The New DdS Silver Slope Diffuser

HAROLD F. SILVER[1]

Several years ago the Danish Sugar Company (De danske Sukkerfabrikker) began experiments in continuous diffusion, hoping to develop an apparatus that would be simpler than the continuous diffusers then available in Europe and America. Among those assigned to the project was Mr. H. Bruniche-Olsen, a young Danish engineer, who conceived certain ideas that were finally embodied in a full-size diffuser of approximately 1,200 tons daily capacity at the Kolding slicing station (1)[2]. This machine, called the "DdS" Diffuser (using the initials of the sugar company), proved to be much simpler in construction than previous continuous diffusers and achieved very satisfactory operating results. Subsequently, a larger machine was built and installed at the Assens factory, and in 1954 a machine of 2,200 tons capacity was installed at the Saxkjobing factory.

During the 1953 campaign in Denmark, the operation of the Kolding and Assens machines was witnessed by the writer, who became interested in the possibilities of this new diffuser. A contract was later consumated between the Danish Sugar Company and Silver Engineering Works, Inc., whereby the latter took over the manufacturing and sales rights in the western hemisphere. It was evident to the writer that American sugar engineers would desire machines of greater capacity and lower retention time than had been developed in Denmark. Silver Engineering Works, Inc.,

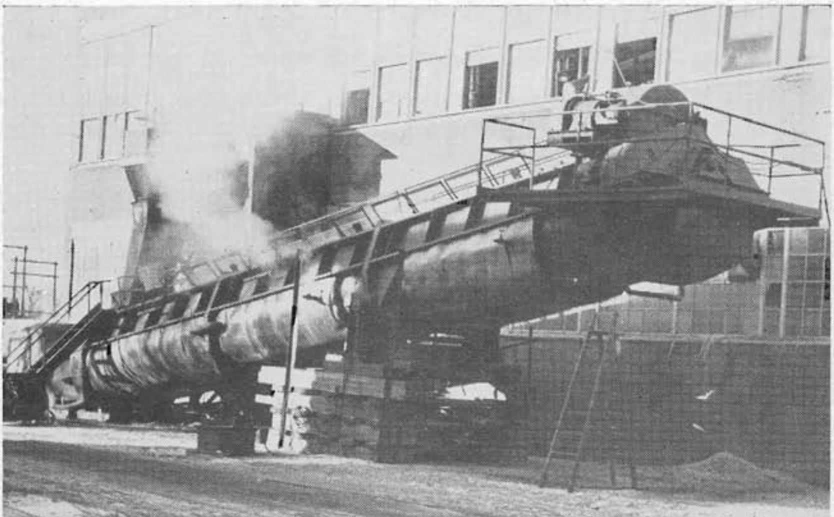

Figure 1.—Pilot diffuser at Gering, Nebraska.

[1] President, Silver Engineering Works, Inc., Denver, Colorado.
[2] Numbers in parentheses refer to literature cited.

therefore, undertook to build a pilot diffuser incorporating certain changes in design that, it was hoped, would make possible the higher tonnages and shorter retention time.

The pilot diffuser consisted essentially of a sloping trough, shaped to fit around two intermeshing scrolls revolving outwardly at the top. The cossettes entered at the lower end and were scrolled to the upper end, where they were removed by a pulp dewatering wheel. The water entered at the upper end and percolated through the cossettes by gravity to the lower end, where the juice was withdrawn through a fine perforated screen, which was kept clean by a pair of rotating scrapers. A photograph of the machine in elevation is shown in Figure 1, and a cross section in shown in Figure 2.

The Great Western Sugar Company made available its Gering, Nebraska, plant for the experimental operation, and the pilot machine was installed for the 1955 campaign. The diffuser was fed by a separate slicer with a separate weighing device and could, therefore, be operated independently of the regular factory Robert battery. Complete controlling and recording instruments were installed, and arrangements were made with the laboratory to take hourly samples of pulp and juice and to make periodic checks of juice purity and pH.

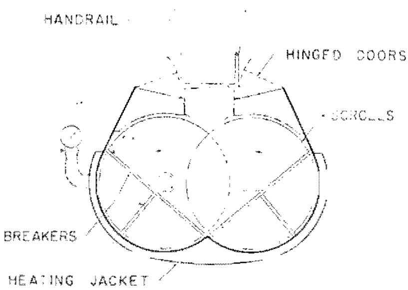

Figure 2.—Section through pilot diffuser.

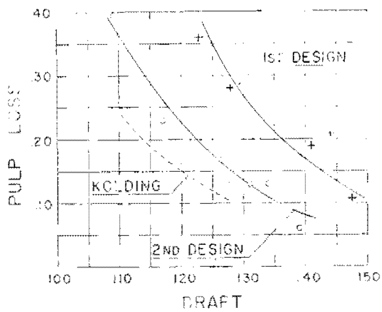

Figure 3.—Draft and pulp loss—first trial runs.

The first operation of the pilot diffuser established that the volumetric capacity had been increased in the Silver design, but the sugar recovery was disappointing. The results are shown as "First Design" in Figure 3. After a few days of operation, the diffuser was shut down and changes were made in the construction of the breaker bars. The machine was then put into service again, with greatly improved performance as to pulp loss and draft. The results of this operation are shown as "Second Design" in Figure 3.

In the Danish machines the scrolls were made up of spaced-concentric, helical bands built as continuous flights. In the Silver version of the machine, the scrolls were built similarly, except that the scrolls were interrupted and separated by breaker bars. One section of one of the scrolls had been supplied with a perforated aluminum plate, in place of the helical bands and this appeared to function much better than the rest of the scroll. The machine was again shut down and the spaced bands were replaced with steel perforated plates. Steel was used instead of aluminum because it could be more readily installed by welding. After the machine was again put into service, it was obvious that the results had been significantly improved. The pulp loss and draft were not only lowered to the range of the Kolding machine, but the capacity was further increased, so that the machine on a volume basis operated at a rate approximately double that achieved in Denmark. The retention time of the cossettes was found to be only 40 to 45 minutes, or about half that of the Kolding machine. The juice retention time was figured to be 30 to 35 minutes.

It was concluded that the general design of the machine was now satisfactory, and arrangements were made to determine the optimum slope of the diffuser. The machine had been built for ready adjustment as to slope and at the time of installation was set on a slope of approximately 9 degrees. Mr. Bruniche-Olsen had originally experimented in Denmark with a slope of 1 in 10 but had later settled on a slope of 1 in 7 (approximately 8 degrees) as being more satisfactory. The writer believed that a somewhat steeper slope might yield better results. The machine was raised to 11 degrees slope and an immediate improvement in the results was noted.

After a few days of operation, the slope was again raised, this time to 12 degrees; but the pulp loss increased and the power exceeded reasonable requirements. The slope was lowered to the 11 degree setting and the results improved. The slope was then reduced to 10 degrees, but the results appeared to be somewhat poorer. The slope was now increased to 10½ degrees and the results improved to about the same range as attained at 11 degrees. It appeared that an angle of 10½ degrees to 11 degrees was the optimum slope of the diffuser. Figure 4 shows the operating results for the "Third Design" at the 9 degree, 11 degree, and 12 degree slopes. The curve for Kolding is also shown for purposes of comparison. The Kolding diffuser was operated with the return of pulp-press water, whereas, the pilot diffuser had no such return. The curve for Kolding has, therefore, been adjusted to what it would have been had there been no return of press water.

An additional benefit was gained by the changes made in the third design. Previous to the installation of the perforated plates the purity of the raw juice from the pilot diffuser was found to be consistently below that of the factory juice from the Robert battery. This appeared to be

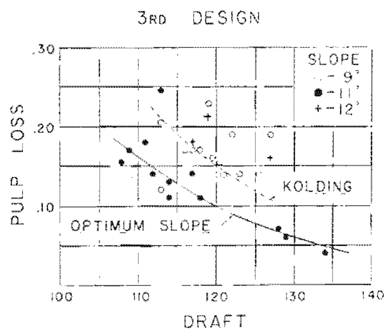

Figure 4.—Draft and pulp loss at various slopes

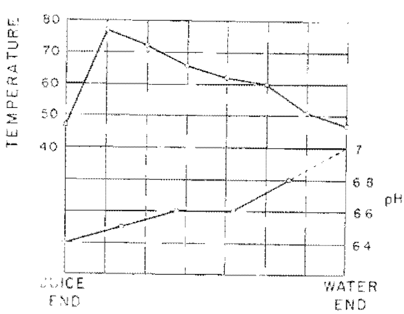

Figure 5.—Temperature and pH through diffuser.

caused by the hanging up of pulp on the scroll arms between the helical bands, which pulp sometimes would turn black before it finally worked itself loose. After the installation of the perforated plates, there was no further hanging up of pulp, and the purity of the raw juice from the pilot diffuser was always either equal to or higher than the factory raw juice.

The pilot diffuser was heated with two steam jackets wrapped around the trough: one at the lower end extending up about 60 percent of the length, and another at the upper end extending down about 30 percent of the length. Figure 5 shows the temperature range throughout the length of the machine and the pH determinations at various points in the machine. The maximum temperature of 77 degrees was reached near the lower end of the machine and gradually tapered off to 51 degrees at the control point at the upper end. It was found that if the temperature at the upper control point was maintained above 51 degrees the pH would be well above 6, but if the temperature dropped below 51 degrees there was a drop in pH to dangerous levels. No formaldehyde or other bactericide was used in pH control. Laboratory tests showed that the lactic acid content of the raw juice from the pilot diffuser was less than for other continuous diffusers in the Great Western factories and about the same as for Robert batteries.

The Danish Sugar Company had found it desirable to use very large cossettes (15-division knives) to get proper circulation. The initial run of the Silver pilot diffuser was made with cossettes from 23 division knives, but it was found that the machine would also operate satisfactorily with cossettes from regular 46 division knives set at 1¾ millimeters up and 1¾ millimeters back.

During part of the campaign the pilot diffuser operated with badly frozen and partly rotten beets without apparent difficulty. While it may be expected that there will be some reduction in capacity with rotten or mushy beets, it was the opinion of the factory superintendent and his staff that deteriorated beets could be processed much more easily in the DdS Silver Slope Diffuser than in the Robert diffusion battery.

The pilot diffuser was built with scrolls 54 inches in diameter and 45 feet long. The over-all length of the machine was 57 feet, and the over-all width was 12 feet. The scrolls were driven with two 7½-horsepower motors, and the pulp dewatering wheel with a 2-horsepower motor. A speed-changing device was used to experiment with various scroll speeds. Up to 1.1 RPM there was no appreciable tendency for foam to form, and the machine handled about 550 tons of beets per day without the use of foam-breaking oils. At higher speeds and capacities, a small amount of oil was required. It appeared that about one gallon of Balab, Steffens Type, cut with kerosene, would suffice for each 200 tons of beets. When automobile crank-case drainings were substituted for the Balab, about five times the quantity of oil was required. An interesting observation was made in the use of these oils. It was found that the Balab, a vegetable oil compound, seemed to travel mostly with the juice, and, therefore, had to be added near the middle of the diffuser to be most effective. On the other hand, the crank-case drainings, a mineral oil, seemed to travel with the cossettes, and had to be added at the lower end to give the best results. At the top speed of 1.4 RPM, a maximum capacity of 753 tons of beets per day was reached, and for several hours at a time an operating rate of over 800 tons was recorded. It is believed that a rated capacity of about 650 tons of beets per day should be assigned to the pilot diffuser. Based upon this rating, commercial machines up to 4,000 tons capacity have been projected, as shown in Table 1.

Table 1.—Projected Diffuser Sizes and Capacities.

Size (Scroll Dia.)	Floor Space Required (Approximate)	Connected Horsepower	Capacity Tons Per Day
78″	14 Ft. x 60 Ft.	40	1300
90″	16 Ft. x 62 Ft.	50	1750
102″	18 Ft. x 64 Ft.	60	2200
114″	20 Ft. x 66 Ft.	80	2700
126″	22 Ft. x 68 Ft.	100	3300
138″	24 Ft. x 70 Ft.	120	4000

The 1955 campaign averages of pulp loss and draft for most of the factories of the large beet sugar companies in the United States are plotted as points on a chart in Figure 6. Also shown on the chart for comparison is the curve of operation of the pilot DdS Silver Slope Diffuser. This indicates the large potential of sugar and coal saving that may be made with this new diffuser. It is the most simple and the most accessible apparatus yet devised for continuous diffusion. It should have a very long life, as witnessed by the fact that the maximum thickness of metal removed from the shell of the pilot machine by erosion and corrosion was only .008 inch in over 60 days of full operation.

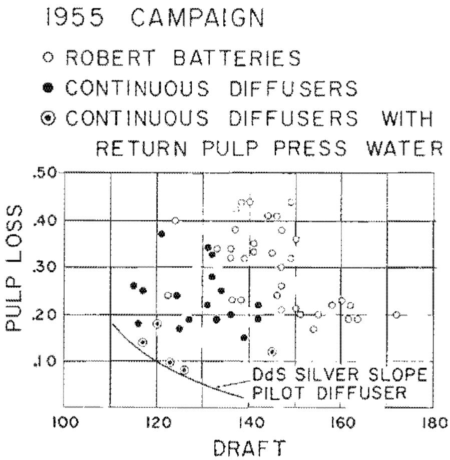

Figure 6.—Draft and pulp loss campaign results—American factories.

The first commercial diffuser of this type has been ordered by The Great Western Sugar Company for operation at its Eaton, Colorado, factory during the 1956 campaign. This could well inaugurate a new era in diffusion, with the DdS Silver Slope Diffuser becoming the new standard of the sugar industry.

References

(1) BRUNICHE-OLSEN, H. Evaluation of non-cell-divided continuous diffusers III. Sugar Magazine, Vol. 49, No. 6, June, 1954.