STRIKE SEQUENCE CONTROL

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Abstract

In the Regensburg Sugar Factory of Südzucker AG a decentralised processing system is installed for the automatic strike sequence control of 20 discontinuous boiling pans.

By monitoring the levels in the thick juice tanks, minglers and the centrifugal capacity, the program co-ordinates the starting times of the pans, determines the set points for the vapour pressure control and controls the boiling time of each pan. This has resulted in uniformity of operations at the sugar end, increased capacity and energy savings.

The purpose of strike sequence control is to introduce greater uniformity to the overall process at the sugar-end by determining the most favourable starting point for each of the discontinuous vacuum pans. One of the main objects is to ensure a uniform sugar-end vapour intake because this in turn, leads to a constant thick-juice density. Moreover, accurate process control can reduce the amount of water evaporated by optimizing the water intake into the vacuum pans and keeping the "strike hold" times to a minimum.

The results depend on how successful the operators have been in achieving uniformity with the crystallization and starting of the strikes. This success requires that the operators have an overview of all that is going on at the sugar-end. Because there are normally at least 2 operators controlling the sugar-end, correlation is that much more difficult. A change of shift, for example, causes a break in the operations because, although those on the new shift have access to the data of the moment, they will not know the trends.

Strike sequence control eliminates this human error because new trends are detected as soon as they start and the necessary corrections are made gradually.

The end results are greater uniformity in the work at the sugar-end and at the evaporator station. The greater uniformity reduces the number of disturbances at the sugar-end, allowing increased capacity to be anticipated. Energy savings are another obvious benefit.

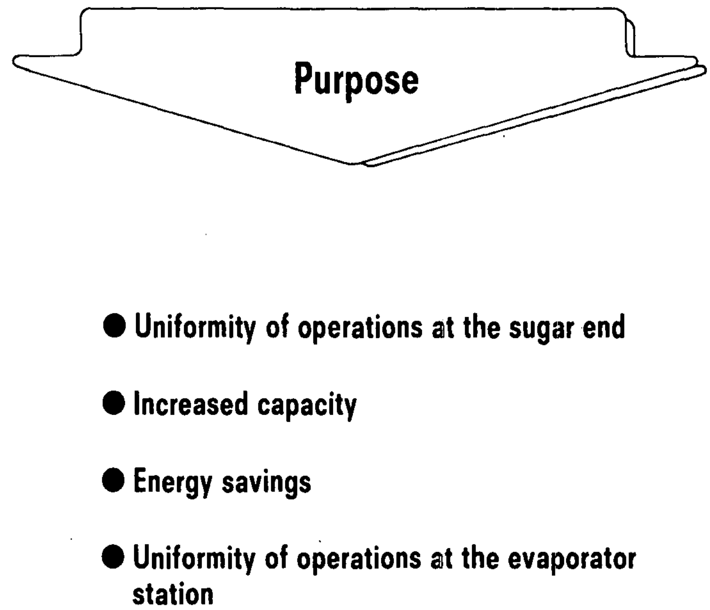


FIGURE 1 Strike sequence control

The first steps towards the practical realization of a strike sequence control system were taken in 1979 at the Ochsenfurth Sugar Factory where computers are used for automatic control. Because of a shortage of memory capacity, the initial plans could not be brought to fruition.

Development of the present program began in 1982. The program was structured and trials began at the Regensburg factory during the 1982 season.

The Regensburg factory was ideal for the purpose because:

- the 20 vacuum pans are controlled automatically by four AS 220 controllers;

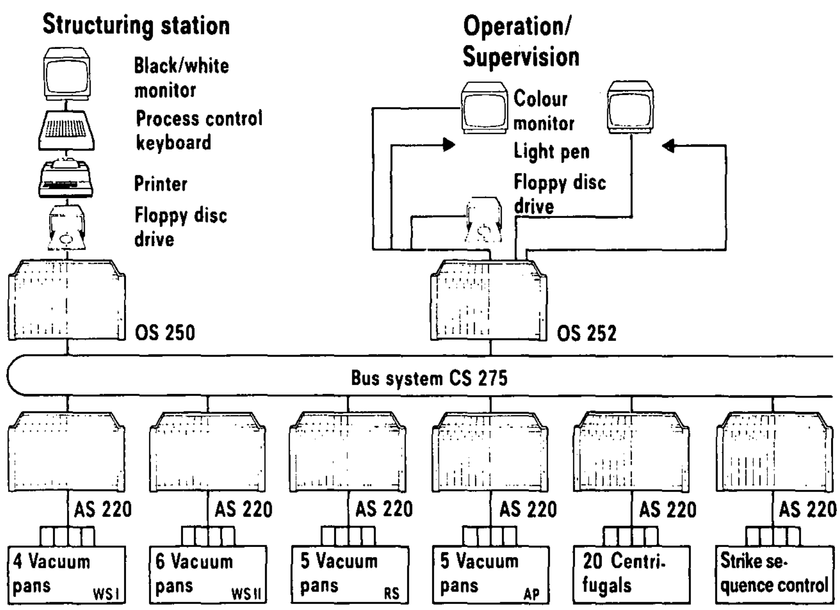


FIGURE 2 Processing system at the Regensburg Sugar Factory

- there is an automatic control system with a total of 20 control loops for the centrifugal station and for supervising the 20 intermittently operating centrifugals.
  The centrifugals have their own controller. In the AS 220 the progress of the cycle is monitored and displayed on the screen at a separate centrifugal control station. The AS 220 issues the start signals for the individual centrifugal and sets the relevant times. For the strike sequence program, a separate AS controller is not needed for the centrifugals;
- for the strike sequence control a separate AS 220 was used for trial purposes and for making modifications without disturbing the process or the operators. Another reason was that a memory capacity of 34 kbytes was needed for the trial program because of the intended analysis of the system and the preparation of reports.

The actual memory requirements on the decentralised processing system for strike sequence control are, 16 kbytes for the boiling station and 4 kbytes for the centrifugal station.

Since each automatic controller of the vacuum pans has approximately 30% spare capacity, it is simple to structure the strike sequence program on two existing controllers, ie a future strike sequence control system will not need a separate automatic controller.

The program comprises a separate co-ordination program for the boiling station with sections for each product, and a separate co-ordination program for the centrifugal station.

The first stage for the 1982 campaign was to link up the boiling station. The centrifugals for white sugar (first boiling) were added to the centrifugal station at the end of the 1983 campaign. The original strike sequence control program for the 1982 campaign provided initially for the strikes to be started in the same sequence for all products, ie from the quantity of thin juice, a specific number of strikes per day was calculated for all the vacuum pans. Then, a specific time interval for strike-start was calculated for each product. However, the strikes should be started according to a regular, overriding clock pulse for all products.

At this stage, the strike sequence control only provided a guide for the operators at the control station, eg when to start a strike or to change a pan prematurely from first-stage boiling to tightening. There was no provision for intervention from the AS 220 strike sequence control in the actual process.

The criteria on which the start depends will be dealt with later. The recommendations of the strike sequence control could not always be followed by the operators because in the Regensburg factory, 3rd and 4th vapours are used for boiling.

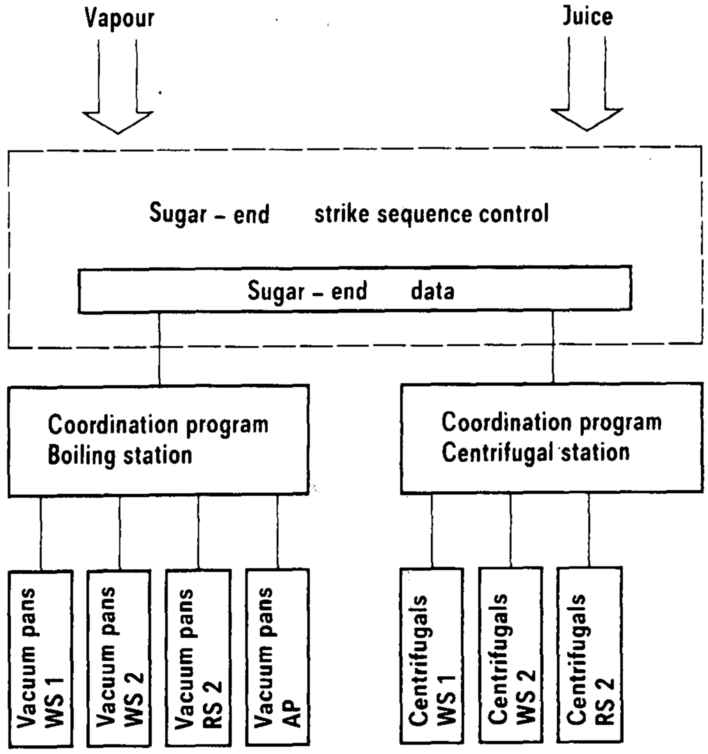


FIGURE 3 Layout of strike sequence control program

Agreement would have been better if a single vapour (ie only the third vapour) had been used for boiling. When using two vapours, however, it was apparent that the strike sequence control system was sometimes too inflexible. Often the product-related and overriding clock pulses had elapsed before the other conditions for a strike-start had been satisfied. The delay until the next possible start was then excessive.

For the 1983 campaign, the program was modified primarily so that all strike-starts would be product-related, ie a separate clock pulse for strike-start is calculated for each product.

The clock pulse for strike-start is calculated for each product from the quantity of juice or it can also be initiated manually. At the Regensburg factory, for example, the cycle time for WS II and RS II was calculated from the quantity of thick juice, whereas for WS I and AP the average number of strikes per day and product were taken as the basis.

WS I = white sugar (first boiling)
WS II = white sugar (second boiling)
RS II = raw sugar (second boiling)
AP = after product boiling

Test record of 16.11.1982

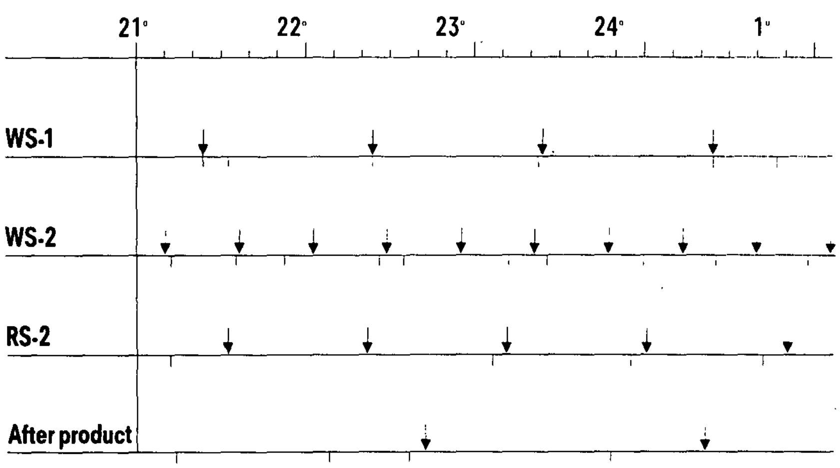


FIGURE 4 Comparison of reference strike starts with actual strike starts

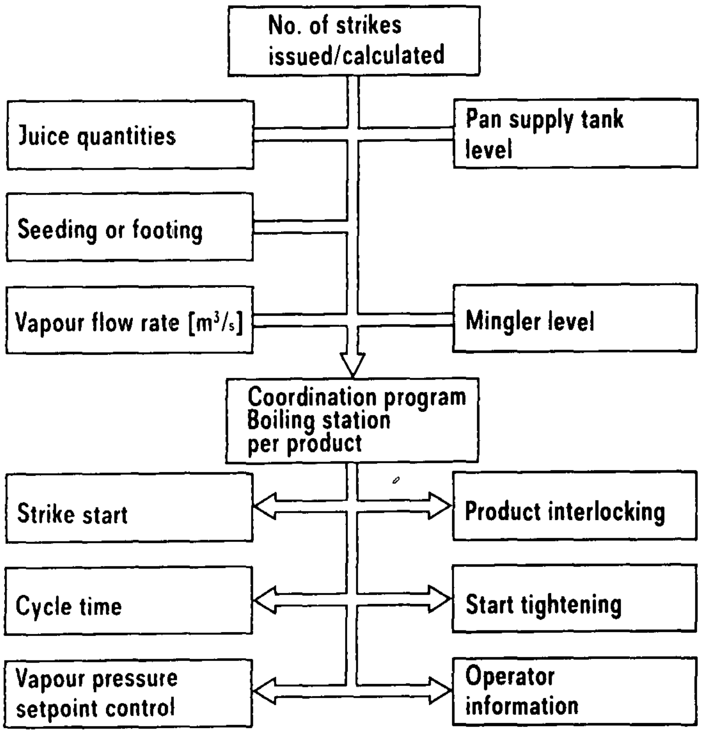


FIGURE 5 Basic concept of strike sequence control program

The number of vacuum pans in use and whether automatic or manual operation is being employed on individual pans is taken into account.

The starting time calculated in this manner is subject to dynamic correction as follows:

- according to the degree to which the pan's supply tank is full. The actual level is measured and the value transformed by means of a polygon software module into a factor which in turn determines to which degree the clock pulse for starting a pan is to be prolonged or shortened. As the system continuously monitors the level in the pan supply tank as described above, there is no danger of overflow. Before a vacuum pan is started, the level in the supply tank is checked to ensure that it is sufficient to fill a vacuum pan to above the calandria.

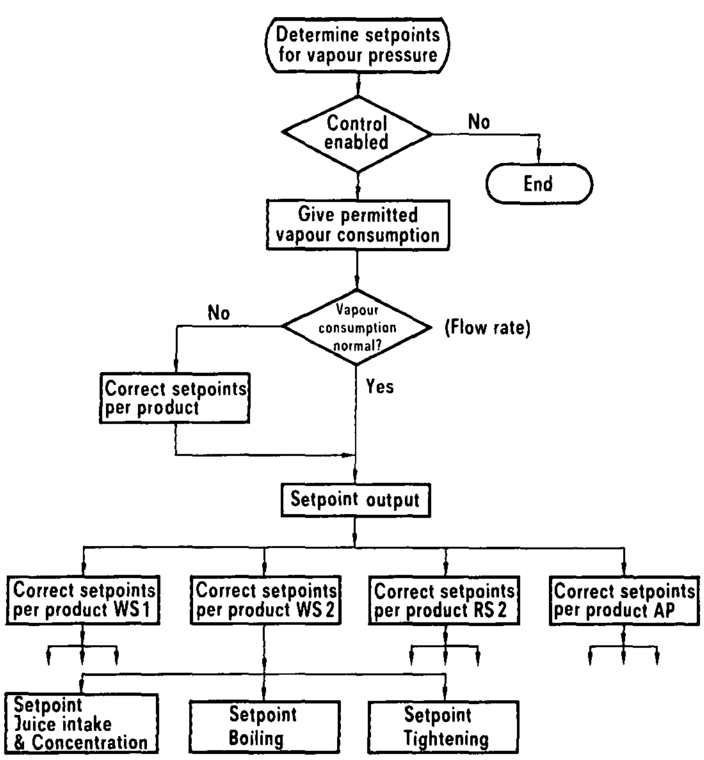


FIGURE 6 Strike sequence control — vapour pressure control

- the level in the mingler is checked continuously to ensure that there is sufficient room before a vacuum pan prematurely commences thickening. The rate of change is determined from the mingler level so it is possible to say that, for example, after the constant tightening time, there will be sufficient room in the mingler. Also, any spare capacity in the centrifugals can be utilized for making more room in the mingler.
- the vapour flow rate is regulated to produce a uniform vapour discharge from the evaporator station. The vapour control system will be considered later.

From the above preliminaries, the program fixes the start of strike and determines the cycle time which is matched dynamically according to the input parameter as described before. A separate interlocking program ensures proper correlation of the products so that each vacuum pan can operate under optimum conditions regarding vacuum. The controlled variable on the boiling pan is the ability to start tightening earlier to adhere to the predetermined starting time.

The control range at the Regensburg factory is between 77 and 90%, ie up to 13% below maximum level. The vapour pressure is regulated by issuing variable setpoints for the vapour pressure of the individual products.

A setpoint correction for vapour pressure is only made at those vacuum pans which are at the intake and concentrating phase, in the second half of the first boiling, or in the tightening phase. For vacuum pans in the graining phase and in the first half of the first boiling, the required vapour pressure is maintained for technological reasons.

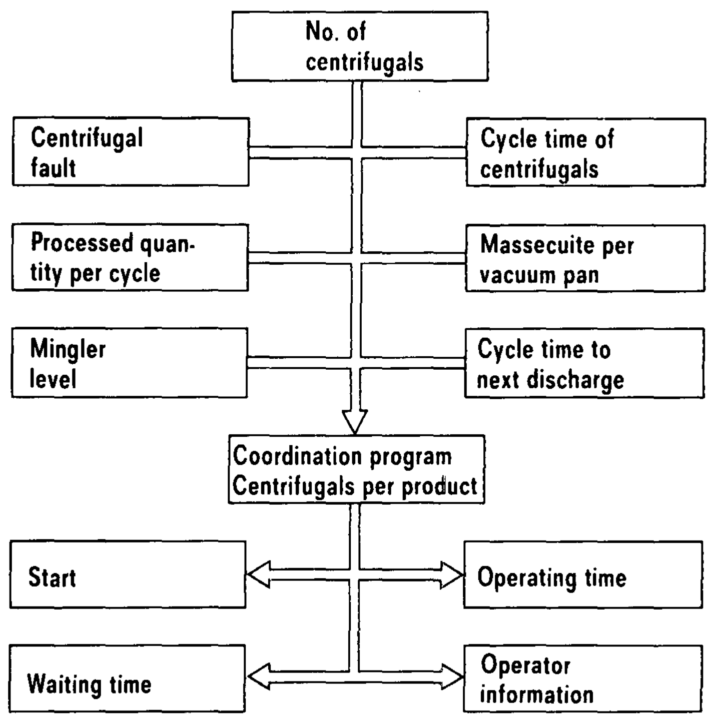


FIGURE 7 Basic concept of centrifugal control program

For the 1983 campaign, the co-ordination program for the centrifugals was set up and tested on four WS I centrifugals. This program is also product-related. The centrifugal program is to support the boiling program by using the centrifugal capacities available.

The program determines the starting time and the waiting time for the individual centrifugals from the mingler level, the amount of massecuite produced by the boiling station and the available capacity of the centrifugals. If the equilibrium is disturbed, the waiting time is shortened or extended appropriately.

If the waiting time becomes too long, eg longer than a cycle, a message on the screen indicates that a centrifugal can be stopped.

The incoming amount of massecuite to be processed is calculated from the massecuite volume in the vacuum pans. The strike sequence program for the boiling station provides the information on when the next pan will be discharged. The quantity of massecuite that can be processed is calculated from the number of centrifugals in operation, the massecuite capacity of each centrifugal, and the number of cycles per hour of the individual centrifugals.

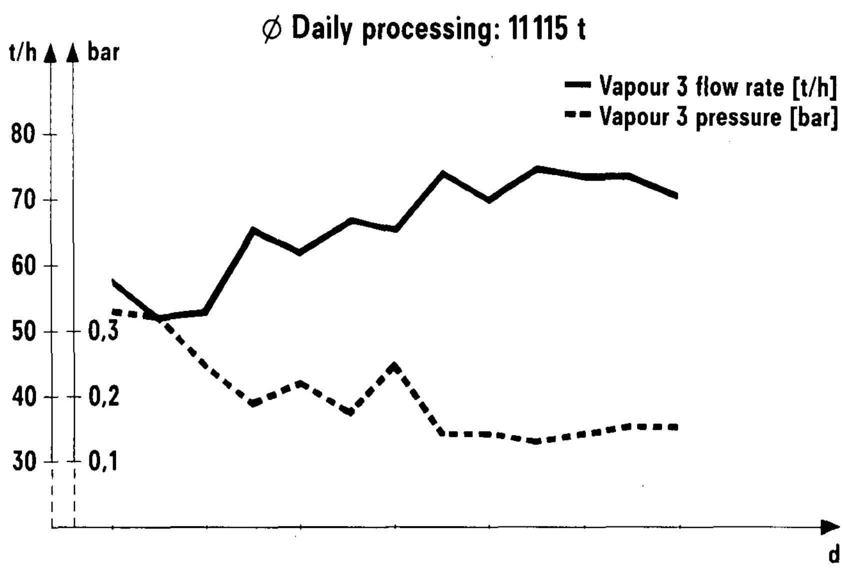
The equilibrium check is made from the mingler level and its rate of change. At the normal rate of processing, the mingler level must fall by a certain amount in unit time according to the quantity separated out. If this is not so, it indicates better or worse separation by the centrifugals and the waiting time is then corrected appropriately.

To provide a clear indication of the effectiveness of the strike sequence control during the 1983 campaign, 14-day periods with and without the control in operation were selected and the following comparisons were made:

	WS 1	WS 2	RS 2	AP	Sum
Strikes per day	29	57	35	13	134
Automatic strikes	27	49	34	7	117
Manual strikes	2	-	1	6	9
Footing*	-	8	-	-	8
Percentage of automatic strikes:	93	100	97	54	93

*not covered in strike sequence control program

FIGURE 8 Analysis of automatic and manual operation



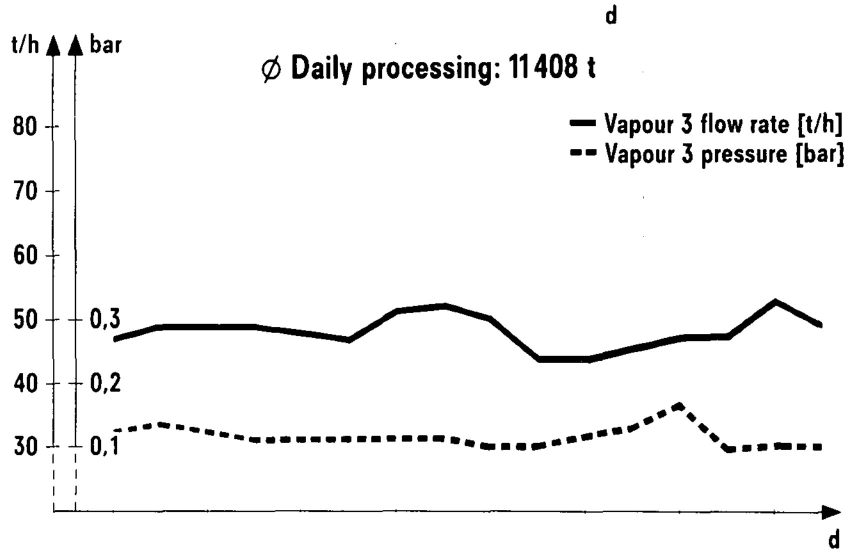


FIGURE 9 Vapour 3 flow rate and pressure

It should be noted that the manual intervention with white sugar (first boiling) was due to the insufficient size of the standard liquor storage tank. This vessel was enlarged for the 1984 campaign.

It was not possible to implement full automatic control for the after products because of the difficulties with the vapour 4 control due to the excessively low quantity. Here too, modifications to the evaporator station were necessary and in the 1984 campaign, all products were boiled with vapour 3.

Nevertheless, once these problems have been solved it is clear that, in the near future, manual intervention will be eliminated almost entirely.

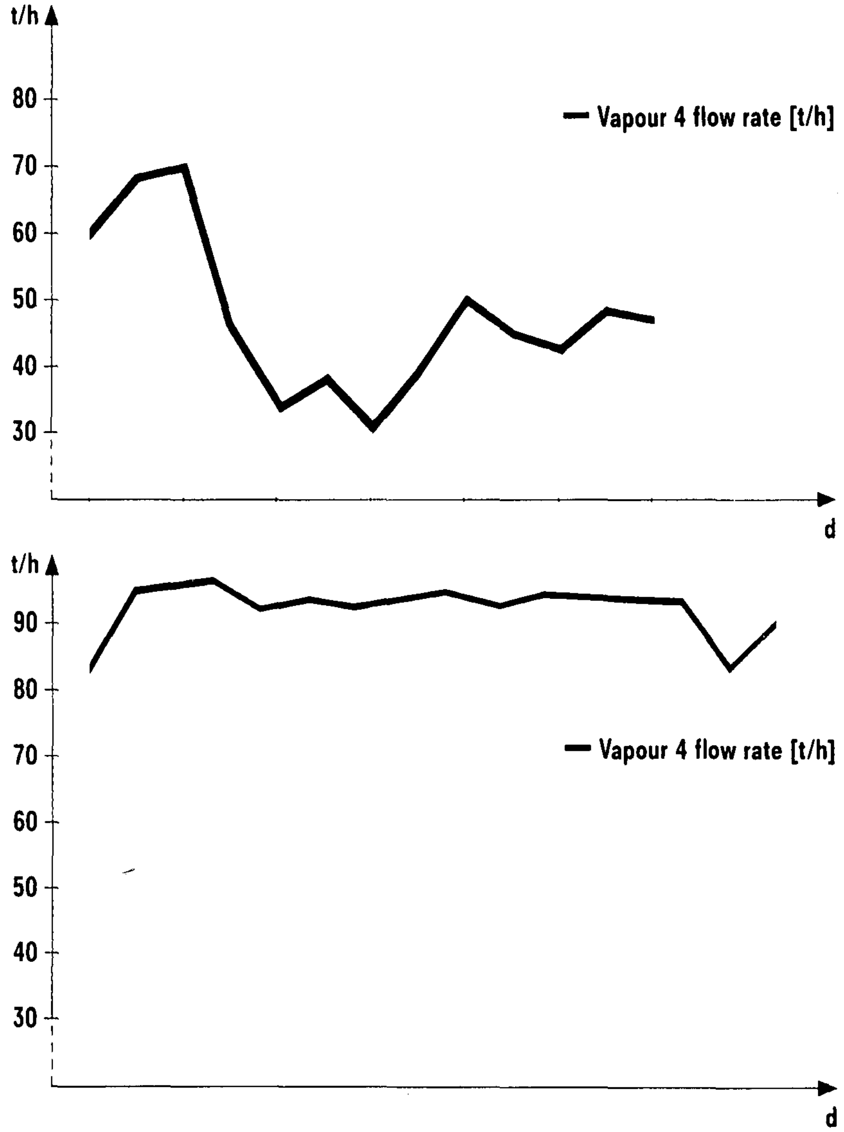


FIGURE 10 Vapour 4 flow rate

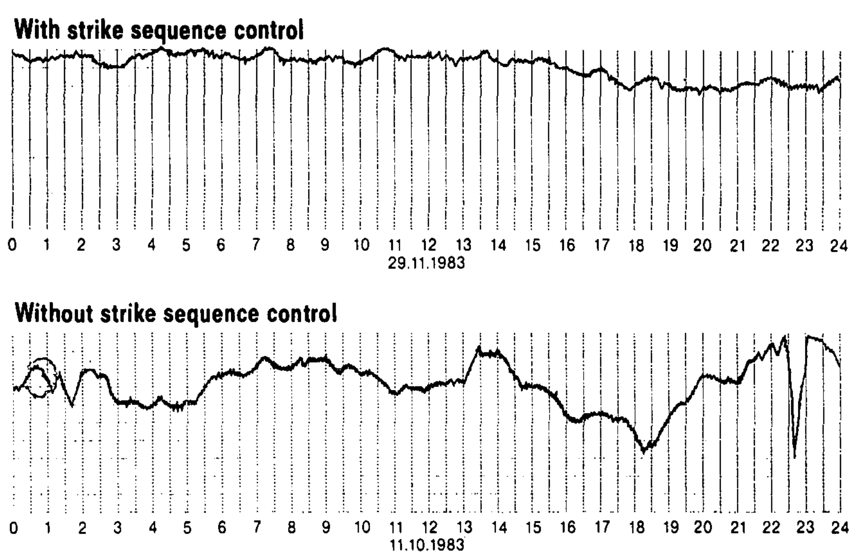


FIGURE 11 Daily pattern of dry substance in thick juice

The shift in the flow rate when comparing the two graphs is caused by the fact that when the measurements without sequence control were taken, only the after product was fed by vapour 4. When the second series of measurements were made, both after product and white sugar (first boiling) were on the vapour 4 line.

The various curves and the analyses of manual intervention demonstrate the success of the strike sequence control in ensuring uniformity in the operation of the evaporator station and sugar-end.

When, in addition to the above, the water intake can also be reduced, there will be a further improvement in the form of energy savings. In fact, a considerable reduction in water intake could be attained at the Regensburg factory. It is undoubtedly a matter concerning the individual factories and for this reason has been deliberately omitted.

Our goal was to be able to offer an effective strike sequence control system to stabilize and even the work at the sugar-end. That goal has been attained.