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Review

Ironability of a three-layered polymer coated steel Part 1: Experimental investigation

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ABSTRACT

Food and beverage containers are common in Western society, with over one billion beverage containers produced annually in the United States alone. One of the environmental concerns associated with the manufacture of these products is the production of volatile organic compounds during the coating of the can interior with a protective polymer. This issue can be resolved by using pre-laminated steels as a base stock, so long as the polymer coating is robust and can survive the can making operation. Recognizing that ironing is the most demanding metal forming operation in can making, a series of formability tests were conducted on novel laminated polymer-coated steel specimens using an ironing simulator. It was found that the laminate-coated steels could display good ironability with tin-free steel substrates. The surface quality was evaluated and related to process parameters, of which the ironing angle was determined as the most important factor. With proper tooling and layer design, polymer laminate base stocks have been demonstrated to be suitable for drawn and ironed containers.

Contents

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1. Introduction

The can manufacturing industry is of enormous scale worldwide. Can makers are extremely competitive, and often calculate the cost of a can to millionths of a cent because of the high production volume. Process modifications which increase or decrease the cost per can even marginally can have a significant impact on the industry. Metal beverage cans first began being produced over 150 years ago. Today, essentially all beverage containers in the United States are manufactured from aluminum, whereas beverage cans made in Europe and Asia are approximately 55% steel, and 45% aluminum alloy. Food containers are still mostly made from steel stock in both Europe and North America.

The metal forming processes for producing most of the food and beverage containers uses essentially the manufacturing steps shown in Fig. 1. A circular blank is punched from rolled sheet stock, redrawn, ironed in two or three stages, domed, necked, filled and seamed. In between the doming and necking operations, the cans are placed in a wash/coat process which removes the residue lubricants from metal forming (which are invariably toxic in large amounts) and applies a base coating to the metal. The cans are then subjected to one or more spray operations to present a suitable surface to the can contents. The spray often consists of a polymer resin in a carrier such as methyl ethyl ketone, which is then boiled off as a volatile organic compound (VOC). This is a significant environmental and health concern, and the reduction or elimination of VOC production is a major goal of the canmaking industry.

An alternative to the traditional manufacturing process is to use thermoplastic or thermoset laminated rolled steels as base stocks. Such materials consist of pre-heated steel coils that are sandwiched between one or two sheets of polymer. The heated sheets are then immediately quenched, which yields a strong bond between the layers. Such polymer-coated steels were investigated by Jaworski and Schmid (1999) and Jaworski et al. (1999), and found to be suitable for ironing with carefully controlled conditions.

A novel multi-layer polymer coated steel has been developed for container applications. This material presents an interesting extension to previous research on polymer laminated steel in ironing, and offers several advantages over the previous material, including:

- The polymer bonded to the steel can be selected to maximize adhesion at this interface.
- The exterior surface can incorporate desired permeability to aid in decoration.

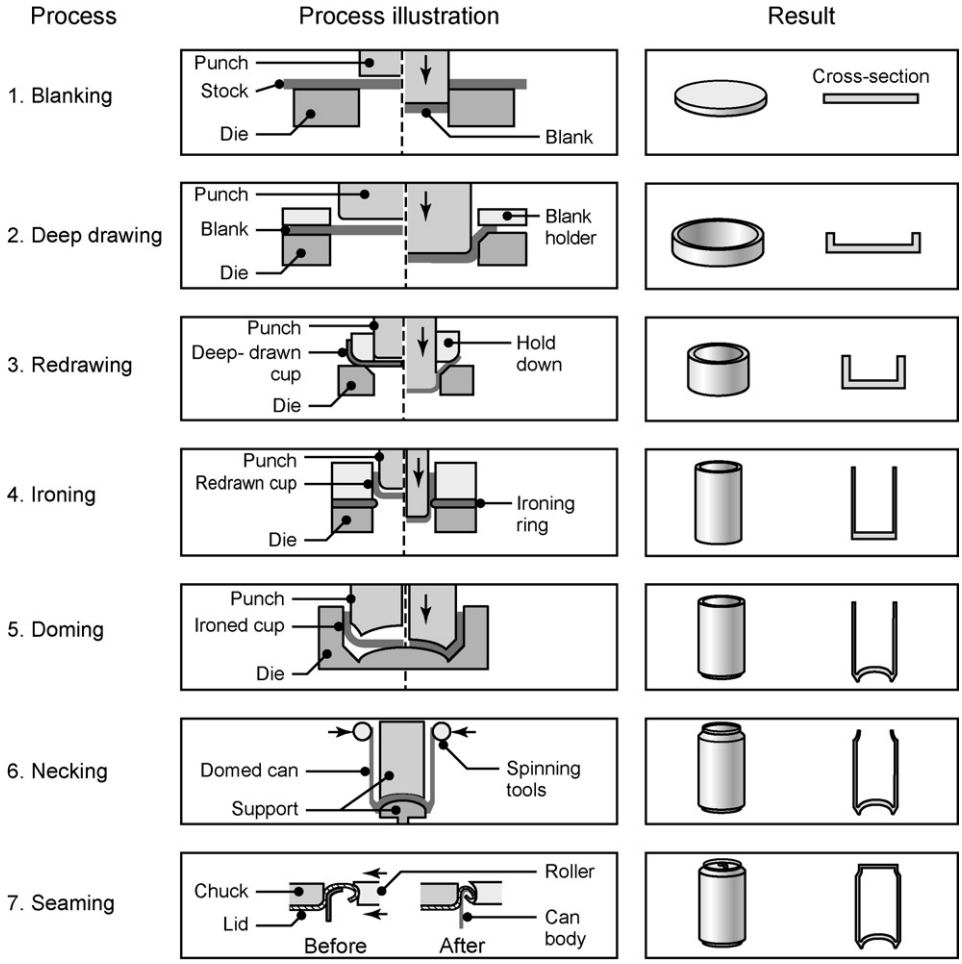

Fig. 1 – The metal forming steps involved in can manufacture. ***Source:*** **Kalpakjian and Schmid (2006).**