CORROSION SCIENCE AND TECHNOLOGY, Vol.3, No.4(2004), pp.172~177

Polyester Film Laminating Technology for Chip Condenser

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Biaxially oriented polyethylene terephthalate copolymer(BO – PET)film laminated aluminiums have been applied for chip condenser case. The BO PET film is characterized by high molecular which gives high corrosion resistance, good adhesion and high heat resistance.
The higher orientation lowers formability of the film. So, optimum orientation has to be controlled during the laminating process.
And to confirm the adhesion between BO PET and aluminium and to guarantee the formability of PET laminated aluminums, we have controlled the chromium oxides weight on the aluminium and laminating condition (laminating temperature, soaking temperature and lag time after nip roll and quenching conditions)
This paper discusses the effect of the laminating conditions on the formability of laminated aluminums.
As results, it is clear that the orientation of the BO PET film decreased with an increase in the strip temperature. When the film temperature is over the melting point of the film, its orientation drastically decreased.

Keywords *: BO – PET, laminating condition, orientation, formability, chemical treatment*

1. Introduction

In general, the epoxy coated aluminums have been applied for chip condenser. But those coated aluminum sheets are considered to be disagreeable for the environment and formability point of view because the lacquer coating process generates plenty of discharged carbon dioxide and the lacquer coated aluminums are not good for deep drawing for the manufacture of the chip condenser.

In place of the coated aluminiums, polyester film laminated aluminium sheets have been developed. Biaxially oriented polyethylene terephthalate (BO – PET)co – polymer has been applied because of its high corrosion, heat resistance and good adhesion. The BO – PET film consists of the two layers comprising an inner layer of a substantially non-crystalline linear heat sealable polyester having a melting point below 200℃ and an outer layer of a biaxially oriented linear polyester having a crystallinity greater than 30% and having a melting point above 250℃.

The high molecular orientation of the film gives high corrosion resistance but lowers formability (especially deep drawing). So a degree of the orientation has to be optimized to obtain both properties. The orientation of laminated film is controlled by laminating and post heating temperatures.

This paper discusses the effect of the laminating conditions on the formability of laminated aluminums.

2. Experimental

2.1 Aluminium substrates

Aluminiums(H 1100series) for lamination have to be taken chemical treatment in order to advance the adhesion between the substrates and PET film. The optimum weights of chrome oxide on the surface of the aluminium for lamination are 3-5 mg/m^2.

2.2 Film

The structure of the used film for lamination is below

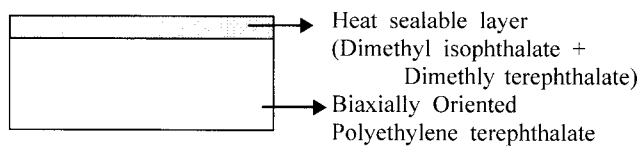


Fig. 1. the structure of polyester film for lamination

The applied films are cast coextruded materials. The outer layer is a biaxially oriented polyethylene terephthalate having a crystallinity 30 – 50 % and a melting point above 250℃.

The heat sealable layer is a substantially non crystalline linear polyester having a softening point below 200℃ and

having a melting point between 150℃ and 250℃, which is lower than the melting point of outer film.

And the thickness of the inner layer film is normally in the region of 10 – 20 % of the total film thickness.

2.3 Process

The process is carried out in a number of stages, see Fig. 2. In the first stage, there is a chemical treatment on the surface of aluminium. To confirm the adhesion between aluminium and polyester film, the chrome oxides on the surface of the aluminum are controlled to 3 – 5 mg/m^2.

In the second stage, the aluminium is preheated by induction heating roll to the temperature above the softening point of the inner polyester film, preferably above the melting point but below the melting point of the outer layer film.

In the third stage, the film and aluminium strip are brought together to the laminting nip rolls to establish an intimate and uniform wrinkle free contact. At this stage the outer layer of film must not exceed its melting point in order to prevent adhesion to the laminating rolls.

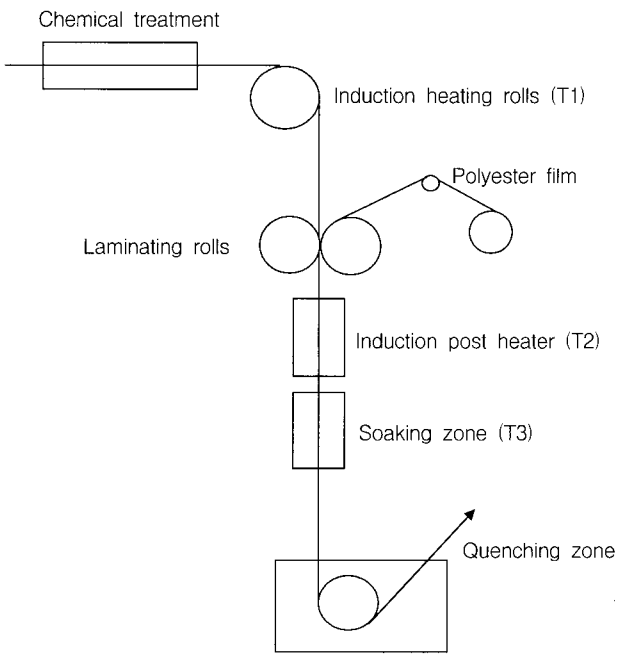


Fig. 2. Process schematic

In the fourth stage, the resultant laminate is reheated (postheated) by induction heater heating the aluminium to a temperature above the melting point of both film but the outer surface of biaxially oriented polyester should be kept below the melting point of the outer layer film to control the extent of melting parts.

In the fifth stage, the 'soaking zone', In order to achieve the interaction between the aluminium and the inner polyester layer for the adhesion of the laminate, the temperature of the laminate is maintained above the recrystallisation temperature of the polyester films for 1 ~2 seconds.

In the final stage, the laminate should be quenched before the polyester film could recrystallize to any extent, so the polymeric structures of the respective film established in fourth stage are retained.

2.4 Obersevation of laminated film

The laminated films were sliced in 3㎛ in thickness after dissolving the aluminum in a 5 %HCl solution and the cross section of the film observed by polarizing microscope.

2.5 Formability of laminate

The PET laminated aluminiums have been tested at the process making condenser case. The forming ratio of cupping chip condenser case is over 1.5 (Length/Depth)

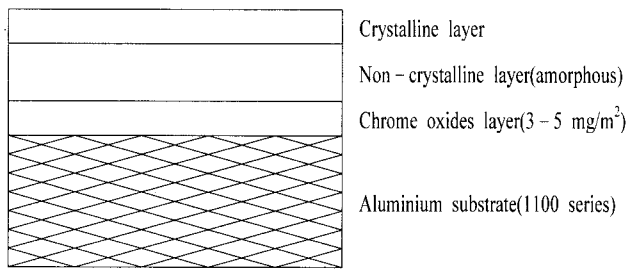


Fig. 3. Schematic cross-sectional diagram of the PET film laminated aluminium

3. Results

3.1 Effects of chrome oxides on film adhesion

The relation between chrome oxides on the aluminium surface and adhesion is that ;

Chrome oxides (mg/m^2)	0	1	2	3	4	5	6	7
Adhesion (kg.f/25 mm)	3.6	4.2	7.5	10.6	12.7	13.4	11.3	9.5
	Not acceptable			Acceptable			Not acceptable	

When the chrome oxide weight on the surface of aluminium is below 3 mg/m^2, the adhesion of between polyester film and aluminium is not acceptable to form condenser case.

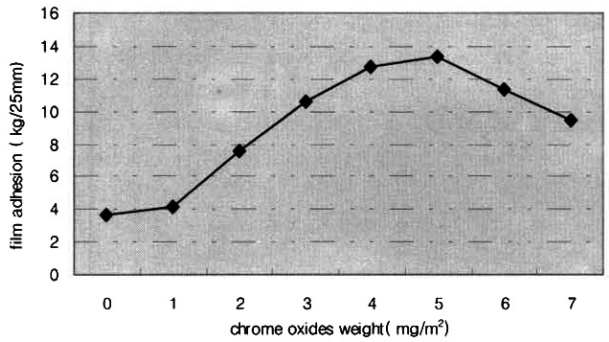
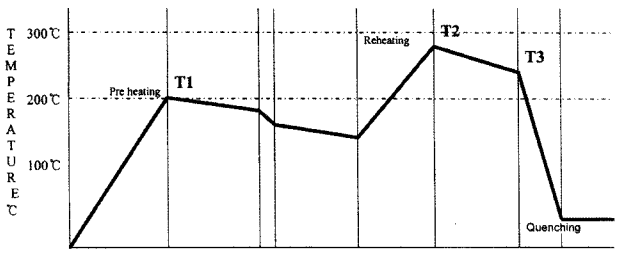


Fig. 5. Relationship between chrome oxides and film adhesion

And when the chrome oxides weight is over 6 mg/m^2, the colour of the aluminium surface is changed to yellowish. The colour of the aluminium surface for condenser should be clear. The acceptable adhesion for forming condenser case is over 10 kg/25 mm.

So the optimum weights of chrome oxides on the surface of the aluminium for lamination are 3-5 mg/m^2.

3.2 Temperature distribution of laminating process



- T1: temperature of aluminium before nip rolls
- T2: reheating temperature
- T3: soaking temperature
- Quenching: room temperature

Fig. 6. Temperature distribution of laminating process

Fig. 3 shows the temperature distribution of laminating process. The aluminum is pre heated to the temperature T1 above the softening point of the inner heatsealable layer, preferably above the melting point of the inner layer, but below the melting point of the outer BO PET. T1 is about 200℃.

T2 is the reheating temperature of laminated aluminum by induction heating(indirection). The temperature of aluminium reaches above the melting point of the outer BO PET, but the outer surface of the BO PET layer should be kept below the melting point of the outer BO PET to control the extent of melting in the outer BO PET.

When the outer surface temperature of the BO PET is over the its melting point, its orientation disappeared and its formability decreased drastically.

T3 is the soaking temperature of laminated aluminium to achieve the interaction between aluminium and polyester film.

After 1~2 seconds in soak, the laminates should be quenched rapidly and uniformly. And the quenching should be accomplished by curtains of cold water directed at the strip. To prevent polyester recrystallisation, the laminates should be quenched by the temperature above 200℃, and to prevent blistering the laminates should be quenched by the temperature below melting point of polyester.

3.3 Effects of reheating temperature on the orientation of laminated films(outer BO PET)

Orientation of films was measured by X-ray diffractometer(Cu Ka radiation 40 kv, 20 mA). The orientation of the laminated film was defined by the (100)plane intensity ratio of after and before lamination.

Fig. 6 shows the relationship between reheated strip temperature and the orientation of the laminated film. The film orientation after lamination has hardly decreased in reheated strip temperature range from 210℃ to 240℃. However when the temperature of the reheated laminates is 240℃ or more (around the melting temperature of the outer BO PET layer), the laminated film orientation decreased rapidly and became constant near in temperature over 270℃.

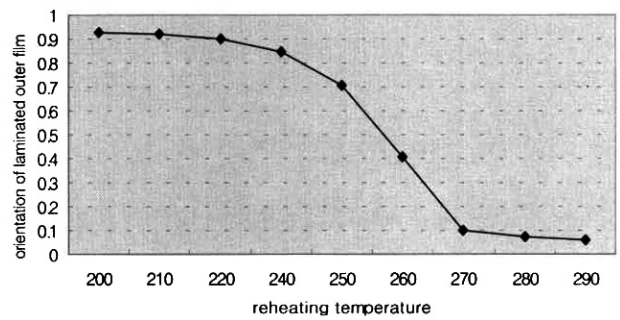
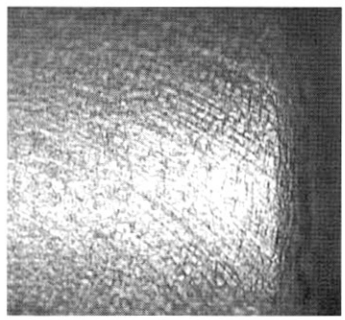
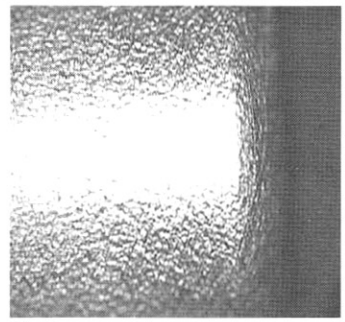
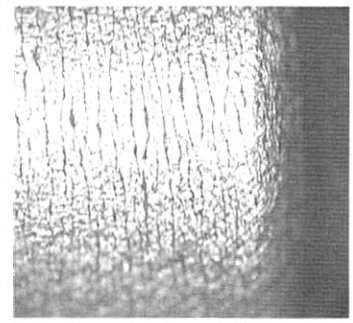
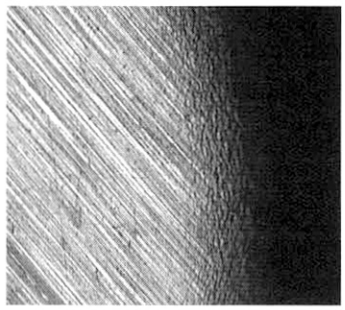
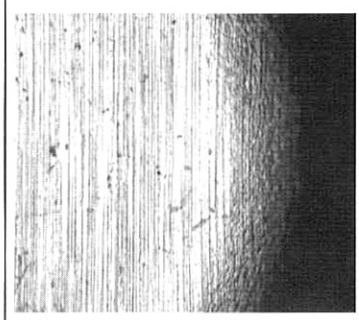
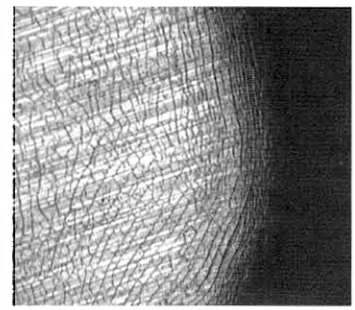
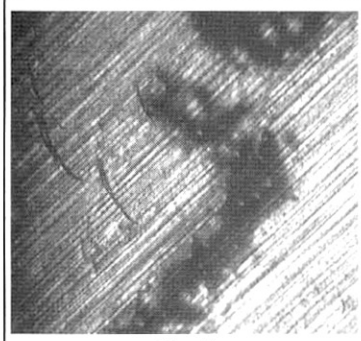
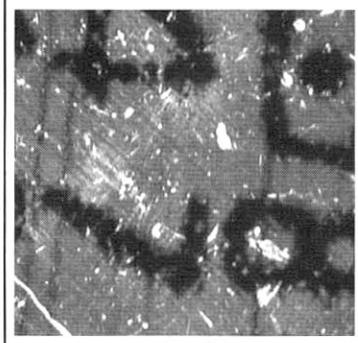
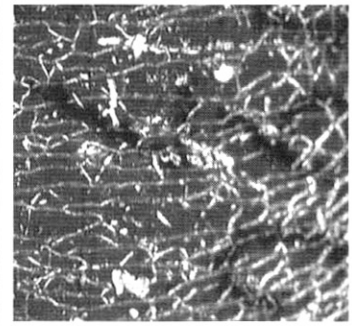


Fig. 7. Relationship between reheated strip temperature and orientation of film

3.4 Effects of reheating temperature on the formalities of condenser case

Fig. 8 shows the effects of the temperature(T2) of the reheated aluminiums on the formability, lacquerability, the orientation and adhesion of laminated film and reflow test of chip condenser cases.

When the reheating temperature(T2) is above the melting point of the inner heat sealable layer and below the softening point of the outer BO PET, the interactions between aluminum and polyester film are not sufficient to have enough adhesion for making a condenser case and

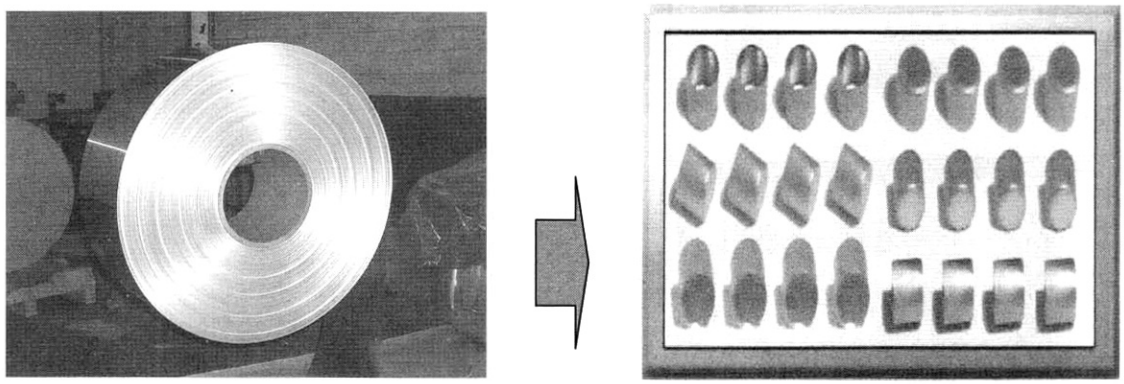
	Condition A	Condition B	Condition C
Lamianted film orientation	0.86 – 0.94	0.1 – 0.4	0.05 below
Laminated film adhesion	4.7 kg.f / 25 mm	12.5 kg.f / 25 mm	12.6 kg.f / 25 mm
Condenser case wall	 Good	 Good	 Poor
Condenser case bottom	 Good	 Good	 Poor
Lacquerability on case	 Good	 Good	 Poor
Reflow test (250℃ x 30 sec)	Poor (Film heat shrinkage on case wall)	Good	Good

• Condition A : melting point of the inner heat sealable layer 〈 T2 〈 softening point of the outer BO PET
• Condition B : melting point of the outer BO PET 〈 T2 〈 oxidative degradation point of the inner heatsealable layer
• Condition C: oxidative degradation point of the inner layer polyester 〈 T2

Fig. 8. Effects of reheating temperature on the formabilities of condenser case, Microscope X 50 after forming condenser case # 6353

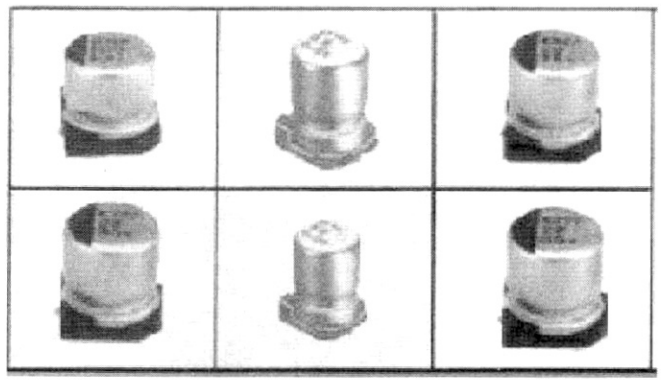
the weak film adhesion(about 4.7 kg.f / 25 mm) causes to shrink the polyester film on the condenser case wall in the reflow test.

And when the reheating temperature is over the



Polyester film laminated Aluminium

Chip condenser case



Polyester film laminated chip condenser

oxidative degradation point of the inner layer polyester, the total thickness of the laminated film becomes non-crystalline layer(orientation ratio after / before lamination : below 0.05).

Though its adhesion is so good (over 10 kg.f / 25 mm) in codition C, its formabilitiy is poor and the original properties of the polyester disappear. In the process of cupping condenser case, the cracks on the condenser case wall are easily happened.

Finally provided the reheating temperature is over the melting point of the outer BO PET but below the oxidative degradation point of the inner heatsealable layer and the outer surface of the outer layer film is maintained below its melting point, its laminate has a good formability, good lacquerability, good heat resistance (reflow test) and good adhesion to make condenser cases.

The residual proportion of non-crystalline(melted) and biaxially oriented(non-melted) polyester in outer layer controls the tensile properties of the formability in cupping condenser case(deep drawing). The amount of retained biaxially orientation is inversely related to deep drawing and should be controlled to match the intended forming demands. If the orientation ratio of after/before lamination is 0.1 – 0.4, its laminated aluminium can be accepted to make a condenser case.

4. Conclusions

The relations between the condition of the polyester laminating on aluminium and the formabilities of its laminates were studied and the following results were abtained

1) As the reheating temperature increases, the amorphous layer(non-crystalline) thickens and the degree of orientation in laminated BO PET film decreases.

2) The residul orientation after lamination is inversely related to deep drawing and should be controlled to match the intended forming demands.

3) The transition of the film structure affects on the properties of PET film. So it is very important to control the laminating temperature(specially, reheating) on the lamianting process

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