GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT INITIATION

Date: ~~May 11, 1973~~

Project Title: Urethane Panel Study

Project No.: A-1531

Project Director: W. T. H. Windle

Sponsor: Chamberlain Manufacturing Corporation; Monroe Division

Effective . May 9, 1973 . . . . . Estimated to run until: . June 8, 1973 . . . . . .

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REPORTS REQUIRED: Final Report

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Assigned to . Sensor Systems . . . . . Division

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GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

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PROJECT TERMINATION

Date July 16, 1973

PROJECT TITLE: Urethane Panel Study

PROJECT NO: A-1531

PROJECT DIRECTOR: Mr. J. M. Akridge

SPONSOR: Chamberlain Manufacturing Corporation; Monroe, Georgia

TERMINATION EFFECTIVE: June 4, 1973 (Final Report submitted)

CHARGES SHOULD CLEAR ACCOUNTING BY: June 30, 1973

Contract Closeout Items Remaining: Final Invoice as soon as all charges clear.

Sensor Systems Division

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Georgia Institute of Technology
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FINAL REPORT

Project A-1531

URETHANE PANEL STUDY

by

John F. Kinney

May 1973

Prepared for
CHAMBERLAIN MANUFACTURING CORPORATION
MONROE DIVISION
MONROE, GEORGIA

URETHANE PANEL STUDY

Introduction

This report presents results from a study conducted by the Engineering Experiment Station at Georgia Tech for Chamberlain Manufacturing Co. The purpose of the study was to investigate the probable cause of variations in thickness (waviness) observed in urethane-foam motel structural panels produced by the company.

Background

On the existing urethane-panel production machine, the panel is formed on a conveyor by laying an 8 x 24 ft wooden backing directly on the conveyor belt, and placing aluminum studs on appropriate 2-ft centers. The sides of the panel are formed by two conveyors at right angles to the horizontal located 8 feet apart, protected by a strip of Kraft paper which feeds along the conveyor with the panel. The urethane mixing and spray head oscillates back and forth across the 8-foot-wide conveyor. Each pass of the spray head applies to the panel a section of urethane approximately 4 inches deep. The catalyst originally used was one that completed the foaming (rising) action in 3 to 5 seconds. As the panel advances down the machine, a cover of Kraft paper is applied before the urethane has time to set; this paper provides the backing for the panel.

The panels produced by this machine appear to be relatively uniform, but occasionally a peculiar waviness shows up in the cooled, cured wooden-backed panels; this degrades the quality of the panel, and reduces salability. The cause of this waviness is the primary concern of the present investigation.

Several possible causes of the waviness have been considered:

1. Irregularity of the feed.
2. Inconsistency of the mixture ratio.
3. Dirt, grease, or oil streaks on the wood panels.
4. Variation in temperature or cooling rate within the structure of the panel.

The last factor, variation in temperature, was felt to be the most likely cause, and the experimental work performed was aimed at investigating that possibility.

Experimental Work

On 4 May 1973, Georgia Tech personnel went to the Monroe plant of the Chamberlain Manufacturing Corp. with temperature measuring equipment.

At that time, Chamberlain had tried several different urethane formulations, on advice from EES personnel that slower rise-time foams should reduce the waving problem, and had decided to use the Upjohn 385D formula. All tests conducted on 4 May used the slower rising 385D (rise time 25 seconds). The slower rising urethane should produce better panels, permitting a more even distribution of the urethane before completion of the reaction. Chamberlain personnel appeared to be satisfied with the panel produced by the 385D material. A relatively minor deviation from flatness appeared approximately 6 inches down stream from each stud (1/4 the distance between studs) which appeared to be a depression in the surface. This will be discussed later.

The machine with the 385D formula was set up, without heating the plattens, and chromel-alumel thermocouples were located at various points ahead of the sprayhead, such that the temperature rise for various locations could be measured. Thermocouple readings (32°F cold junction) were recorded on a Sandborn Model 320 two-channel recorder. The data were reduced from the recorder charts and plotted as Figure 1.

Discussion

Figure 1 shows results from the six test runs that were made; in each plot, temperature observed from the thermocouples is shown as a function of time. For each run, two thermocouples were embedded in the material at locations described in the captions below the plots. Run A shows results for thermocouples placed 18 inches in from the side, one directly on a stud and one 4½ inches away from the stud; the lower temperature in the immediate vicinity of the stud is apparent. Run B is a similiar measurement with one thermocouple on the board and the other at mid-depth 4½ inches from a stud; the lower temperature near the board is apparent. For Runs C and D, the thermocouples were 2½ ft from the side, one on the paper in the middle of

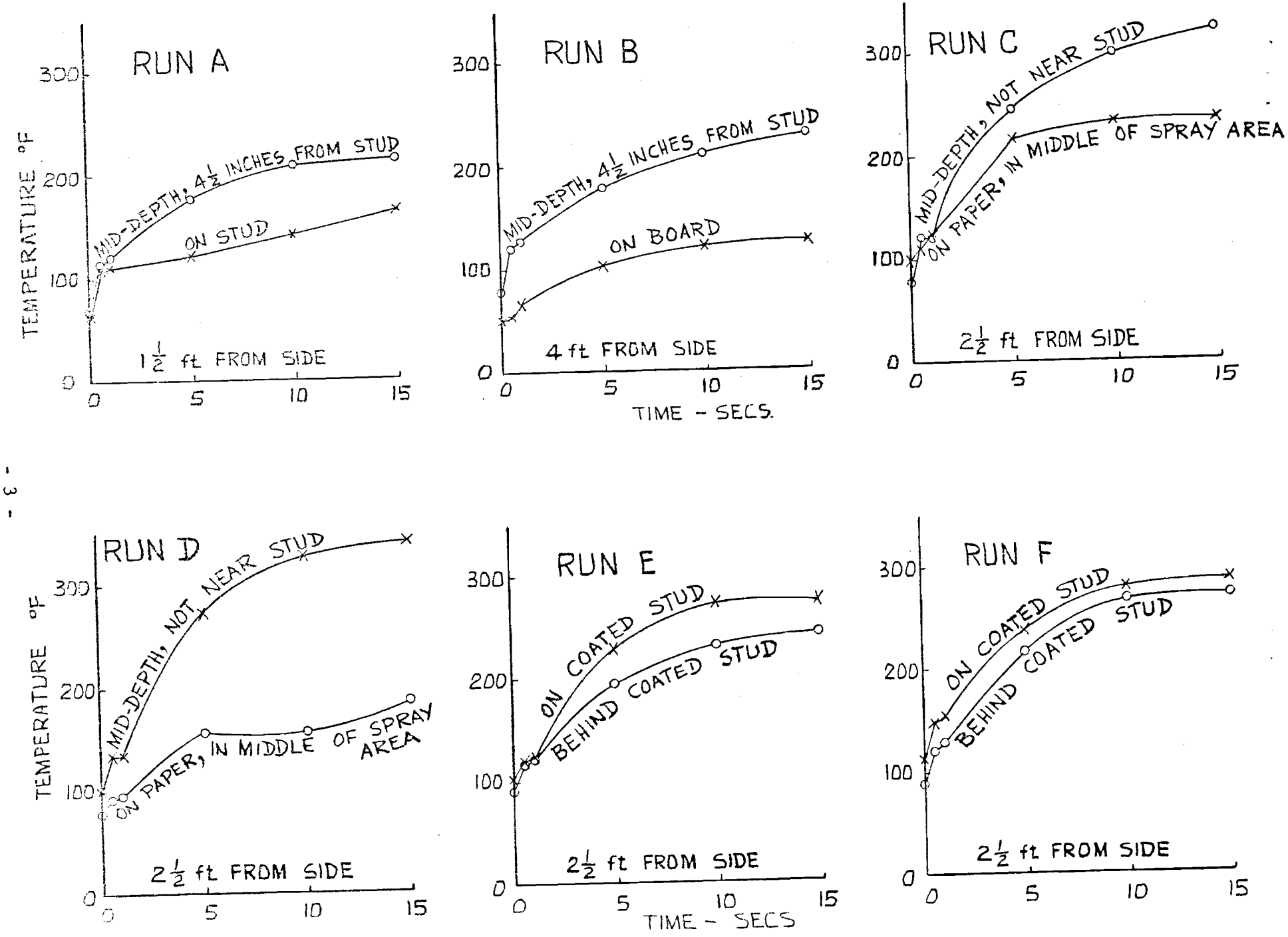

Figure 1. Temperature versus time for six tests.

the spray area and the other at an isolated mid-depth location not near a stud. In each case, the isolated thermocouple shows a much higher temperature curve, reaching 325° in one case and 340° in the other. These curves are believed characteristic of the isolated reaction mass not near any foreign body. Comparison with the "on paper" curves in Runs C and D shows the reaction to be much cooler near the paper. (The considerable difference in the two "on paper" curves is believed to be associated with the way the thrmocouples were attached to the paper. The adhesive tape fixing the thermocouple position was located approximately 1/2 inch away from the thermocouple junction, and the spray striking the junction could have caused the junction to move slightly off the paper in Run C, thus putting the junction in a region of somewhat higher temperature.) Comparison of the "isolated mid-depth" curves in Runs C and D with the results for locations on the stud, on the board, and on the paper in Runs A - D plainly shows that the reaction temperature is greatly lowered in the vicinity of these "foreign" bodies, which serve as heat sinks. In particular, on the stud the temperature is about half that of the isolated reaction mass. This result is considered significant.

Runs E and F were taken with pre-coated studs, that is, studs to which a thin coat of urethane had been sprayed and allowed to cool prior to the tests. Comparison of the curves in E and F for thermocouples on the coated stud with the curve in Run A for an uncoated stud shows a considerably higher reaction temperature with the coating, about 275° to 285°, versus 160° without the coating, for the 15-second readings.

Also of significance is the temperature indicated by the second thermocouple in Tests E and F, which was located behind the stud (away from the head). Thus, the urethane was sprayed through the openings in the stud to the area where these thermocouples were located. The reaction temperature in this area is lower than on the coated stud, but of the order of the mid-plane temperatures in Tests A and B, which were near other heat sinks, and 75°-90°F below the mid-plane temperatures half-way between the studs.

This temperature reduction downstream of the stud may explain the depression mentioned earlier, and is a result of spraying through the openings in the stud.

In summary, the test runs clearly show that the temperature of the reaction mass is greatly reduced in the vicinity of any "foreign" body which can act as a heat sink, such as the stud, the board, and the paper. They further indicate that pre-coating a foreign body such as a stud with a thin layer of the urethane to serve as an insulator is an effective technique for avoiding the heat sink effect. Further, Runs E and F show that a significant cooling occurs behind the coated stud.

In order to interpret the effect of the observed lowering of reaction temperature, we may note that the rate of a chemical reaction increases with increase of temperature, in many cases doubling with each $10^{\circ}C$ ($18^{\circ}F$) rise in temperature. The time for complete reaction at $250^{\circ}F$ may be estimated, assuming that the reaction goes to completion in 25 seconds at 350° F. In this case, the difference in temperature is $100^{\circ}F$, and

$$\frac{t_{250}}{t_{350}} = 2^{100/18} = 2^{5.6} \text{ , or}$$

$$t_{250} = 25(2^{5.6}) = 1212 \text{ seconds} \approx 20 \text{ minutes.}$$

This sample calculation makes clear that a very much longer reaction time will prevail in the vicinity of the studs.

Conclusions

It is concluded that

1. The uncoated stud significantly depresses the reaction temperature of the urethane mixture in its vicinity.
2. The temperature of the reaction is also depressed at other surfaces but the effect is uniform, since the front, back, etc. are area-extensive surfaces.
3. Use of the pre-coated studs reduced the cooling effect of the stud on the reaction temperature.

Recommendations

It is recommended that:

1. The studs be pre-coated with a thin coat of the urethane, as long as an unheated panel-forming machine is used.
2. A multiple spray nozzle be used, at least during the period that the urethane is being sprayed through the studs to reduce the throttling effect of spraying through the stud.

3. The stud be placed as close to the previous foamed section as possible. This will lessen the quantity of mixture which must be sprayed through the stud openings.

4. The effect of slowing down the traverse rate when foaming through a stud while still maintaining the same mixture flow rate should be investigated. This should increase the quantity which reaches the space behind the stud, and partially compensate for the chilling effect and the masking effect of the stud, resulting in less depression behind the stud.

5. The spray nozzle or nozzles should be tilted slightly upward to compensate for the foam running before it begins to set.