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DEVELOPMENT OF A FILM-INSERT MOLDING PROCESS FOR AN AUTOMOTIVE PART

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Abstract: *Green manufacturing is a requirement for reducing pollution and saving natural resources. This paper presents the development of an environmental friendly manufacturing process for making an automotive radiator grill. The new process applies film-insert moulding technology replacing for the traditional manufacturing process that the chrome plating and painting stages are involved. The green manufacturing approach not only avoids the environmental pollution, but also reduces the manufacturing cost and capital investment. The results show that the cost of the radiator grill made by film-insert moulding method reduces 7.8 % in comparison to the one made by a traditional decorating method.*
Key words: *film-insert moulding, injection moulding, radiator grill, green manufacturing process*

1. INTRODUCTION

Front radiator grill is one of the important components in an automobile, in terms not only technical aspect, but also aesthetic appearance. It is usually made by plastic injection moulding followed by a chrome plating process for decorating. This traditional manufacturing process is becoming high cost and harmful to the environment, nowadays (Sherman, 2004). The use of bright film laminated to an ABS substrate allows automotive makers to produce chrome-like plastic parts without the need for post-moulding and chrome plating. The new manufacturing technique that can replace the traditional moulding and decorating plastic part is film-insert moulding (FIM). In literature, the studies on film insert moulding techniques mainly focus on film thickness distribution after forming (Kim et al., 2009), thermoviscoelastic behaviour of film-insert moulded parts (Kim et al., 2008) and interfacial characteristics of film insert (Leong et al., 2006). Although laminate insert moulding and FIM for manufacturing automotive panel instrument have been being studied and applied, some practical problems still exist in particular circumstances. Our study develops a manufacturing process for making a chrome-like radiator grill by applying film-insert moulding technique. New advanced technology and automation as well as practical solutions that reduce the defects due to the complication of inserted films have been utilized effectively.

2. THE APPLICATION OF FILM-INSERT MOLDING FOR MANUFACTURING A CHROME-LIKE RADIATOR GRILL

FIM, a form of in-mould decoration, has moved on quickly since its introduction several years ago. New developments in material technology and the wider acceptance of technology by both designers and manufacturers have helped FIM to expand rapidly. FIM was originally developed as an innovative method of plastic product decoration replacing for lengthy and costly traditional post-mould techniques. Figure 1 shows a comparison between a traditional manufacturing process with coating and a FIM technology. It can be seen that the traditional process prolongs the cycle time and consists of some environmentally harmful stages. On the contrary, FIM shortens the manufacturing process and avoids the plating and painting processes that cause air and water pollution. FIM involves four steps: film making, forming, trimming and moulding. Generally, the film in the form of sheet coil is made and supported by a professional manufacture. The sheet is then transferred to a vacuum and thermoforming press where it is formed to the exact shape that the outer side of film becomes the outer side of the finished component. After being formed, these 3D films must be cut out of the waste or undesired material in order to create individual components with desired size. Finally, they are inserted in a female mould cavity, where the molten polymer is injected behind the films. The bonding between the two materials creates a solid and final decorated part that is ready for use.

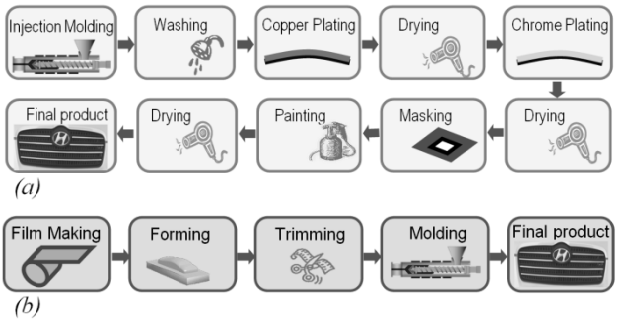

Fig. 1. Traditional process of chrome plating for plastic part (a) versus in-mould decorating or film-insert molding (b)

Nowadays, FIM technique has been widely used in automotive industry (Sherman, 2004; Zöllner , 2007; Kim et al., 2008) for decorating interior and exterior automotive parts such as fascia, IP bezel, bumper, roof strip, instrument panel, and rocker panel by some of the leading automakers such as Crysler, Ford, GM, Honda, Mercedes, Volkswagen and Volvo. The radiator grill made by FIM (Fig. 2) was first introduced in the model Verna at the end of the year 2008 by Hyundai Motor. Previously, the grille was chrome plated followed by painting. FIM technology with bright film is replacing two processes with one green manufacturing process. The selected inserted film is a Fluorex® bright film; it passes all material requirements such as UV resistance, scratch resistance and cleanability with high pressure power washing equipment.

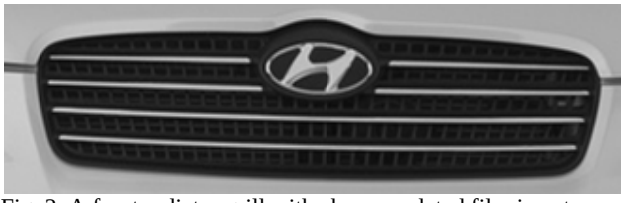

Fig. 2. A front radiator grill with chrome- plated film inserts made by FIM method

The manufacturing processes mainly perform automatically from film forming, film trimming, handling and moulding (see Fig. 3). The radiator grill was produced at Hanguk Mold (Korea) company by the development and cooperation with Hyundai Motor, ECOPLASTIC and University of Ulsan.

(a) *(b)*

Fig. 3. Articulating robot (a) picks up, holds the inserted films in places them in the female mold cavity (b)

3. CHALLENGES AND DEVELOPMENT OF SOLUTIONS FOR REDUCING THE DEFECTS

One of the most important considerations when using FIM technology is how the films position and hold in place in the mould cavity during injection moulding process. The worker assembles six inserted films to the robot's arm tool. Subsequently, the robot holds the films with suction by vacuum, moves to the female mould cavity, places the films in desired positions and releases the vacuum. Resin is injected to the backside of inserted film. The momentum of the resin flow tends to push the inserted film move out of desired location, so it is necessary to prevent this displacement in order to avoid overlap and dislocation phenomena (see Fig. 4). Variables that influence these defects are the number of gating points, the rate of volumetric flow for each injection point and the design of the injection points. Poor injection control results in inserted film distortion or dislocation. To avoid undesired displacement of the inserted films, the initial injection speed and injection rate should be low (Osswald, 2008). This leads to a prolongation of filling time, and short shot can occur due to a higher viscosity.

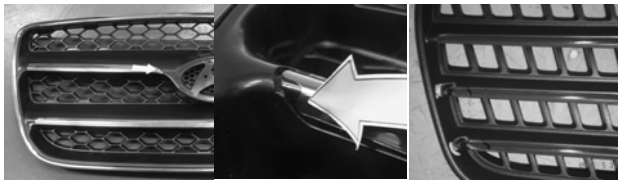

Fig. 4. Overlap phenomena occurring in the radiator grill.

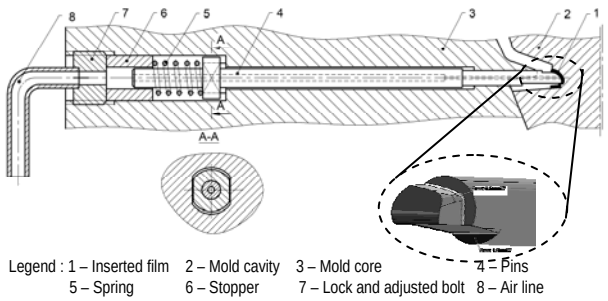

Fig. 5. Retention mechanism for fixing films in the mould

At the beginning, eight gates were designed at the both sides (left and right) of the grill for reducing the initial injection speed and injection rate at each gate as well as momentum of the resin flow in order to avoid undesired displacement of the inserted film. All the attempts were made including changing the process parameters, adjusting and checking electrostatic state; however, the defective rate caused by overlap phenomena was up to around 20%. New improvement was done by changing the films holding method by electrostatic to adaptive retention pins mechanism as shown in Fig. 5. When the mould closes, the pin pushes the inserted film against the mold cavity's surface securely by spring force. After the resin reaches the pins' tip, they finish their function and retract for avoiding imprinted holes on the product. This retention mechanism allows the injection speed to increase as a usual injection moulding method. Also, multi-gate was replaced by sing gate located at the center of the molded part in order to avoid undesired weld lines at the middle of the product.

4. RESULTS

After applying the new retention mechanism using pins and springs, the defect rate caused by overlap significantly reduced from 20% to 3%. This defect rate is acceptable in practical injection moulding. The hot runner and single gate at the center save material and avoid the undesired weld lines, respectively. Holding the film with electrostatic was altered by holding with the mechanical retention system. This change allows the increment of injection pressure and injection rate. Consequently, filling time or cycle time is reduced, and it is not necessary to use any special molding process. Moreover, the quality of the molded part is also improved. The manufacturing cost per product reduces 7.8 % compared to the traditional process. The benefit of FIM technique for manufacturing the grill is more than that if the environmental cost is included. This innovative technology was recognized as a finalist in SPE Automotive Division Innovation Awards Program.

5. CONCLUSIONS

FIM is a relative new moulding technique that reduces the manufacturing cost, shortens the manufacturing time and helps to protect the environment in comparison to traditional decoration method. Chrome-plated film insert molding was applied successfully for manufacturing the automotive radiator grill. Other exterior parts in automotive industry will be the further object for applying FIM technology. The successful application of FIM for manufacturing of the automotive radiator grill contributes to reduce the manufacturing cost and indirectly to make the car to be friendly to the environment.

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