

USING SURGE IRRIGATION FOR AUTOMATION

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Introduction

Furrow irrigation continues to be a primary method of water application in the central high plains of the U.S. In Nebraska alone, over 3.5 million acres of land is irrigated using some form of surface irrigation. The number of furrow irrigated acres have declined due to the conversion from furrow to center pivot irrigated systems. The primary reason for conversion is irrigators looking for methods to reduce labor costs. Yet not all situations allow for conversion to a center pivot, installation costs are high and land area to be irrigated sometimes does not allow for circular fields.

In those situations where furrow irrigation needs to be used, systems that provide automation can still be implemented. Automation comes in the form of surge irrigation. Surge irrigation gives furrow irrigators some labor savings without a significant investment in equipment. Surge irrigation or surge flow is the process of intermittently applying water in an irrigation furrow. This is compared to continuous flow which is the conventional process of applying water for the entire irrigation set time. Surge irrigation was first studied as a method of reducing the amount of runoff that occurred during irrigation. It was discovered that in addition to reducing runoff, the time required for water to move to the end of the field could also be reduced.

The intermittent application of water is accomplished by cycling irrigation water between two irrigation sets. In years past, the idea of cycling irrigation water was used when water was not getting to the end of a field. The irrigator would move on to subsequent sets and return in one or two days to finish irrigating the partially watered sets. When irrigated a second time, the irrigation water would be moved all the way to the end of the field because the soil surface had sealed and more water was available in the furrow at that point where flow had previously stopped. This same thing occurs when using surge irrigation, except three to six cycles are used and the cycling is done automatically at short durations, 20 minutes to 2 hours.

How Surge Irrigation Works

When water first makes contact with the soil in an irrigation furrow, the rate of infiltration is high. As the water continues to run, the infiltration rate at that point in the furrow is reduced to a near constant rate. When water is shut off to the furrow all water remaining in the furrow will, within a few minutes, infiltrate the soil. During this process, the surface soil particles are consolidated near the surface and the result is the formation of a seal in the furrow. When water is reintroduced to the furrow the intake rate in the previously wetted section is

further reduced due to the sealing action. The result is more water being carried down the furrow rather than infiltrating the soil.

High infiltration of water at the head end of a furrow irrigated field is common with continuous flow irrigation and can lead to poor irrigation system performance due to deep percolation and poor water distribution across the field. Surge irrigation, by reducing the rate of infiltration in the top of the field, not only reduces the loss of water due to deep percolation, but also improves the distribution of water between the top and bottom portions of the field. In other words, the amount of water applied at the top of the field is more closely the same as the amount of water applied at the end of the field. In figure 1, the infiltration pattern of surge and continuous flow are shown to demonstrate the difference in uniformity of water application between the two systems.

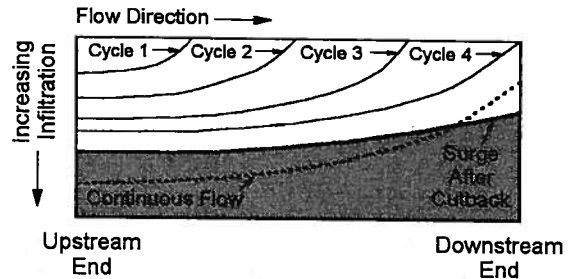


Figure 1. Infiltration patterns for continuous flow and surge irrigation.

Rather than manually moving irrigation sets to achieve an on-off cycle, a surge valve is used to automatically alternate flow between two irrigation sets. Figure 2 shows one method of using a surge valve. Cycle times used with surge irrigation vary with soil texture and slope. Fine textured soils respond less to using surge irrigation than do coarse textured soils that have higher initial intake rates. If field slope is so steep that it causes a rapid rate of advance, the effects of surge irrigation will also be reduced. Finally, if the intake rate of a soil is low due to soil texture, tight soils or compacted layers, surge irrigation is likely to be less effective in reducing the irrigation advance times below those for continuous flow.

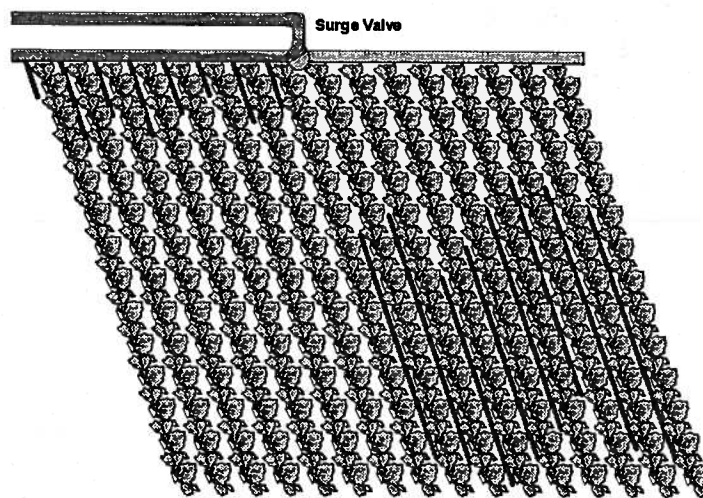


Figure 2. One method of using surge valve for irrigation.

The most significant improvement in water advance using surge will likely occur during the first irrigation of the season. This is probably the most important because following winter freezes and thaws, spring tillage and crop cultivations, the soil can be left loose and dry just prior to irrigation. These are the conditions that provide the greatest potential for improvement when using surge. Yet, as the season progresses, the soil in the furrows becomes more firm and water advance may not pose that much of a problem. However, whether it is late in the irrigation season or field conditions are such that water advance is not a problem, the advantages of using surge is not diminished.

Once water is advanced to the end of the field, surge flow can reduce irrigation runoff. This is accomplished, by using short duration cycles that advance water nearly to the end of the field before being cycled to the other irrigation set. This process continues until adequate water has infiltrated at the bottom end of the field. This helps maintain high uniformity of water application and improve overall irrigation performance.

Another advantage to surge irrigation, unrelated to the improvements in irrigation system performance, is that the surge irrigation valve can be used to improve irrigation system management without an increase in labor requirements. When setting water, two irrigation sets are made at one time. Although the time requirement is more than making a single set change, the savings come from not having to return to the field at a second designated time to make the second set change. Rather, the return time is to simply check the progress of the two irrigation sets and make any adjustments. Again, later in the season when furrows are firm and advance is much more predictable, returning to check the water may not be necessary, saving more labor.

In some cases if surge is not needed, the surge valve can simply be used as a set changer. For example, if irrigation is being applied using 12 hour sets, two irrigation sets can be made, one on each side of the surge valve. The surge valve can be set to irrigate the first irrigation set for 12 hours before switching to the other set. In this case, the irrigator only has to return to the field every 24 hours.

There are two primary concerns when using a surge irrigation system. First, surge flow will not always be effective in reducing the advance time of water down the furrow. When this occurs, as discussed above, there are still benefits of labor savings and runoff reduction. A second concern, as a result of lower infiltration rates associated with surge flow, is a reduction in total water application. With lower infiltration rates, less water may be applied to the soil during an irrigation set. If this occurs, the irrigator must compensate by irrigating more frequently or increasing set time to avoid under watering.

Surge Irrigation Field Tests

The University of Nebraska has tested and evaluated surge irrigation since 1983 and as recently as 2000. The tests have compared continuous flow irrigation to surge irrigation in various forms. The tests have been conducted on a variety of soil types throughout Nebraska.

In over 35 tests to compare surge irrigation with continuous flow irrigation, surge

has never been less effective in advancing water to the end of the field. The average reduction in advance times across a field using surge irrigation compared to continuous flow is between 15 and 20 percent. The differences have ranged from no difference to over a 50 percent reduction in advance time using surge. The majority of these tests have been conducted during the first irrigation. Yet depending on soil type and climatic conditions, surge also resulted in advance time reductions during second and third irrigations as well. Keep in mind, as with conventional continuous flow irrigation practices any difference in soil preparation, soil compaction and soil moisture during field operations or during irrigation can impact the results of using surge irrigation.

Common Questions About Surge Irrigation

IS THERE RESEARCH TO SUPPORT THE BENEFITS OF SURGE IRRIGATION?

Yes. Research has been conducted in Nebraska since 1983. There has been additional research done by many of the Land Grant Universities in the Western US. Their results are similar to those found in Nebraska; improved water distribution, reduced labor needs and water saving.

DOES THE SURGE VALVE REQUIRE PRESSURE IN ORDER TO OPERATE?

No. The valve can operate under open discharge or gravity flow conditions. The only requirement is the valve and pipe diameter must be large enough to accommodate the flow requirements. See figure 3.

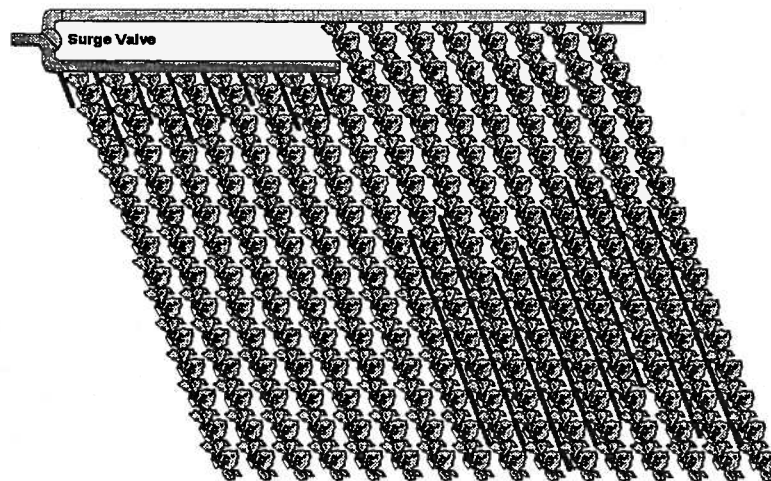


Figure 3. Surge valve under open discharge or gravity flow conditions.

WHAT IF I DON'T USE GATED PIPE?

The use of plastic or lay flat tubing can work as well as gated pipe. If using plastic tubing, locate the valve so flow is always downhill in the tubing regardless of flow direction in the valve. See figure 3.

I DON'T HAVE ENOUGH GATED PIPE TO GET TO THE MIDDLE OF THE FIELD, WHAT DO I DO?

Using a surge valve often requires that somewhere in the system pipe is used to convey water to the desired location of the valve. Try using some of the lay flat plastic tubing as a low cost alternative.

SHOULD I REDUCE MY FURROW STREAM SIZE AND GO TO LARGER SETS BECAUSE OF IMPROVED IRRIGATION EFFICIENCY?

No. You should start with the same stream size and set size that you use under continuous flow conditions. Adjustments can be made to match stream size and the distance the stream moves down the furrow later.

WHAT SHOULD I DO WHEN THE WATER REACHES THE END OF THE FIELD?

Use the valve to reduce the on-time to 65 percent of the last on-time to keep water on the field. Most controllers do this automatically using a cutback phase. On-times during cutback should move water nearly to the end of the field and then switch to the other set. The water should then flow to the end of the field which will result in some runoff. Remember, runoff alone does not insure adequate irrigation, so check soil moisture.

WHAT KIND OF IMPROVEMENTS CAN I EXPECT?

Field tests have shown reductions in irrigation advance times can range from 0 to 50 percent during the first irrigation. During later irrigations you can expect surge irrigation to be nearly the same as continuous flow.

IF SURGE EFFECTS ARE REDUCED AS THE SEASON PROGRESSES, WHAT ADVANTAGES DO I GET FROM THE VALVE LATER ON?

The valve allows you to make two sets before you need to reset the valve and open and close gates. In short, a form of automation. This may mean that you can operate shorter set times and still apply enough water to fill the profile. Runoff may also be reduced by use of cutback cycle times. The ability to apply less water yet provide adequate water for crop growth means deep percolation and pumping costs can be reduced.

ARE ALL SOILS THE SAME WHEN USING SURGE IRRIGATION?

No. The ability of a soil to seal itself after water has been introduced to the furrow is critical to obtain a reduction in the furrow advance rate. A tight soil with a low infiltration rate may not achieve the reduction in advance times as would a sandy soil that has a high initial infiltration rate.

DO ALL MY ROWS HAVE TO COME THROUGH AT THE SAME TIME TO MAKE SURGE WORK?

No. But like continuous flow systems, management is needed to adjust stream size and number of furrows. Results of field tests indicate that the variability among rows tend to be less when using surge irrigation.

WHAT EQUIPMENT DO I NEED TO GET STARTED?

The equipment needed includes the surge valve and possibly enough mainline pipe to locate the valve at the desired location in the field.

WHAT DO SURGE VALVES COST?

Normally, valves will cost between \$1000 and \$2,500 depending on the size of the valve and controller options. Getting over the field during the

first irrigation in half or three quarters of the time it normally takes may more than pay for a valve in a single year. By realizing a water savings, pumping costs can be reduced. For each inch of water saved, pumping costs savings could be in excess of \$200 for a quarter section field. Estimate the savings you could expect and the valve may well pay for itself in just a year or two.

IS THE EQUIPMENT RELIABLE?

Like any technology, equipment has improved with time. Surge valves have been in operation for a number of years and the reliability of the valves has become quite good.

ARE THERE OTHER ADVANTAGES TO USING SURGE IRRIGATION?

Water quality is a major concern in all areas. Irrigation efficiency is often low in furrow irrigated fields and surge can improve irrigation uniformity and efficiency by reducing runoff and deep percolation. The result can be less water applied and less deep percolation which can carry chemicals into the ground water and cause water quality problems.

HOW DO I KNOW AFTER READING ALL THIS IF SURGE IRRIGATION WILL WORK FOR ME?

You don't. Run your own test and compare several rows of continuous flow to rows that you manually surge water between. Make sure the amount of water used in each furrow is the same. Compare the total time that it takes water to get to the end of the furrow.

As an example, let's say water reaches the end of the field for the continuous flow furrows in eight hours. For the surge test furrows water reaches the end of the field in ten hours. But remember, water is being spread between two furrows or twice as many acres. Therefore, for an individual furrow, it takes eight hours to advance to the end of the field using continuous flow while furrow advance is completed in only five hours with surge. This means with the same volume of water you were able to irrigate two rows where normally you only irrigated one.

Summary

Surge irrigation provides furrow irrigators an opportunity to improve their management of irrigation water. By reducing infiltration rates, surge irrigation allows lighter applications which can improve irrigation performance. In addition, reducing deep percolation by using surge means major steps can be taken to reduce the potential for chemical flow to the ground water.

The effects of surge irrigation are most prevalent during the first irrigation when the soils intake rate is high. Although intake rate reduces as the season progresses the advantages of surge continue in the ability to manage water supplies by keeping water on the field and minimizing the amount of runoff leaving the field.

Surge irrigation does not apply to everyone but past success suggests that furrow irrigators should at least consider this water saving technology.