

The State of The Art And Future Innovations in Hay Harvesting Equipment

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Since ancient times, forage crops have served as a marvelous and valuable source of feed and nutrients for animals throughout the world. In North America, alfalfa is the predominant crop, while the majority of European forage involves grass hay.

In all areas where hay is grown, there has been a constant search for efficient mechanized methods of harvesting, preserving and feeding the crop to livestock. Special emphasis has been placed on the conservation of nutrients and feed value. Different crops and conditions have spawned different harvesting systems.

Before exploring the various harvesting systems, it's helpful to look at the factors driving machinery design. During the past three decades, considerable progress has been made in increasing the nutrient value and the yield of many forage plants. It's reasonable to expect this trend to continue. Management of the crop itself is certainly as important as the technology required to harvest it.

The ultimate measure of a crop's value is determined by the relative efficiency of the crop in milk and meat production. The important factors to be considered in the evaluation of a forage crop include: nutrient value, digestibility, volume and harvesting characteristics. These primary factors also need to be considered in the design of the harvesting equipment.

So, equipment must be capable of harvesting the crop, conserving valuable nutrients, and maintaining acceptable production levels. It must also be dependable and affordable.

CUTTING AND CONDITIONING PRACTICES -- NORTH AMERICA

Cutting and conditioning are the first steps in the harvesting process. Over a relatively short period of time, many different kinds of equipment have been developed to handle these processes. One of the earliest was the tractor-mounted sicklebar mower. For conditioning the mower was followed by a crusher. Eventually both processes were combined into one machine--the mower-crusher. This enabled the farmer to mow and condition with one pass through the field; and, unfortunately, plug both the mower cutterbar and the crusher rolls at the same time.

In an evolutionary process, the early mower-crushers led to today's design of the mower-conditioner. North America is the world's largest producer, and user, of mower-conditioners--both pull-type and self-propelled. (A few self-propelled units are sold in other parts of the world--primarily Australia, Saudi Arabia and other parts of Asia.)

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The sicklebar concept was developed in North America in 1833, when Obed Hussey combined the reciprocating knife and slotted guard. That design remains basically the same today. However, a few improvements have been made--notably, the guards are now made from forged steel instead of wood. The popularity of the sicklebar cutting concept in North America led to the broad acceptance of sicklebar mower-conditioners.

Another factor contributing to the popularity of mower-conditioners in North America has been the wide spread use of roll-type conditioning systems to speed crop drying time. This type of conditioning process works well in alfalfa, clover, timothy and other heavy grasses.

CUTTING AND CONDITIONING PRACTICES -- EUROPE

In Europe, we see some entirely different cutting and harvesting systems, brought about by the different hay crops and growing conditions. Much of Europe's forage crop involves grass hay. Very little alfalfa is grown on the other side of the Atlantic. This is due to Europe's cool, damp climate. Those conditions do contribute to the popularity of chopped silage and round-bale silage.

Impact cutting--in contrast to sicklebar or slicing--had its origins in Europe. Records of rotary cutting devices date back to the early 1800's, but it wasn't until the 1960's that large diameter drum mowers began appearing in Europe. They quickly replaced sicklebar mowers and became the European standard. However, the drum design had one serious drawback. It was the small size of the windrow produced. The mini-windrow wasn't big enough to satisfy the appetites of modern forage harvesters and balers.

In the late 1960's and the early 1970's, disc mowers gradually began to replace the drum mowers in Europe and other areas. Disc mowers, like drum mowers, are impact cutters. The design usually incorporates two or three sets of knives attached to a rotor. The knives develop tip speeds around 180 miles per hour--the magic speed where cutting takes place. This is the same cutting principle found in rotary lawn mowers used at home.

The disc mower is ideal for the heavy, wet cutting conditions often found in Europe, because there's nothing in the design to plug. Also European fields--because they've been farmed for thousands of years--are smooth and, unlike North American fields, virtually rock free.

Throughout the 1970's, the European mower-conditioner market grew rapidly. The disc cutting concept was quickly adapted to pull-type, mower-conditioner frames. Most of the early units were limited to five- or six-foot cutting widths. However, as time passed and technology improved, cutting widths widened to 10 and 12 feet.

Europe's wet, high-yield grass crops called for a different conditioning system than the rolls and crimpers being used in North America to protect nutrient-rich alfalfa leaves. The result: the flail conditioning system. In the flail system, a high-speed rotor is mounted behind the disc cutterbar. Flails or fingers, attached to the rotor, impact the crop and subject it to aggressive conditioning as it moves rearward.

In many parts of Europe, hay harvesting is handled by contractors or custom operators, and capacity becomes a prime factor in equipment selection. As a result, large tractors are equipped with front-mounted mower-conditioners **and** pull-type units to double cutting capacity. This configuration is especially important, because narrow roads and streets, in many parts of Europe, limit overall machine width to three meters (10 feet). Though in use in many areas, this push/pull concept has not experienced as fast a growth as originally projected.

Some units have on-board, shiftable cross conveyors to double up windrows and increase capacity. These conveyors place two windrows together to make one large windrow for chopping with self-propelled forage harvesters. Market acceptance for this practice is still relatively limited.

CUTTING AND CONDITIONING -- THE FUTURE

In North America, the disc cutting concept continues to grow in popularity. In the future, additional growth is expected to occur on the east coast and in other areas with climatic conditions similar to those in Europe. However, most of the alfalfa in North America is grown on dry land or under irrigated circumstances, so mowing is best suited to sicklebar cutting.

Other types of cutting systems are continually being developed and tested by corporate and public interests throughout the world. Thirteen years ago, New Holland, in conjunction with Omark Industries, tested a process that involved cutters mounted on a rubber V-belt. This was an impact cutting process. Belt life turned out to be the weakness of the system.

Other cutting concepts under consideration include high-pressure water jets, with pressures up to 50,000 PSI, and lasers. Other futuristic concepts will no doubt continue to surface and be evaluated.

In the United States, both Purdue University and the University of Wisconsin have experimented with severe crushing techniques aimed at speeding the drying process. Forage preparation and preservation studies are also underway in Canada and in Europe. In Europe, as might be expected, the emphasis has been on silage.

With silage, field losses are not a big problem. However, during the harvesting process, field-dried alfalfa is very susceptible to leaf shattering and nutrient loss. Recently, at the U. S. Dairy Forage Research Center at the University of Wisconsin, tests were conducted on a system involving the severe maceration of the plant; formation of the material into a mat; and placement of the mat on the ground for drying.

During the process, the material is cut in a relatively conventional manner; fed into a series of macerating rolls; then discharged onto a belt-roller compression system, which forms it into a quarter-inch thick mat. The mat is then laid back on the stubble for drying.

As a result of the cell rupture during maceration and mat configuration, they were able to reduce the moisture content of the alfalfa to 20% with four to six hours of drying time in the sun. The maceration process also appeared to enhance digestibility. Testing is continuing on the packaging and removal of the mat from the field. Wisconsin also has studies underway on forage harvesters and modified square balers.

RAKING AND TEDDING THE DRYING PROCESS

Once the crop is on the ground, the next process is raking and, in some areas, tedding. Most often in North America, we see conventional reel basket rakes being pulled separately, in tandem or with a unitized frame. Initially, the reel basket rake was used in Europe; but by the end of the 1950's and early '60's, rotary raking had taken over. Now, the majority of the raking is handled by single rotor rakes or large double rotor units.

Rotary tedders also had their origins in Europe, and, to date, almost all of these units are manufactured there. During the past 10 to 15 years, rotary tedding has become popular along the eastern coast of the United States and Canada. Not surprisingly, this practice is often found in the same climatic conditions that favor disc cutting; because it helps speed the drying process in damp conditions. Sometimes rotary tedders are used to shake off morning dew; other times they're utilized to spread out windrows that have been rained on. Use of the rotary tedder calls for care, because it has the potential to create extensive leaf loss in legumes.

Another unit that came to North America from Europe is the rake tedder. As the name implies, this implement handles both raking and tedding. So, farmers can get by with one cost-effective machine for both jobs.

PACKAGING AND STORING SYSTEMS

Because of the popularity of silage in Europe, precision-cut forage harvesters are used extensively for the harvesting and preservation of high-quality hay. As mentioned earlier, much of the European hay is harvested by contractors or custom operators using self-propelled units. The market for pull-type forage harvesters is rapidly disappearing and the self-propelled units keep getting bigger. Some self-propelled forage harvesters feature engines that turn out 450 horsepower.

While the ag-bag silage storage system is used throughout North America, it originated in Europe; but it never gained widespread acceptance there.

The bunker or "clamp" silage storage system is used widely throughout England and France. With this system, chopped hay is packed inside a bunker to form an air-tight seal and prevent spoilage. Sometimes this silage is stored with as little as 25% dry matter. One serious problem associated with this practice involves the liquid runoff or effluent of high-moisture silage. Environmental laws in some countries, especially the United Kingdom, are aimed at controlling runoff and violators are subjected to very stiff fines.

Self-loader forage wagons represent another European system used to harvest hay for silage. Most often used in one-man operations, this system picks up high-moisture hay from windrows, chops it into long-cut silage, compresses it slightly as it's placed in the wagon, then unloads it into a bunk or pile. With the growth in popularity of precision-cut forage and round bale silage, self-loader forage wagons are gradually disappearing.

The making of balage, or bale silage, is another popular practice in European areas where excessive rain and dampness make it difficult to dry hay in the field. The system is best suited to the small farmer, but it is not limited to small operations. Experience in Europe and in North America indicates that animals, especially dairy cows, like this feed. The long stems aid the ruminating process. Producers have successfully stored round bales with moisture contents of 25% and higher.

The round bale storage system began with bags. However, that system proved to be labor intensive and moving the bales was cumbersome. Development of plastic wraps helped eliminate the bag problems while still protecting against spoilage. This practice first appeared in Europe about eight or ten years ago and is now expanding rapidly throughout the northeastern section of North America.

A number of manufacturers are working to improve this system. One is currently trying to combine an automatic bale wrapping system in with its round baler. Eventually, a baler that harvests and wraps silage in one pass will be perfected.

Worldwide many different round baler designs are used--fixed chamber, variable chamber, belts, chains and rollers. The bales are packaged in large and small diameters and are wrapped with twine, net and plastic. In Europe, the round baler market is continually expanding.

Big bale silage is another concept that began in Europe. As a result, most of the interest in this practice is centered there. Normally, the bales in this system are two to four feet in diameter with lengths up to eight feet. For ensiling, the bales are placed side by side and stacked three to five bales high. Then, they're compartmentalized and covered with sheet plastic. Wrapping them in separate sections makes feeding out easier.

The large-square-bale silage system requires heavy equipment. A typical lineup would include a large tractor, a big baler, a large loader (capable of handling three tons), a truck and another loader positioned at the stacking area. Because of the extensive mechanization and the large investment in machinery, most of these operations are handled by contractors. Though the big bales are used for silage, their primary use is for straw.

So, while dry hay and small balers--both square and round--form the backbone of the quality haymaking market in North America, European emphasis is on round bale silage making and big-bale silage systems.

In summary, hay harvesting techniques and practices are determined largely by crops and climatic conditions. North America, with its more favorable drying climate utilizes systems emphasizing capacity and the protection of hay quality. In Europe, equipment design and harvesting practices are governed largely by the climatic conditions and type of crop.

The future for the design of new and exciting haymaking products is bright. New technology continues to emerge and the resulting machines and systems will bring increased efficiency and productivity to haymaking.

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