A PLC BASED CANEYARD TRAFFIC CONTROL SYSTEM

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Abstract

The introduction of new legislation covering cane transport into sugar mills has led to an increase in the number of hauliers delivering cane to Maidstone mill. In order to ensure fair access to the mill, in proportion to the haulier's cane tonnage, and to avoid congestion at the weighbridge, it was decided to install a traffic light system controlled by a programmable logic controller (PLC) to regulate traffic flow across the weighbridge. This system has operated for a full season and has resulted in significant cost savings.

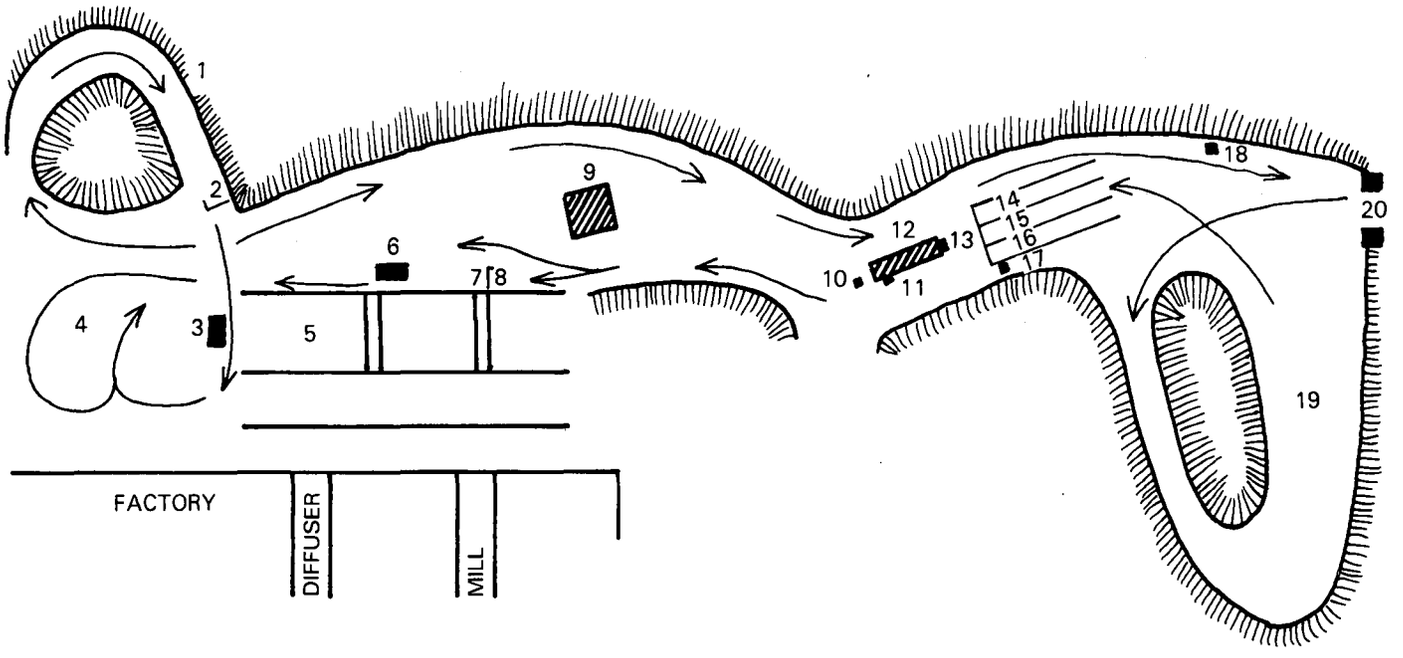
Introduction

One of the results of the Rorich Commission has been the introduction of new legislation covering the transport of cane into sugar mills. The millers' responsibility for cane haulage has been transferred to the growers, with effect from when existing haulage contracts expire or after 5 years from the date of introduction of the new legislation, whichever occurs first. This has resulted in the growers at Maidstone mill assuming responsibility for cane transport from the start of the 1986/87 season.

At Maidstone 92% of the cane received is delivered in spiller type hilo trailers which must arrive ratably to ensure continuous operation of the factory. If only one haulier is delivering all the spiller cane it is relatively simple to ensure ratable delivery to the mill (one load every ± 4 minutes). However if more than one haulier is involved it becomes very difficult to arrange despatching of vehicles from the sidings to arrive at regular intervals, particularly taking into account the requirements of the Mill Group Board that individual daily allocations be met and that equity exist in timing of deliveries by growers. Once it became apparent that more than one major haulier would be involved in cane transport from the start of the 1986/87 season it was decided that some system would have to be installed to discipline and control the movement of traffic through the caneyard.

Two possible systems were considered:

1. A manual system, with an operator on duty 24 hours a day, regulating traffic by assessing the mill's requirements and then directing the appropriate vehicle onto the weighbridge, taking into account the requirements for a fair division between the various hauliers.
2. An automatic system, controlled by a computer (of some sort), which would allow vehicles onto the weighbridge in a pre-determined sequence in response to the mill's requirements.



1. Diffuser photocell
2. Diffuser queue
3. Diffuser hilo spiller
4. Hilo cleaning yard
5. Gantry crane
6. Milling tandem hilo spiller
7. Milling tandem photocell
8. Milling tandem queue
9. Electrical workshop
10. Mill/diffuser call lights
11. Stop/Go light
12. Weighbridges (Gross in, Tare out)
13. Main hilo call lights
14. Haulier reserved lane
15. Haulier reserved lane
16. Direct deliveries lane
17. Direct deliveries push button
18. Staging area call lights
19. Hilo staging area
20. Main gate

FIGURE 1 Caneyard and traffic control system layout

Based on costs it was decided to install a system controlled by a programmable logic controller (PLC) since these devices have been specifically designed for production line sequence control and are thus ideally suited to this application.

Description of the System

Maidstone mill crushes about 360 tons cane per hour on two tandems: a diffuser which crushes 200 tons per hour and a milling tandem which crushes 160 tons per hour. The layout of the caneyard at Maidstone is given in Figure 1 with all the components of the traffic control system shown.

The system consists of:

1. A programmable logic controller (PLC) which is located in the weighbridge. This is the 'brain' of the system. The PLC is programmed in relay ladder logic. The particular PLC chosen for this system can take 1194 program statements and has 16 input channels and 12 output channels.
2. A set of lights at the weighbridge which indicates to the hilo drivers which haulier is to move onto the weighbridge.
3. A second set of lights, located at the hilo staging area, which indicates to the hilo drivers which haulier should move forward into his weighbridge queue.
4. A pushbutton station to allow direct delivery vehicles (including all vehicles, other than hilos, which need to be weighed) to send a signal to the PLC to request a turn on the weighbridge.
5. A set of lights on the exit from the gross weighbridge which indicates to the driver whether to stop or go and to which milling tandem he should go.
6. A control panel in the weighbridge, operated by the weighbridge clerk, which has the following features:
   - Lights showing which call light is on.
   - Lights showing which tandem is calling.
   - Lights indicating if a tandem is stopped.
   - Auto/manual switch.
   - Reset and start buttons.
   - Stop and go buttons.
   - Day/night sequence switch.
   - Switches to operate the call lights in manual mode.
7. A photocell on the milling tandem queue lane to indicate to the PLC when a hilo is required by the mill. Only one hilo is queued at the mill at any time.
8. A photocell on the diffuser queue lane to indicate to the PLC when a hilo is required by the diffuser. Two hilos are queued at the diffuser.

The connection of the various components of the system to the PLC are shown in Figure 2.

Software Development

Once the system hardware was chosen it was necessary to program the PLC to take into account the various requirements of the system and the various situations that can arise in the caneyard. The PLC program is built around a sequence of haulier's calls (i.e. switching on lights) which can be changed relatively easily, to give the required ratio of calls to each haulier.

The initial software was developed during the 1986 offcrop using a scale model of the caneyard which had been set up with lights and switches (to simulate the photocells). This simulator was wired up to the PLC and the program was tested on anticipated situations. This approach had the advantage that everyone involved in the caneyard operation could be brought together and various ideas examined without having to walk the length of the caneyard too often. The simulator was also very useful for training users of the system (weighbridge clerks, hilo drivers etc.).

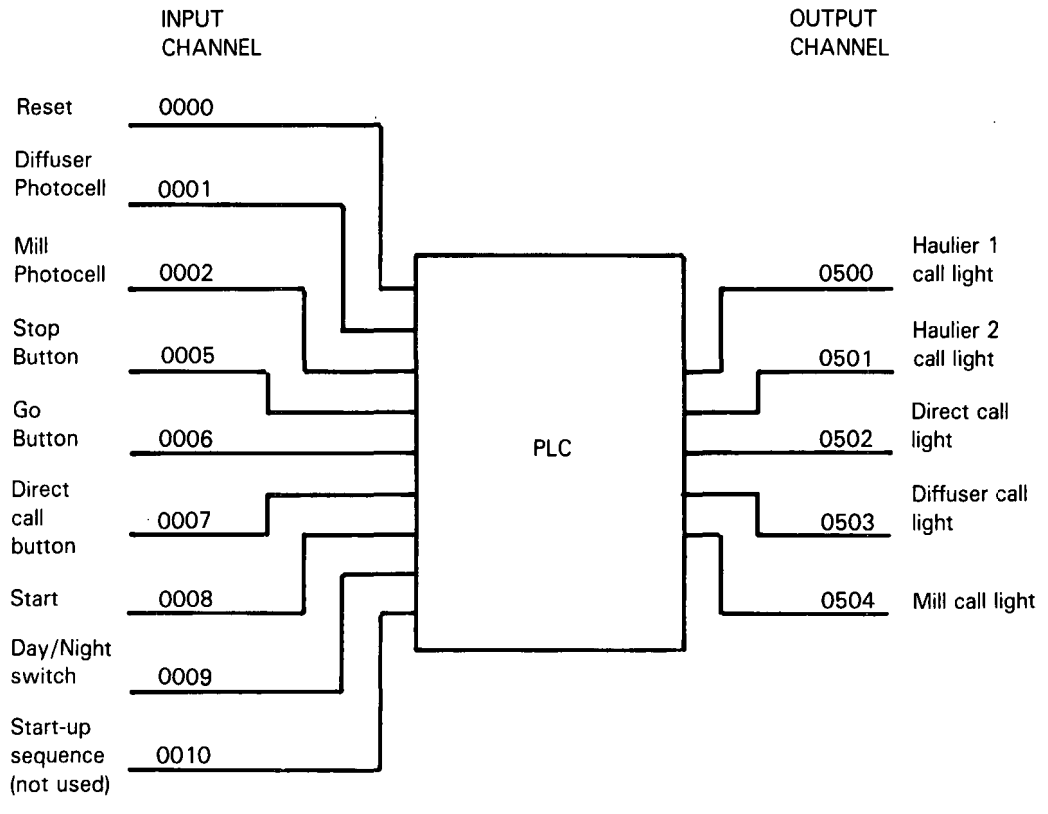


FIGURE 2 PLC inputs and outputs.

Final programming adjustments were made after start-up as situations which had not been foreseen arose or further improvements were suggested.

Operation of the System

For the 1986/87 season the Maidstone mill was supplied by two major hauliers. Two other hauliers were supplying very small tonnages of cane and to avoid overcomplicating the system these were accommodated by letting them use a lane (and call lights) of one of the major hauliers and giving this haulier a slightly higher number of light options to compensate.

Hilo Deliveries

Each major haulier has a reserved lane in the queuing area for the weighbridge, as well as reserved lanes in the hilo staging area. No more than two hilos are allowed in any weighbridge queue at any time. When a hilo arrives at the mill it goes into the staging area and waits its turn at the back of that particular haulier's queue. Only if the weighbridge queue of the haulier in question has less than two hilos in it, which is easily seen by the driver on entering the millyard main gate, may the driver move directly into the weighbridge queue lane.

The operation of the traffic control system is best explained by describing the sequence of events from the time a hilo spiller crane is vacated to the time the next hilo arrives at the tandem in question. Consider the simple case of operation on the diffuser only:

1. A hilo has finished spilling and pulls out of the unloading bay.
2. The front hilo in the diffuser queue pulls into the unloading bay.
3. The second hilo in the diffuser queue moves into the front position.
4. The movement of the hilo from the second spot causes the photocell to open and this sends a signal to the PLC that the diffuser requires a load.
5. The PLC looks for the next haulier in the pre-programmed sequence and switches on the appropriate call light at the weighbridge and at the staging area. The PLC also switches on the light at the exit of the weighbridge indicating to the driver that he must go to the diffuser.
6. Assuming that a hilo is waiting in the haulier's queueing lane, this hilo will pull onto the gross weighbridge.
7. Once the hilo is on the weighbridge the clerk pushes his STOP button. The STOP light at the weighbridge exit is switched on and the PLC switches off the call light to avoid the next hilo in the queue thinking he has been called.
8. In response to the call light at the staging area the next hilo should move into the back of the weighbridge queue as the second hilo in the weighbridge queue moves to the front.
9. Once weighing is complete the weighbridge clerk pushes the GO button on his panel. The STOP light is switched off and the GO light on. The PLC, after a pre-set time delay, switches off the light which tells the driver that he should be going to the diffuser.
10. Once the hilo arrives in front of the photocell at the diffuser the cycle is complete.

A call by the photocell on the milling tandem queuing lane is treated in the same way.

Naturally two tandem operation will lead at times to one tandem calling for a load before the other has received its load. To cater for this the PLC stores a call by a tandem if it is in the process of dealing with a call from the other tandem. It will then action the stored call when the first call has been completed (i.e. the GO button is pushed). Thus in the event of both tandems requiring a load, the first hilo should always go to the tandem which called first.

It will also occur that, even though a particular haulier's call light is switched on in accordance with the sequence, no hilo is available in that queuing lane. To prevent this from starving the mill of cane, the PLC allows the call light to burn for a pre-set time interval. It then switches off the call light and allows a further time interval (to allow a hilo which pulls off towards the end of the call to reach the weighbridge). If the call has not been answered by the end of this second period (i.e. if the STOP button has not been pushed) the PLC goes to the next call in the sequence. It will continue to do this until the call is answered.

Direct Deliveries

Direct deliveries are cane deliveries by tractor-trailer directly from growers without involving a haulier. About 8% of Maidstone's cane is delivered by this method. However, for the purpose of the caneyard traffic control system all vehicles which are not hilos (including sugar tankers, myla trucks etc.) but have to be weighed on the gross weighbridge are considered as direct delivery vehicles. All such vehicles are required to queue in the direct delivery lane.

On the side of this lane is a push button which the driver of the front vehicle lane must push in order to request a turn on the weighbridge. After a pre-set delay to allow the driver to return to his vehicle the light calling for a direct delivery will be switched on by the PLC (unless a mill hilo call is actually in progress or the weighbridge is occupied, in which case the call is stored). The direct vehicle then pulls on to the weighbridge and the clerk pushes the STOP button, which switches off the direct call light, preventing the next driver from thinking he can move. After weighing the GO button is pushed and the direct delivery moves off. Obviously no mill call light is involved.

Each and every direct delivery coming in must push the button to be allowed a call light. Once a direct call has been stored in the PLC it is given priority over the next hilo call. As a result of this priority feature no room is provided in the staging area for queueing of direct delivery vehicles. Should both mills require loads while a direct call is being processed both calls are stored and actioned in the order in which they were received.

Special Features

A number of features of the system are worth noting:

- A pre-set time delay in the PLC program prevents the PLC from reacting to any call from a photocell (i.e. photocell open condition) less than this delay period. This prevents the PLC from interpreting the gap between the horse and the hilo trailer as a call.
- A manual switch is available in the weighbridge on the control panel. With this set to manual the PLC is shut down and the weighbridge clerk may manually operate the various call lights using the switches on his control panel.
- Reset and start buttons are provided on the weighbridge clerk control panel. Should a condition occur which is not catered for by the PLC, such as two hilos going through

on a call etc, the programme can be initiated and restarted by pushing RESET and then START. This should also be done when switching the PLC on (eg. at the start of the season) or switching from manual back to PLC control.

- A day/night switch is provided on the weighbridge clerk's control panel. This allows for a selection of two different call sequences for use during the day and night. This feature is used to cater for any imbalances between hauliers on the day and night sidings.
- A steel shutter is fitted to the housing of the two photocells. When this is shut the PLC assumes that the bay is occupied and effectively stops any calls from this photocell. This is used on a tandem maintenance stop day or during long breakdowns when it is undesirable to keep a hilo on hold in the bay.

Discussion

The introduction of a traffic control system has had a measurable effect on the amount of traffic in the caneyard at any time. This is reflected in a reduction in the gross weighbridge to tare weighbridge turnaround time for hilos from an average of 35,7 minutes for the 1985/86 season to 28,1 minutes for the 1986/87 season. This is especially significant when it is taken into account that the cleaning of hilos is carried out in the caneyard – an operation which takes about 15 to 20 minutes per hilo and which has not been modified from 1985/86 to 1986/87.

Advantages of the PLC based system

The use of a PLC based system compared with a manual control system has had a number of advantages:

1. The PLC based system has more than justified its cost of installation. The total project cost was R12 000 with annual maintenance costs of about R500 p.a. This should be compared with an annual cost for 24 hour operator coverage of about R28 000. This represents a payback period of about 5 months.
2. The system is far less subject to human error than a manual system. It is true that the hilo drivers can occasionally do something out of the ordinary, such as going to the wrong mill, but experience has shown that this does not happen more than twice a week. With a manual system three extra lines of communication must be opened between the caneyard supervisor and the traffic controller, the weighbridge clerk and the traffic controller and between the hilo drivers and the traffic controller. This would be likely to lead to problems.
3. The PLC based system is flexible since the program can be changed relatively easily to incorporate modifications and new features.
4. The recording of missed light options has assisted hauliers by highlighting deficiencies in their scheduling, particularly at the shift change periods. In addition by controlling on entry to the weighbridge the system separates the effects of caneyard delays from delays due to poor scheduling or too many vehicles in service.

Disadvantages of the PLC based system

The PLC based system has some disadvantages:

1. The hilo drivers in the weighbridge queue area must keep their engines idling and their brake pressure up in anticipation of a light option.
2. It is not possible for the system to differentiate between burnt cane and unburnt cane. This means that the old system of favouring one tandem or the other with burnt cane has had to be abandoned.

Current limitations

The system currently has a few limitations although these could be eliminated by program changes or changes in the method of light sequence allocation if necessary:

1. The hauliers with interlinks have a payload advantage over standard trailers as the ratio of light options in the sequence is currently based on number of loads only, and is not weighted according to payload differences.
2. Any haulier with a small tonnage would experience enormous delays if allocated a specific light. As mentioned earlier this problem is overcome by letting the small haulier use one of the major haulier's queue lanes and light options.
3. Should a vehicle proceed to the wrong tandem the system is unaware of this and another load is not called even though it is required. This problem could be programmed out using a time delay routine.

Conclusion

Despite some early scepticism on the part of growers and hauliers about the system, it operated very smoothly from early in the 1986/87 season and was soon accepted by most users of the weighbridge and caneyard. It has prevented any real or imagined prejudice to one major haulier compared with the other. This is particularly important where one haulier is associated with the milling company. The use of a PLC based system has resulted in significant cost savings and has imposed a discipline on all users of the caneyard which has led to smoother and more efficient traffic flow throughout the system.