Utilization of Controls for Managing Limited Water Supplies

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Summary:
Water for food, fiber and forage production continues to be a world concern. Currently most discussion about mechanical move irrigation systems focuses on the placement of the water. While where and how water is placed for irrigated crop production is critical, other components of an irrigation system are also important for the optimum management of water supplies.

This paper will focus on control options available for center pivot irrigation equipment and how these options help growers better manage limited water. Specific examples will be discussed. Data on the costs and benefits of manual and automated control will be included and compared. Data will include initial investment, operation and maintenance costs. In addition a brief discussion will be included on updating existing mechanized irrigation equipment to take advantage of the gains, which can be achieved.

Objective:
To discuss specific examples of how controls can assist a grower better manage limited water supplies when using center pivot irrigation equipment.

Introduction:
Since the energy concerns of the mid 1970's and drought cycles significant research and commercial development has been focused on reducing pumping costs and reducing the potential for wind drift and evaporation. Center pivots have seen a dramatic increase in improved irrigation efficiencies.

Recently more farmers have recognized due to limited or unknown water supplies, they need to change their management strategies to maximize returns. Besides concerns for maximizing water use efficiency, growers are also concerned with managing more center pivots with less labor as they irrigate more farmland. They have explore options including changing the method of irrigation. One option some consider is drip irrigation and particularly sub-surface drip (SDI). While drip and SDI in particular may reduce the volume of water required to irrigate it dose not meet the need in many cases for the flexibility of management and the grower's needs to

reduced their labor input. SDI control systems tend to be more complex and costly. In addition changes to the system are costly and flexibility difficult to achieve.

Mechanical move irrigation equipment manufacturers have continued to develop controls to help make management of irrigation systems easier for growers since the early 1990s allowing maximum operational flexibility while reducing labor requirements.

When sufficient water supplies are not available to optimally irrigate an entire field and the grower has maximized their irrigation efficiency for their center pivot, new techniques are explored. One technique is to manage the entire pivot for reduced yields. Another technique is to split the field and raise two different crops – one with higher crop water needs than the other. Also more growers are varying their application rate by sectors for soil types. Controls to change the water application depth, reverse the equipment or to completely shut the water off are important to these scenarios. While it is possible to do many operations with mechanical control panels, many times it is easier, more dependable and more cost effective to do with automated control panels.

In addition to managing the water differently for the different crops, commonly the crops will have different nutrient requirements particularly nitrogen. Instead of the farmer needing to be in the field to make a change in the nitrogen application, an automated control panel may be used in conjunction with the fertilizer injection pump.

Lastly to maximize profitability farmers may want to manage the available water or nitrogen applied differently as the center pivot moves around the field and crosses varying soil types. Again an automated panel provides the flexibility to meet the farmer's need.

Discussion:
In the past mechanical switches mounted on or around the pivot point were used to 'trigger' necessary changes to the pivot operation such as end gun shutoff, auto reverse, stops for service roads and application depth changes. These in some cases are difficult to change settings and do not offer flexibility of operation. In addition the number of changes is limited. Once the switches and stops are set most customer will not change the settings. Generally it is difficult to do more than one change or maybe two operation changes in the field due to the physical mounting of the switches.

Most mechanical move irrigation equipment manufacturer's today offer both manual and automated control panels. To maximize the effectiveness of the automated panel, the position of the center pivot in the field is critical. Manufacturers' use a variety of devices such as resolvers or

encoders to provide a signal to the automated panel providing information on where the pivot is in the field, usually in degrees to a known reference point such as a road or North. Another piece of critical information is water pressure. Mechanical panels have switches with a single set point. Most automated panels are equipped for analog inputs from a pressure transducer. This allows decision making and programming for a range of pressures. In addition the automated panels have a variety of digital and analog inputs and outputs.

With these inputs and other information available at the pivot point, the automated control panel monitors pressure, wind speed, rainfall, position, voltage, control circuit status, operating direction and water status to name a few.

This information allows the operator to 'program' changes to the operation of the pivot based on the inputs and not have to be in the field to make the changes manually. Whether public power or an internal combustion engine provides power, an automated panel may be the best choice to meet the grower's needs to minimize labor and most efficiently manage available resources.

Examples (these are generalized scenarios and may not reflect actual situations but are designed to be instructive):

Example 1 – New 130 acre center pivot five miles from farmhouse, grower is limited on water to 15 inches during the growing season, center pivot is on public power. Typically the grower's primary crop requires 18 inches of water to produce optimum yields for his management system. The grower decides to split the field into two crops – one his primary and apply 18 inches and a second crop, which typically uses less water.

The grower has a couple of choices as how to manage this.

- Always be in the field to make the decision as to how to operate the center pivot
- Add the mechanical switches to a manual panel
- Utilize an automated panel and program crop operations

Typical costs to meet this customer need:

- Annual additional costs to manually operate the panel $ 1,125
  - Based on
    Labor cost of $45 per hour
    $0.32 mileage allowance

- Mechanical switches for a manual pivot panel $ 1,675
  - Switches to allow
    Autoreverse plus endgun shutoff
    Pressure

- Automated panel addition cost compared to a manual $ 2,745

The grower would have a payback of less than 2½ years over total manual operation and under 2 years over the mechanical switches for the investment in the automated panel. Plus the mechanical switches do not allow any flexibility such as programming on the automated panel to allow for varying operations on each revolution or based on sensor input.

Example 2 – New 130 acre center pivot ten miles from farmhouse, grower has two distinct soil types – approximately one half is loamy sand and the other half a clay loam and the center pivot and pump are on public power. Off-season most years the soil profile is recharged to near field capacity. On similar fields the grower has learned that early in the season he probably will need to begin irrigation on the loamy sand before the clay loam. The grower decides to use the same crop but manage the water applied differently.

The grower has a couple of choices as how to manage this.

- Always be in the field to make the decision as how to operate the center pivot
- Add the mechanical switches to a manual panel
- Utilize an automated panel and program the changes

Typical costs for this example

- Annual additional costs to manually operate the panel $ 1,690
  - Based on
    labor cost of $45 per hour
    $0.32 mileage allowance

- Mechanical switches for manual pivot panel $ 2,025
  - Switches to allow
    Autoreverse plus endgun shutoff
    Pressure
    Application depth changes

- Automated panel addition cost compared to a manual $ 2,745

In this example the grower would have a payback for the automated panel of less than 1½ years for either case and have the additional features of the automated panel.

Example 3 – Existing five year old 130 acre center pivot five miles from farmhouse with a mechanical panel, public power, grower is limited on water to 12 inches during the growing season instead of 18 he feels is necessary for optimum yield. Typically the grower's primary crop requires 18 inches of water to produce optimum yields for his management system. The grower decides to split the field into two crops – one his primary and apply 18 inches and a second crop, which typically uses less water.

Again the grower has a couple of choices as how to manage this.

- Always be in the field to make the decision as to how to operate the center pivot
- Add the mechanical switches to his existing manual panel
- Upgrade to an automated panel

Typical costs

- Annual additional costs to manually operate the panel $ 1,410
  - Based on
    labor cost of $45 per hour
    $0.32 mileage allowance

- Mechanical switches for manual pivot panel $ 1,515
  - Switches to allow
    Autoreverse
    Application depth changes
    Including labor to upgrade

- Automated panel $ 3,015
  - Conversion costs
    Assuming a modular panel
    Includes upgrade labor

The grower would have a payback of just over 2 years over total manual operation and under 2 years over the mechanical switches for the investment in the automated panel. And as stated earlier the mechanical switches do not allow flexibility such as programming so the pivot does not do the same operation on each revolution.

Conclusions:

With the changes growers are seeing requiring better and more efficient management this is moving them to consider center pivots with automated control panels. In many cases the payback can be within two years. In addition the automated panel will bring the grower other features not available in the manual panels such as diagnostics, record keeping and programming.

One area of concern to many growers as they consider automated panels is reliability and durability. As with other technologies in the agricultural sector the automated control panels used by center pivot manufacturers have under gone a number of changes since their introduction over ten years ago. These changes in many cases focused meeting the reliability and durability requirements of the farming community. Today due to changes in design and manufacturer in many cases the maintenance costs for an automated panel are similar to a manual panel. Plus the impact of transient and induced voltage has been greatly reduced due to improved printed circuit board design.

As shown by the three examples above in many cases farmers can see a payback in less than two years for the additional investment in an automated panel and may in many cases justify upgrading existing panels to better manage their available water resource and fertilizer.

As water resources for food, fiber and forage production continues to be a world concern and available time growers have to manage their irrigation is a challenge, more will move to mechanical move irrigation and automated control panels to provide the flexibility they require. Other irrigation technologies may offer water savings but do not allow cost effective operation as growers move to more closely manage their fields.

References:

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