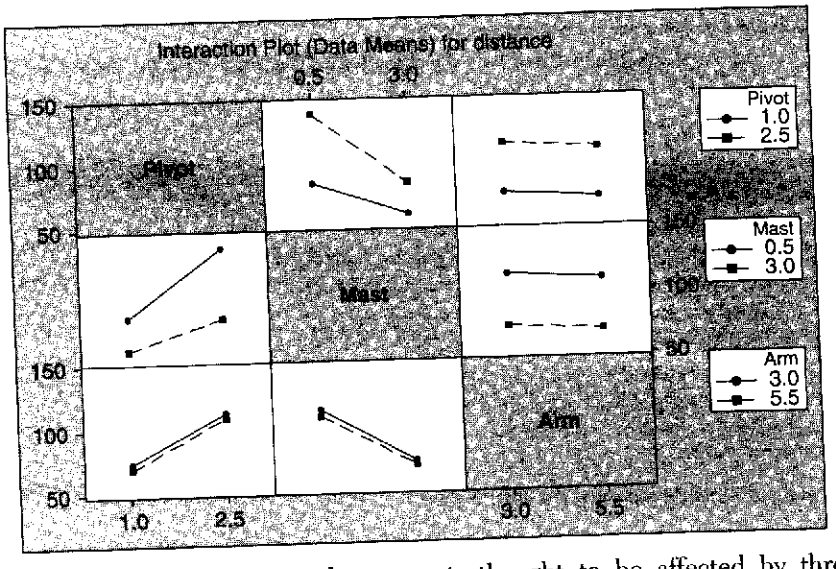

7. The yield from a chemical process is thought to be affected by three process conditions: temperature, pressure, and time. Process engineering has determined that reasonable operating ranges are 120°C and 150°C for temperature, 800 psi and 1,000 psi for pressure, and 15 minutes and 20 minutes. for time. Develop a 2^3 full-factorial design with one replication.
8. Develop an L_4 Taguchi orthogonal array as an alternative to the full-factorial design in Problem 7. Discuss the tradeoffs in using the L_4 design rather than the 2^3 design.

CASE STUDY 7.1: *The Case of the Variable Laminates*

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A plywood manufacturer has asked for your assistance in solving a problem in the log-peeling operation. The peeling process consists of soaking debarked logs in a hot bath, fixing the logs in chucks, and rapidly spinning them while shaving off a continuous thin section called a lamination with a sharp knife blade. The laminations are then cut into sheets to be laid up, glued, and pressed into plywood sheets. The manufacturer is having difficulty maintaining a controlled thickness when peeling laminations from a log.

Discussions with engineering and the process operators indicate that four variables are related to laminate thickness: soak time, soak temperature, knife pressure, and knife setting. The knife setting is pretty straight forward and is not felt to be a source of variation in the process. Specifications call for logs to be soaked for 60 minutes, but no process control for this process is in place. Some logs are peeled after as little as 30 minutes soak time.

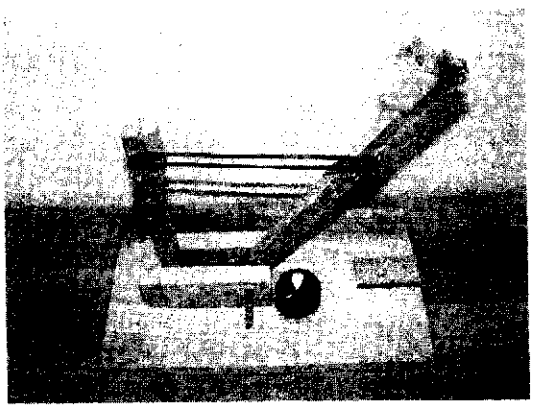
The operators believe that this causes some of the variation, but they are under the gun to keep the peeler busy, even if it means compromising on the soak time. The engineers feel that knife pressure may contribute to the thickness variation. Knife pressure setting is not standardized—operators set it between 250 psi and 300 psi based on their experience. Soak temperature varies between 150 degrees and 200 degrees, depending upon how much bark has accumulated around the heating coils.

Thickness measurements are made every 15 minutes on the laminate. The variation does not seem to follow a particular pattern.

Design an experiment that will assist the process engineers in determining what actions to take to reduce laminate thickness variation. Provide them with your assessment of the causes of the variation and how to use the results of the experiment to define the optimal operating conditions for the process.

EXERCISES AND ACTIVITIES

1. The Catapult Exercise



A catapult can be used to teach experimental design in the classroom. The one shown in this exercise was built from half-inch thick red oak. The mast is 7.5 inches tall and the arm is 11 inches long. The base is 12 inches by 7 inches. The brakes are two layers of self-adhesive weather stripping. The cradle is a piece of oak with a 1.25-inch hole that does not go completely through the piece. Plans for the catapult may be found in Deane & Burgess (1998). The balls are ping pong balls covered with self-adhesive Velcro. There are three positions for the rubber band on the arm and the mast. These are partially opened eye bolts. There are three positions for the hinge location. The hinge is a hardwood dowel. Construction time is approximately one hour using a table saw and a hand drill or drill press.