273 t (300 tons) of hay and straw. The intent of the test was to evaluate functional performance and an extended durability evaluation was not conducted. No significant mechanical problems occurred during functional testing.

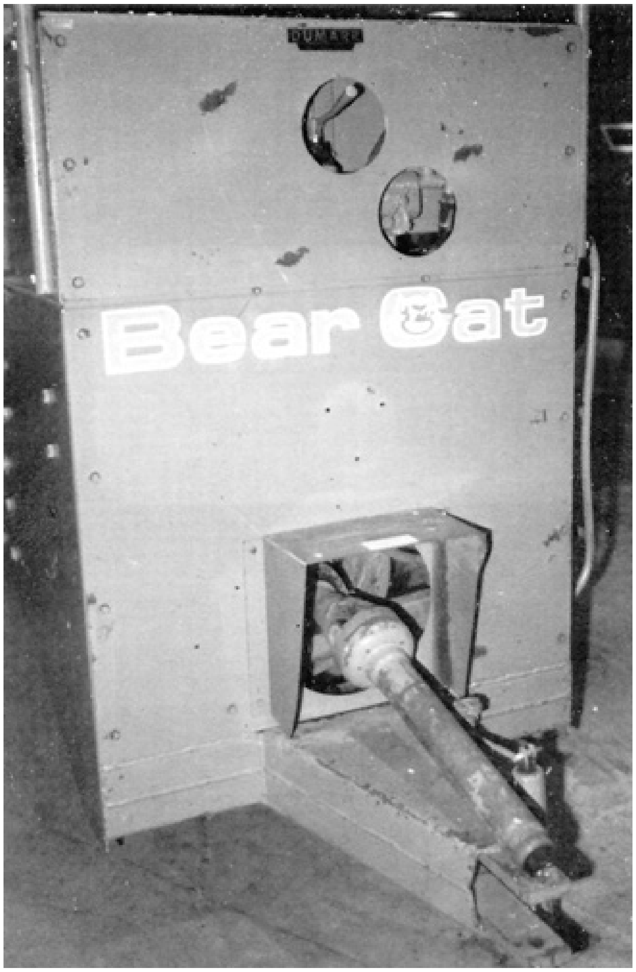


FIGURE 10. Tub Speed Control.

APPENDIX I

SPECIFICATIONS

MAKE: Bearcat
MODEL: 4200
SERIAL NUMBER: 503
MANUFACTURER: Western Land Roller Company
Hastings, Nebraska
U.S.A. 68901

OVERALL DIMENSIONS:

-- height	3580 mm (141 in)
-- width	2920 mm (115 in)
-- length	10360 mm (408 in)
-- ground clearance	140 mm (5.5 in)

WEIGHT:

-- hitch	260 kg (573 lbs)
-- left wheels	1272 kg (2804 lbs)
-- right wheels	1266 kg (2791 lbs)
(TOTAL)	2798 kg (6168 lbs)

SUSPENSION: Solid

TIRES:

-- size	2 - 12.5 L x 16, 8 ply

TUB:

-- top diameter	2820 mm (111 in)
-- bottom diameter	2310 mm (90.9 in)
-- depth	1490 mm (58.7 in)
-- loading height	2820 mm (111.0 in)
-- type of governor	hydraulic
-- tub speed range	0 to 10 rpm
-- drive	A 5.90/6.00 x 9, 6 ply rubber tire against outer rim of tub, driven by chain off hydraulic motor.

HAMMER MILL:

-- length	1000 mm (39.4 in)
-- diameter	560 mm (22 in)
-- shaft diameter	61.9 mm (2.4 in)
-- hammers	
-- length	196.9 mm (7.75 in)
-- thickness	12.7 mm (0.5 in)
-- type	sharp 2 sides
-- number of rows	4
-- hammers per row	2 rows with 12, 2 rows with 14
-- total number of hammers	52
-- pin size	25.4 mm (1.0 in)
-- drive train	belt driven off pto shaft
-- speed at 1000 rpm power take-off	2166 rpm
-- speed when governor engages tub	2050 rpm
-- speed when governor disengages tub	1750 rpm

HAMMER MILL APRON CONVEYOR:

-- type	continuous drag chain with slats
-- length	1410 mm (55.5 in)
-- width	610 mm (24 in)
-- minimum clearance to screen	216 mm (8.5 in)
-- drive	chain driven off elevating conveyor drive
-- speed	1.22 m/s (240 ft/m)

ELEVATING CONVEYOR:

-- type	rough top rubber belt
-- length	7010 mm (276 in)
-- height at 25 incline	3050 mm (120 in)
-- width	457 mm (18 in)
-- depth	198 mm (7.8 in)
-- drive train	chain driven from belt driven gearbox
speed	1.4 m/s (267 ft/m)

SCREENS:

-- type	one piece
-- length	1050 mm (41.3 in)
-- circumferential length	1150 mm (45.3 in)
-- thickness	6350 mm (0.25 in)
-- screened area	1.21 m^2 (1875 in^2)

MANUFACTURER'S MAXIMUM RECOMMENDED TRACTOR SIZE AT 1000 RPM 112 kW (150 hp)

APPENDIX II

MACHINE RATINGS

The following rating scale is used in PAMI Evaluation Reports.

(a) excellent	(d) fair
(b) very good	(e) poor
(c) good	(f) unsatisfactory

APPENDIX III

METRIC UNITS

In keeping with the Canadian metric conversion program, this report has been prepared in SI units. For comparative purposes, the following conversions may be used:

1 hectare (ha)	= 2.47 acres (ac)
1 kilometre/hour (km/h)	= 0.62 miles/hr (mph)
1 kilogram (kg)	= 2.2 pounds (lb)
1 tonne (t)	= 2204.6 pounds (lb)
1 tonne/hectare (t/ha)	= 0.45 ton/acre (ton/ac)
1 tonne/hour (t/h)	= 36.75 pounds/minute (lb/min)
1000 millimetres (mm) = 1 metre (m)	= 39.37 inches (in)
1 kilowatt (kW)	= 1.34 horsepower (hp)
1 litre/hour (L/h)	= 0.22 Imperial gallons/hour (gal/h)

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