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CONTINUOUS
FOAM BILLET
FABRICATION

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ABSTRACT

A process for the fabrication of large, continuous billets of polyurethane foam is discussed. A conveyor mechanism used in conjunction with a foam mixing machine and control console proved to be feasible for this purpose. Six continuous billet runs were made. The largest billet produced was 10 feet long, 2-3/4 feet wide, and 9 inches high. The maximum width and height with this equipment would be 6 feet and 2-1/2 feet respectively. The length is limited only by the capacity of the foam mixing equipment and by shipping convenience. Processing improvements resulted in a more uniform height in the sixth billet than that achieved in the earlier billets. This improvement in the product indicates that additional billet runs to optimize the processing variables could result in billets of higher quality.

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Section 1

SUMMARY

A process was developed that resulted in the production of polyurethane foam billets up to 10 feet long, 2-3/4 feet wide, and 9 inches high. The process proved the general feasibility of using a conveyor system, foam machines, and a control console for the fabrication of large continuous billets.

The original objective was to modify the standard process for the fabrication of high-carbon-content, good-quality, continuous polyurethane foam billets, suitable for carbonization, in sizes up to 10 feet long, 6 feet wide, and 2-1/2 feet high. Since the need for carbonization of large foam billets did not materialize, the project requirements were modified to prove only the basic capabilities of the equipment.

Six continuous billets were run, and results indicated that the original objectives could have been attained with the equipment used if optimum materials and processing techniques had been developed.

Section 2

DISCUSSION

PROJECT OBJECTIVES

The original purpose was to adapt and/or modify the standard processes, first developed in Germany and now used by several companies in the United States, for the fabrication of continuous billets. The objective was to develop a three-component, rigid foam system, using Varcum as the third-component additive to a conventional two-component system. This process was to have been used to produce large polyurethane foam billets of good quality and high-carbon content, suitable for carbonization. The maximum size of the billets was planned to be 10 feet long by 6 feet wide by 2-1/2 feet high. Due to the Bendix management decision to discontinue all carbonization work, the need for this material no longer existed. The primary objective was then modified to prove the general feasibility of the equipment (including the conveyor, foam machines, and control console) which had already been obtained and assembled prior to the cancellation of the carbon foam requirements.

PROCESS DESCRIPTION

The Continuous Billet Process utilizes a conveyor system to transport the freshly poured foam away from the mixing head at a predetermined velocity so that the foam rise will occur as a continual process at a constant distance down the conveyor from the pouring station. In this manner the foam material may be poured without interruption, so that it gels into one continuous bun-shaped billet as it is conveyed away from the stream of foam material being discharged from the mixing head. A single continuous billet is formed and, theoretically, the only limitation on the length of the billet is the capacity of the material storage tanks of the adjacent foam dispensing machine. In practical application, however, the billet is sectioned into the lengths desired to facilitate shipment or for the requirements of a particular application.

Continuous billet equipment, for both rigid and flexible foams, has been in operation at various companies in the United States and in Europe for the past 15 to 20 years.

DESCRIPTION OF EQUIPMENT

Since the foam dispensing machine and its control console are typical of those used in foam production, these two items will not be included in the detailed discussion of the equipment.

The continuous billet equipment, designed and built to BKC specifications by the Leon Machine and Engineering Company, Riverside, New Jersey, consists of four major components:

- Traverse mechanism;
- Powered conveyor;
- Free-roll transition conveyor; and
- Free-roll conveyor with cut-off saw.

The traverse mechanism is a free-standing unit which spans the conveyor and has a 500-pound capacity carriage to which the mixing head of the foam dispensing machine can be attached. The carriage speed is adjustable between 15 and 150 feet per minute, and the carriage stroke is adjustable up to 72 inches of travel. The mechanism also has an adjustable dwell time at each end of the carriage stroke.

The powered conveyor uses a 6-foot-wide, rust-resistant, self-aligning metal belt made up of individual links of aluminum slats, 6-feet long by 6 inches wide. The belt is driven by a variable speed motor and gear linkage that provide a conveyor speed adjustment range of from 1.2 to 22.4 feet per minute. A flat belt length of 20 feet is available between the turn-around points. Adjustable side walls provide for production of billets from 2-3/4 to 6 feet in width. The slope of the conveyor is adjustable from 0 to 10 degrees, and a fume collection hood covers the 14 feet of the conveyor immediately past the pouring station. The side walls and conveyor belt are protected from foam adherence by a moving paper liner which is attached to, and pulled by, the belt. The paper is fed into the back end of the conveyor where it passes between forming rollers and guides that shape the paper into a channel of the desired billet width.

The free-roll transition conveyor is an 8-foot-long section of rollers that functions as a floating connection between the powered conveyor and the saw conveyor. The transition conveyor has a pivot-point connection with the powered conveyor and a horizontal floating pivot-point connection with

the stationary saw conveyor. This arrangement provides the flexibility required by the necessary angular adjustments of the powered conveyor.

The free-roll conveyor with cut-off saw consists of an 18-foot-long segment of rollers that is spanned by a stationary cut-off saw. The horizontal band saw has a quarter twist in the blade on its lower pass so that it can cut down through the billet in a vertical plane. Air cylinders provide an automatic feed and retraction of the saw.

EQUIPMENT TRYOUT

Before making any trial runs, several processing variables must be established. The free-rise density of the foam system must be determined and the desired billet width and height chosen. The proper combination of discharge rate and conveyor velocity should be determined in such a manner that these five variables maintain the following relationship.

$R = DWHV$ Where:

R = discharge rate (lb/min)₃
 D = free-rise density (lb/ft³)
 W = billet width (ft)
 H = billet height (ft)
 V = conveyor velocity (ft/min)

The optimum values for other processing variables, such as conveyor angle, traverse speed, and stroke and dwell timing, are more difficult to determine. Since these four parameters are dependent upon the viscosity of the material being poured, and also upon the rise rate and gel characteristics of the foam, these four processing variables must be optimized by trial and error methods. The procedure must be repeated each time a new foam system is considered. If these variables, as well as the discharge rate and the conveyor speed, are properly coordinated to the particular foam system being used, the foam should continually gel at a fixed distance down the conveyor from the pouring station. The height of the resulting billet should be nearly uniform both across the width and along the length of the billet.

Calibration shots, to verify the discharge rate, must precede each trial run. Foam dispensing machine variables, such as pump revolutions per minute, line pressures, material temperatures, and nitrogen pressures, must be coordinated and stabilized during these calibration shots so that the discharge rate will be a known and repeatable value. Other pre-run preparations include placement of the Kraft paper liner through the forming rollers and taping of the Kraft paper to the conveyor belt at a point several feet beyond the pouring station. Also, a cardboard dam is

constructed and attached to the conveyor belt at the front end of the paper liner. The initial distance from the pour station to the dam is a variable that can also affect the height uniformity of the billet.

The material used for the six trial runs of this study was BX 4002-4, which has a free-rise density of approximately 3.8 pounds per cubic foot. A discharge rate of about 30 pounds per minute was used on all six runs. Other processing parameters were varied from run to run as deemed necessary after considering the results of each previous run. The narrowest possible billet width (2-3/4 feet) was maintained, and targets for billet heights were only 3/4 to 1-1/2 feet so that material usage could be kept to a minimum. Conveyor velocities were varied from 2.0 to 4.0 feet per minute, conveyor angles from 3° to 8°, and traverse speed from 16 to 45 feet per minute.

The best results were obtained on the sixth (last) run of the study, when a discharge rate of 30.4 pounds per minute was used in conjunction with a conveyor velocity of 3.93 feet per minute. The conveyor angle was 5° and the traverse mechanism setup had a speed of 45 feet per minute, a stroke of about 2-1/4 feet, and 1.0-second dwell time at each end of the stroke. The resulting billet had a nearly uniform 9-inch height, both across its width and for its entire 10- to 12-foot length.

PROBLEMS ENCOUNTERED

The mixing head became frozen during the first trial run and the result was a bent mixing-head shaft, a ruined needle bearing, and a difficult clean-up job on the mixing head. It was determined that the failure was caused by insufficient purging of the calibration shots which were made just prior to the first billet run. The residual foam in the mixing head reacted and set up during the trial run. This caused the material to back up in the head and as it, in turn, started to react, the mixing head was finally frozen to a complete stop. The problem was resolved by shortening the distance (from approximately 30 feet to about 6 feet) from the solvent and air purge valves to the mixing head so that the solvent and air purges could reach the head much quicker and with greater force when the valves were actuated. After a new shaft and needle bearing were obtained this problem did not recur.

A problem encountered on later runs was the failure of the traverse limit switch to be actuated. This permitted the carriage and mixing head to travel past the pouring channel walls and to pour foam outside of the paper liner. The run had to be aborted when this occurred, as the foam dispensing had to be stopped while the carriage was manually returned to its correct position between the limit switch actuators. This problem was resolved when the limit switch actuating pins were lengthened and made of a metal more resistant to wear.

CONCLUSIONS

Six continuous billet runs were initiated during this feasibility study, and the basic practicality of using a conveyor system in conjunction with a foam dispensing machine was demonstrated. The quality of the billets obtained from these runs was far below that which would have been required if the original objective of this project had been pursued. However, the results were encouraging considering that the final combination of processing parameters probably did not even approach the optimum because of the limited number of runs made. Also, the foam material (BX 4002-4) was chosen because it was the least expensive and most readily available material, and not because it was known to be suitable for the intended use. The final billet showed much improvement over the previous ones, which indicated the potential of the equipment to produce quality billets if optimum material and processing techniques were employed.

Appendix A

PHOTOGRAPHS

Figure 1. Continuous Billet Fabrication System. The continuous billet conveyor mechanism is on the right, and the foam dispensing machine and control console are on the left. In Figures 1 and 2, the mixing head has not yet been attached to the traverse carriage and is seen in the more conventional location on the foam dispensing machine. The operator is at the control panel of the traverse mechanism where adjustments to carriage speed and dwell times are made.

Figure 2. Continuous Billet Conveyor Mechanism, with the cut-off saw in the foreground, and the Jennings foam machine in the background. The operator is at the foam machine control console.

Figure 3. One of the early billet runs shows the typical height variations which occur when the various processing parameters are not properly coordinated.

Figure 4. Sections of the final billet run are shown on the conveyor. This billet, having benefited from various processing improvements, displays a much greater uniformity in height than did any of the previous runs.

Figure 1. Continuous Billet Fabrication System

Figure 2. Continuous Billet Conveyor Mechanism, Cut-off Saw, and Foam Machine

Figure 3. One of Early Billet Runs, Showing Height Variations

Figure 4. Section of Final Billet Run, Showing More Uniform Height Resulting From Processing Improvements