DEVELOPMENT OF THE GEAR CUBE MACHINE

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Description of the Principle

The Gear Cuber principle is protected by U.S and foreign patents pending

Gear cubing is accomplished by using two or more gears meshed together. The gears are different from ordinary gears in that they have voids between the lobes or teeth. Although the gear is a monolithic, one piece casting, one can think of it as being a three part sandwich composed of a circle, a series of gear teeth spaced around the circle, and a third member, an open centered circle laid on top of the teeth. The holes between the teeth serve as dies to compress and exit the hay cubes. The hay moves toward the center of the gears in a series of segmented charges. The compressed material meets a breaking cone and falls off as a cube onto an elevator. The voids, having a taper, provide back pressure to assist compression.

Development of the Gear Cuber

Sometime after the gear cube concept developed, an idea of stacking gear lobes into a broad-faced, multi-tracked die occurred to me. Several sets of dies later, a machine was built that could go through the field making cubes directly from long hay. The stacked gear dies have a theoretical capacity of twenty tons per hour. Due to weight considerations, only enough horsepower could be carried to provide ten ton capacity. The feeding mechanism tended to deliver to the dies uneven hay bunches left from the swather or caused by wind, and the equipment powered out.

The single track concept developing at the same time answered the problem of overfeeding. A single track has one row of gear lobes in each gear. A prototype was built having two such wheels. Next a four-geared unit was assembled. The gears are arranged foursquare in the machine and each gear interacts with two of the others so they are double acting.

The Single Track Quad

The present cuber in limited production is what I call a Single Track Quad. The four gears turn in a horizontal plane above a feed tank floor having four large holes. There is one hole under each gear to let the cubes fall out. On the top of each gear is a steel cone covering the hub. Each cone has one or more auger vanes to force hay down to the gears. Enclosing the entire assembly is a feed tank to hold the incoming hay over the dies and to provide a reserve to smooth out variations in the delivery. The gears are self limiting and cannot be overfed when adequate horsepower is applied.

Operation of the Quad

The Quad is driven at die speeds from 130 to 225 R.P.M. Lower speeds tend to cause loping, and higher speeds tend to reject the material from the die openings. When speed, power, and moisture are properly regulated for the material being cubed, the Quad is self limiting and cannot be overfed to plug up and bog down. Adjustable spoilers assist in trimming capacity to available horsepower. The spoilers tailor the amount of material the dies pass into the junctures. By adjusting the spoilers to leave a reserve of unused power, the machine can run with less attention. Thus, it can be self-limiting on a wide variety of materials that have different flow rates and potential capacities. Materials such as alfalfa, grass seed straw, paper, wood fiber, manure, and cotton gin trash, have been cubed.

When restarting the Quad after disuse or power outages, a little extra water applied to the cones will relieve starting strain. If the downtime was unexpected, such as from a power outage, the machine could not be "put to bed" by gradually increasing moisture where it may be necessary to remove the loose material poised above the dies in the feed tank. The proper technique is to run the dies nearly empty with extra water as a lubricant and slowly add fresh material. The light charges entering the dies cause slight movement of the cooked-in cubes without strain. Only a few minutes are required to purge the set cubes - - it is actually quicker than it takes to tell about it.

The Gear Cuber is capable of producing cubes over a wide range of moisture and material variations. Cubes can be made of dry alfalfa hay by adding water, or molasses and water. As the moisture level elevates from humidity, dew, or plant juices, no additional moisture may be needed. From this point on the operator must judge when to quit cubing. The Quad will not know since gradual moisture changes do not affect the passing of the material through the dies. Cubes have been made at well over 30 percent hay moisture without plugging the machine. But at some level, the cubes will display a marked tendency to separate into segments without making durable cubes. Operation should stop unless the cubes are intended for immediate local use.

When storing high moisture cubes, I find it practical to place an A-frame under the pile and duct air to it from fans. With a reasonable volume of production, costs of reducing the moisture using unheated, forced air, should be less than $.50 per ton in the Columbia Basin of Washington.

Operation Continued

Quads have been operated using 150 H.P. electric motors and by 6-71 G.M. diesel engines running at 1750 R.P.M. The power is direct drive through a line shaft without belts or reductions other than provided in the integral angle box in the cuber.

With the above power, in alfalfa hay, the operator can expect to produce 7 tons per hour. Capacities up to 9 tons have been observed. In general, coarse chopped hay (four inches) will produce less output without significantly increasing hay lengths in the cube. Chops of two inches produce the 7 tons per hour mentioned. Shorter chopping and/or the addition of fines, such as supplements or ground grains, through the feed tank will increase the tonnage rate without significantly increased power requirements. Supplements can be placed in or metered into the feed tank. The counter-rotating cones and auger vanes do a vigorous mixing job at no additional power or investment cost.

A torque tamer or shear bolt setup is recommended in the main drive line to protect the power source in the event tramp iron locks up the cuber. Although no serious damage has been inflicted in the dies by tests using tramp iron, drive lines have parted and created some excitement. Drive lines should be contained by sturdy hoops affixed to the frame at close intervals. The whole assembly should be shielded from operators and spectators.

Maintenance

The oil level in the main drive case should be checked to prevent low level operational damage. Periodically, the high temperature grease should be replaced in the four hubs carrying the cubing gears. Grease fittings provide for routing maintenance.

All bearings are standard tapered roller types and are available from local shops. The drive components are assembled from heavy duty highway truck parts to they too are readily available.

There are no bearings located in the intake assemply. They all are shielded from contamination and are oversized for long life. The cubing dies are the only parts subjected to hay wear. There are no press wheels or rails to wear.

After long use the cubing gears may be rebuilt or replaced. Present replacement costs are $2,400.00 per set of four dies, F.O.B. Moses Lake. The actual tonnage cubed can vary widely depending on the amount abrasiveness of soil in the hay, operator care, etc. Gear life is surprisingly long because of the use of abrasive-resistant metal in the critical wear areas. Also the gears run cool, and this adds to their life.

Under local conditions on my farm in the Columbia Basin, I estimate the die costs at $.80 per ton. This does not include bearings, drive components, or repair time.

Downtime for repairs as a general rule should be very little since gear life is long and replacement is simple.

Characteristics of the Product

Gear cubes can be produced over a wide moisture range so lengths in the cube will vary with conditions. In general, dry hay has a tendency to be reduced to shorter lengths in the cube than moist hay. Regardless, cubed lengths are longer than the industry is familiar with. Where hay still has some natural moisture, fibers in the cube tend to extend from one side of the cube down through the deep curvature to the other side. This results in fiber lengths greater than the cube size, which is one and three eights inches square. The cube expands slightly from the one, and one quarter inch die at discharge.

Since the cube is built with a series of charges as the lobes repeatedly close into their respective voids, the cube is easily separated along the segments. The curved segments are more securely bound internally than to each other. In any event, the cubes are easily chewed by cattle and maximum hay lengths provide remen stimulation.

Since the character of the hay entering the cuber is disturbed less, the resulting cubes are easier to check for quality. Bloomy hay is easily identified, as is the overripe or weather damaged.

The Gear Cubes are knit together by deep curvature and cross-hatching of long hay lengths, as well as by the natural or introduced adhesiveness of the materials being cubed. Binders formerly considered too difficult to use in sufficient quantities may be added so difficult materials can be cubed. For instance, a Quad Gear Cuber is now being tested at Tangent, Oregon, for use in the rye grass straw residue problem. This material, left from rye grass seed production, formerly was disposed of by burning. The dies in use at Tangent are 21-tooth, medium density. Also available are 19-tooth, high-density dies, and 23-tooth, moderate-density dies. All are interchangeable in sets in the same basic unit. The next tests at Tangent will probably be with 19-tooth dies. The 19-tooth dies should be ideal for cubing extremely difficult material. The medium 21-tooth dies at Tangent have produced 26 lb. per foot cubic density using a sodium hydroxide binder. Other, less effective binders have produced 22 lbs. per foot and higher cubic densities, depending on the amounts and conditions prevailing. The 23-tooth dies are ideal for domestic alfalfa cubes and for easily-cubed materials like wood fibers, paper, and manure. The 21-tooth produce a heavier alfalfa cube, and perhaps will be the most commonly used die since it can handle variations of material in both directions. The 19-tooth dies should be used for crop residues that are slick and relatively difficult to cube. Alfalfa cubes of great density could also be produced but power consumption per ton per hour would increase.

If maximum hay lengths are not required, any of the die systems will produce heavier products and tonnage will increase by reducing particle size of the intake material.

For the Future

Gear Cubers can be expanded. Any number of gears can be installed in a similar fashion to the Quad. Three more idlers can be built opposite the three idlers in the Quad. This would double the capacity but also the power required. Then, two more idlers could be added to the combination to have three rows of three gears, or nine in the box. This would triple production over the Quad. Of course, some practical limit will be reached, such as power required or weight in field cubing; or drive component expense in stationary cubing.

In this article I have discussed the Gear Cuber principally as a stationary unit. However, I have built and operated field machines. The wide moisture characteristic in field work has always been a limiting factor in field cubing. Gear Cubing can handle a very wide range of moisture. This means that the promise of working the field earlier in the curing period, earlier in the morning to later in the evening, and in high humidity areas, makes the Gear Cuber very exciting as a field machine. All that is necessary is a selfpropelled platform pushing a chopper and carrying a Quad with an engine to drive it, and an elevator to discharge the cubes. I have such a unit under construction at Moses Lake and hope to test it there in the coming season.

Inherent in the Quad is the ability to act as a feed mixer at no extra cost in investment or power consumption. Material is mixed in the feed tank by the counter-rotating, vaned feeding cones. This feature could be utilized to make all ration cubes since the gear cube has long hay lengths to stimulate the rumen. A cube could be made to a basic grain level for cows in a loose holding area, to cut down on parlor eating time.

At present, prices of all machinery are increasing with rising costs of material and labor. All I can say about price of the basic unit is that we are studying the production costs at this time and feel that we can be competitive in the market. The real costs of any machine can be determined only by its performance in producing a desirable product and by the costs of doing so. In this respect, Gear Cuber is going to interest a lot of people.

Multi-track Cubing
Pending

Single Track Cubing
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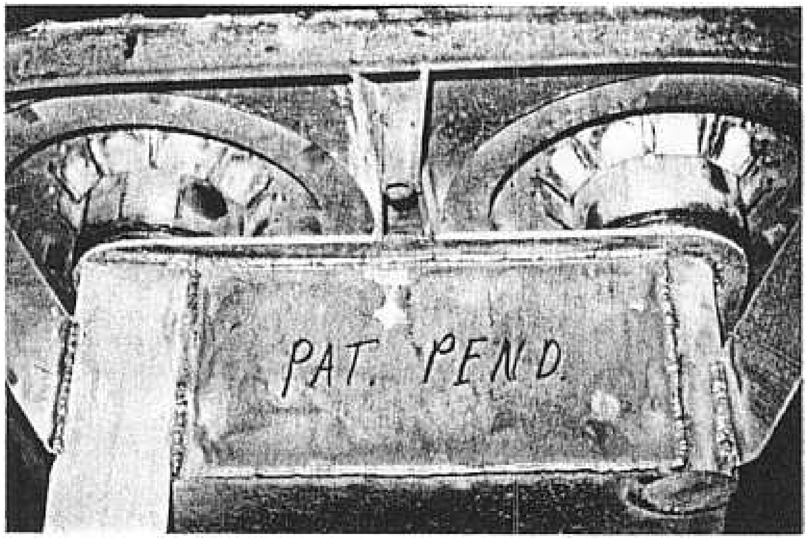
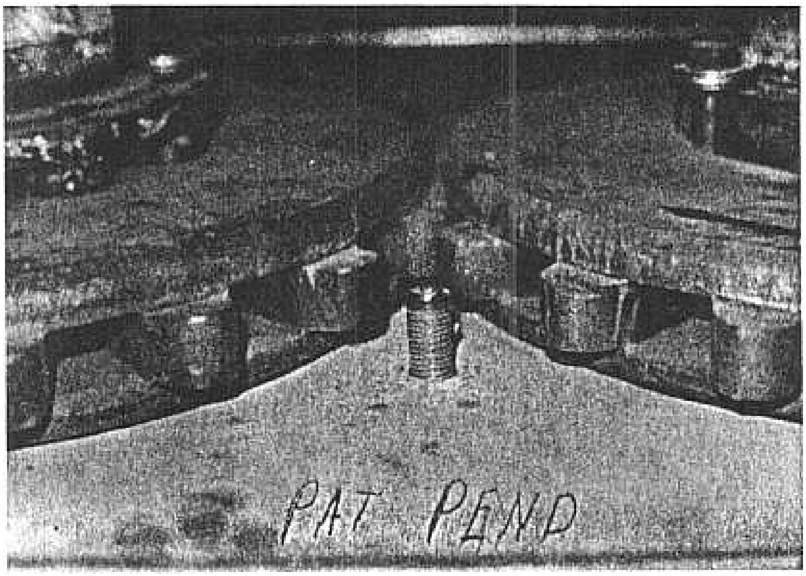
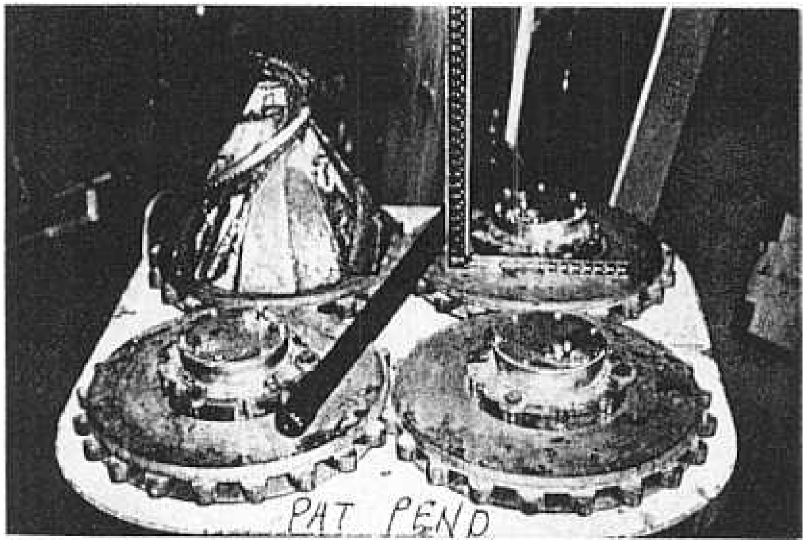


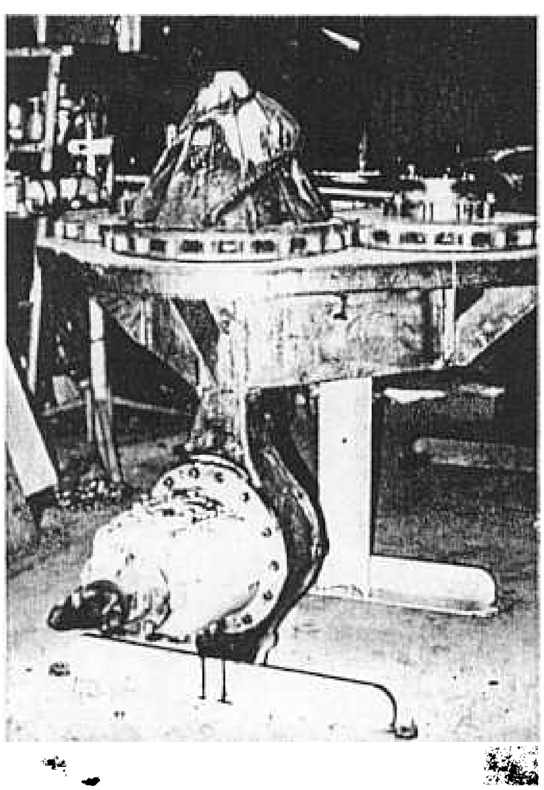
Bottom View of Quad Showing Cube Discharge Openings
Pat. Pending 1974



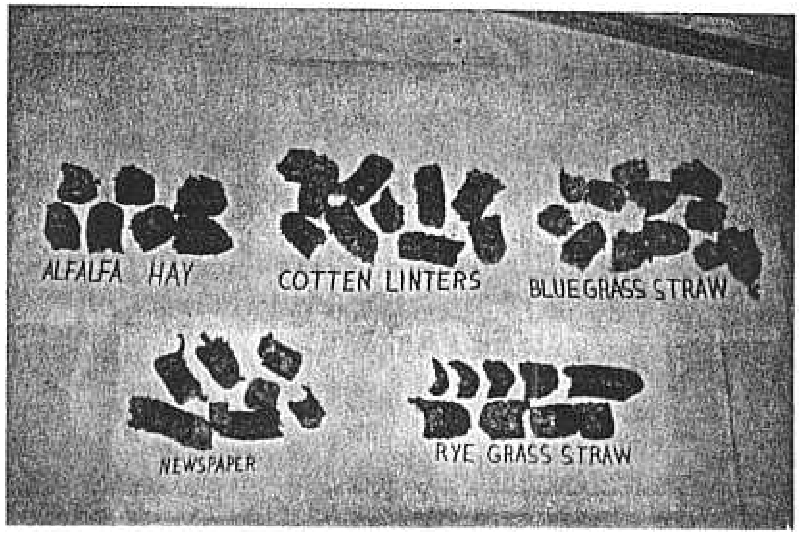
Quad cubing juncture showing limiter partially raised
Pat. Pending 1974



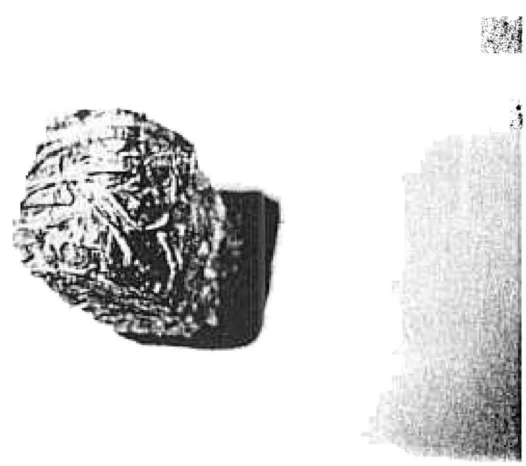
Top view of Quad with one cone & auger in place, feed tank removed. Drive shaft and 2 ft. square are for size comparison. Pat. Pending 1974.



Quad with one cone & auger to feed tank. Drive box is shown below. Pat. Pending 1974



Assorted Cubes
23-tooth gears were used except for rye grass which were 21-tooth



Alfalfa cube made with 23 tooth gears