AGRICULTURAL ENGINEERING

George Pratt, Chairman

Many new concepts and designs have been incorporated into engineered systems for agricultural production in North Dakota since 1956. Equipment that has come into common use includes four wheel drive tractors, big balers, center pivot irrigation systems, slatted floors for livestock buildings, computerized controls and closed circuit television. Courses for students majoring in Agricultural Engineering and Agricultural Mechanization have been modified to keep up with these changes. The pattern of the program of research indicates that scientists in the Agricultural Engineering Department have maintained investigations that supported this progress.

Agricultural Engineering Teaching Program:

Enrollment in the teaching program that leads to a degree in Agricultural Engineering has increased from about 40 students to about 80 students. This degree is granted through the College of Engineering and the program is accredited by the Engineering Council for Professional Development. Many of the graduates are in positions of leadership at major Land Grant Colleges, federal agencies, electric power companies, irrigation equipment manufacturers, farm building manufacturers and tractor and machinery companies.

Enrollment in the program which provides training that leads to a degree in Agricultural Mechanization has grown from 50 to 120. The degree is granted by the College of Agriculture. More than half of the graduates are now farming in North Dakota and Minnesota. Others are successfully engaged in such agriculturally related businesses as sales and service of farm equipment and buildings, management of manufacturing plants that process agricultural products, and service with university and federal agencies. Opportunities for employment for graduates of this program are good.

Power and machinery used in agricultural production have become highly refined during the time since 1956. Research at NDSU has been directed into areas which would solve current and future needs of North Dakota farmers. Cooperative projects and assistants to other departments and branch stations have been an important part of power and machinery efforts.

A major part of North Dakota farm energy is expended in tilling the soil. Power requirements of tillage tools and systems under North Dakota conditions were measured when 60 HP tractors were "big" and continue today on our new larger machines. With accurate information on power and fuel requirements more efficient systems can be selected by users.

Studies of alternate methods of tillage and seeding have found little differences in tillage before seeding. As long as the drill can deposit the seed to the correct depth, and weed growth is controlled by chemicals or other methods, there was little difference due to tillage before seeding. More research into various alternate tillage and seeding methods is currently needed.

Early studies showed the importance of combine adjustments in the harvesting of malting barley. These results have been the basis for nationwide recommendation by the Malting Barley Association to producers.

Current research shows very efficient farm adjustment of combines. The majority of field losses occur before combining due to shatter, swathing, and pickup. Once the crop is in the combine losses measured near one bushel per acre for small grains, except barley where losses were near two and a half bushels per acre. These are considered acceptable in minimal losses. Continued studies of alternate methods particularly straight combining versus swathing, and performance of new types of combines are needed.

Various machines have been designed for special purposes for other departmental use. They include:

- A soil profile meter to measure soil surface relief and changes in bulk density.
- A soil penetrometer used to measure soil compaction and changes of bulk density.
- Sound level demonstration booth which illustrates harmful and safe levels of sound and the effects of personal protection, and
- A leaf squeezing machine to aid juice extraction from leaves for lab virus studies. Plans for this simple device have been sent throughout the U.S. and overseas.

Grain Alcohol Fuel Mixes:

Tests were conducted in the Agricultural Engineering Department at NDSU to determine how alcohol performs in engines. Gasoline, diesel tractor engines and automobiles were tested.

Various blends of ethyl alcohol and unleaded gasoline were used in the tractor engines. Tests were run to compare the benefits of using 190 proof ethanol as compared to 200 proof ethanol in the alcohol-gasoline blends. To achieve a satisfactory mix and one that will not separate out over time it was found that the alcohol portion must be essentially pure (200 proof).

As the quantity of alcohol blended with the unleaded gasoline was increased the maximum horsepower which the engine was capable of producing decreased. In addition, the fuel efficiency measured in hp-hr/gal also decreased. Automobile tests showed that mileage measured in miles per gallon also decreased while using blended fuel.

Livestock Housing:

Research since World War II on livestock building design has been aimed at human labor reduction and optimum environment for the livestock. Research results were coordinated in the decade from 1960-1969 to produce livestock housing facilities that were highly mechanized and produced top quality livestock products. Egg production systems were developed utilizing cages for housing laying hens. Highly mechanized environment controlled housing for hogs became common and adapted well to North Dakota. The milking parlor developed in the early part of the decade from 1950-1959 became a standard component of dairy systems. Beef feedlots were mechanized and cold confinement barns for beef became commonly accepted.

Ventilation of Livestock Buildings:

The lack of heat in livestock structures is a problem in North Dakota climates. The heat loss through needed ventilation plus the loss of heat through the walls generally exceeds the heat produced by livestock at temperatures below +10°F. A heat exchanger developed at NDSU used a double heat sink with dual fans. One unit forced air in through a bed of rock while the warm air was forced out through a second bed of rocks on the other end of the building. The cycle was reversed every 5-10 minutes. The rocks gained heat from the exhaust air and heat stored in the second bed was picked up by incoming air. The system has improved conditions within the barn by removing additional moisture. A system of this type is being installed in the new dairy barn addition at NDSU.

Manure Management:

Systems that include slatted floors for handling manure are being evaluated. Storage of manure in liquid form in a basement under a slatted floor is used as a standard for comparison. A scraper under a second slatted floor has illustrated that liquid wastes can be drained from a building and the solids handled separately. A piston pump has been used to move the solid manure through an underground pipe to a stack. Producing livestock under a roof controls the amount of waste water and makes it feasible to dispose of it by evaporation ponds. Solid manure creates less odor than liquid slurries. The volume of solids that must be transported for disposal is much less than the volume that must be transported if it is in a slurry form.

A computer model was developed to predict feedlot runoff. Feedlot runoff was modeled using past records of precipitation, temperature, and evaporation for three different locations in North Dakota. These results were used to investigate design criteria and management options for runoff detention ponds.

Water used to wash a hog barn floor and that coming from cattle feedyards in the form of runoff are collected in an experimental lagoon. This water is spread on an area of about 15,000 square feet of land where a shelterbelt is planted.

Crop Storage:

Field production of high quality grain is a well developed technology. Maintenance of crop quality in storage has not advanced as well but research is in progress.

Much of the research on grain storage has involved drying and other practices that lead to maintenance of quality. The effects of high temperature drying air on the quality of Hard Red Spring Wheat, Durum, and barley have been evaluated. Drying temperatures for feed grains can be higher than for grains processed for human food. Limits have been established for wheat to be milled into flour, Durum to be processed into pasta and barley to be malted. These results are being used in the grain processing industry.

Sugarbeet storage-ventilation and freezing of sugarbeets in storage can reduce the loss of sugar due to respiration and microbial activity. The sugar loss from beets in conventional storage can average 27.5 pounds per ton. For a plant processing 5,000 tons of beets per day, the average daily sugar loss would be 137,500 pounds or 15,125,000 pounds for a full normal campaign of 110 days. Research was conducted to determine the feasibility of forcing cold air (below freezing) through piled sugarbeets to reduce spoilage and lengthen storage period.

Sugarbeets are carried into sugar refining plants for processing in a stream of water pumped through a concrete flume system. Soil, organic matter and other wastes are left in the water after the beets are removed. This water is ultimately wasted to storage ponds where it is held until it can be disposed of in a way that will not pollute the environment. The ponds generate odors, and materials in the water limit the ways that it may be disposed of. Removal of filterable materials from the waste water is being considered as a practice to control the odors and improve the handling characteristics of the water.

Farm Homes:

Modern farm homes are providing farm operators with environments that are pleasant for themselves, their families, those they do business with, and their friends. Research programs in engineering at NDSU that have aided this development have emphasized water quality and sewage disposal.

Water quality on farms in North Dakota varies considerably. Much of the water is below recommended standards and in some cases unsuitable for livestock or irrigation. Water softeners are effective only in removing hardness and do nothing for other mineral and organic contamination. In 1968 a demineralizer (Electrodyalysis) was installed on a farm near Hillsboro. Performance of the unit was not satisfactory, because sediment was difficult to filter out of the water.

In October 1973 two installations using the reverse osmosis principle were installed on farms near Dickinson and Reeder. An additional unit was installed at the Langdon Experiment Station in 1975 and a fourth unit was installed on a farm near Hettinger.

The installation near Hettinger was a commercial installation. It was a failure probably due to a large open storage previous to the treating equipment.

The three units now in operation have exceeded the expected life of three years. The cost of the reverse osmosis is about $1,400 for this size of unit. Operating costs have been about $1.00 per 1,000 gallons. The quality of water has been excellent, making it satisfactory for all farm uses including washing clothes.

In 1947 electricity had been introduced to only 15 percent of the North Dakota farms. With electricity came water systems and with water systems came sewage disposal systems. Soil conditions in clay soils in North Dakota were not suitable for the common absorption-type disposal field. The Nodak system was developed to provide better percolation. It provided for easy maintainence of the above-ground disposal field and back flow into the basement was controlled during periods of high water. Later installations have used a small lagoon in place of the disposal field. When placed in shelter belts and protected areas these have functioned very well. The Nodak system has been modified in many other states and known as the "Mound" system.

Irrigation, Drainage and Weather Modification:

Control of water used in crop production has been stimulated by the Garrison Diversion irrigation program and the development of weather modification. The latter also shows promise as a technique for controlling hail losses.

Modern irrigation systems of the center pivot type permit a high degree of control over water application. Depth applied per irrigation can be preset by simple adjustment of a control mechanism that regulates the speed at which the system travels over the land surface. When in operation this system can be viewed as a traveling rain shower that may be scheduled as to timing and amount applied. Knowledge of the current unfilled water storage capacity in the plant root zone should indicate the maximum amount to be applied.

The electronic computer has made possible irrigation scheduling on a large scale and has led to the development of the commercial irrigation scheduling service.

In Agricultural Engineering, we have pursued a research program which is designed to adapt this irrigation scheduling approach to North Dakota conditions. Crop coefficient curves, as needed for the estimation of crop water use rates, have been developed and tested for corn, wheat, alfalfa, soybeans, potatoes, and sugarbeets. These data are being used by several commercial irrigation scheduling services now operating in North Dakota.

A simplified water balance method entitled, "Checkbook Irrigation Scheduling" has been developed. This method provides farmers with a scheduling tool that they can readily apply on an individual basis. This method has also be adapted for use in Minnesota by the Minnesota Agriculture Extension Service.

Seasonal distributions of water use rates have been measured for a range of irrigated crops. These data indicate both the seasonal and peak water requirements which must be considered in the sizing of irrigation pumping plants and water distribution systems.

Research is being planned to develop and test plant growth and other simulation models for the purpose of developing optimal water management criteria for expected future resource, economic or management constraints.

A research program in weather modification was carried out in the Agricultural Engineering Department at North Dakota State University from 1965 to 1970 under the direction of Dr. Allen F. Butchbaker. Most of the work was conducted in Bowman and Slope counties. The work was initiated as a result of a cloud seeding program carried out by Mr. Wilbur Brewer and Mr. William Fisher who were actively associated with the Bowman-Slope Hail Suppression Association. The objectives of the work were to characterize climatology of hail storms and to determine if cloud seeding changes hail storms or rainfall; to compare hail fall in target areas with areas not seeded; and to measure hail storm intensity by recording the energy dissipated from falling hail. A 30 to 60 percent reduction in hail intensity in the target area compared with the south and west control areas was noted.

Critical challenges exist for agricultural engineers between now and the year 2000. Technology must be developed to maintain supplies of agricultural produce that are adequate for all people of the world. This must be done without deteriorating the environment. Fossil fuels must be conserved and in many cases replaced with agricultural products. Efficient utilization of water supplies is a problem today and will continue to be a problem. Agricultural engineers are trained to solve these problems and will continue to build research programs to meet this need.