Influence of water cooling temperature on film stretchability, superstructure in double bubble tubular process of linear low density polyethylene

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Abstract

It is a common concept for film production maker that the purpose of cooling water process of molten resin extruded from circular die in the double bubble tubular process is to restrain crystallization and to obtain good film stretchability or good film quality. But the report as to the effect of crystallization restraint on stretchability and physical properties was hardly reported and not clarified. It was found from previous report [1] that the change of cooling water temperature of water cooled film of random polypropylene(r-PP) in the double bubble tubular film process hardly influenced on film stretchability and physical properties. Therefore stretched film of r-PP having approximately same physical properties industrially can be produced, even if the cooling water temperature was changed by season factor and so on.
This presentation reports the relationship among the process conditions, the film stretchability, the film superstructure change and the film physical properties in the double bubble tubular process of linear low density polyethylene (LLDPE) used widely like r-PP. From this investigation, it was clarified that the rise of cooling water temperature influenced stretching stress and stretched film physical properties (shrinkage) of LLDPE. But this investigation also indicates that producing the stretched film of LLDPE having stable physical properties industrially can be accomplished by controlling the stretching stress.

1 Introduction

The research of the double bubble tubular film was done in terms of the processability, the materials characteristics, and film physical properties as a basic research of product development[2 to 4]. However, since various double bubble tubular films have been developed with development of double bubble tubular machine, there are few fundamental reports of research. It was thought that the low crystallinity of water cooled film(WCF) by water cooling gives good stretchability and film quality of stretched film. However, there are few detail reports about the influence of cooling water temperature change on the stretchability and film physical properties. So, it showed clearly how the change of cooling water temperature influences film stretchability and stretched film physical properties, and further the difference of the film superstructure at each process was investigated.

2 Results & Discussion

The film temperature change at the entrance of preheating process and stretching stress one as a function of the cooling water temperature of the cooling water ring with 15, 25 and 35 or 52 °C were measured by using the machine shown in Figure 1. As a result, it became clear that stretching stress becomes low with the rise of cooling water temperature. Because stretch temperature became high, stretching stress was low, and the rise of film temperature at the entrance of the preheating process is considered to be one factor of low stretching stress which causes stretchability debasement. In addition, since physical properties of stretched film have a very close relation to stretching stress, it is necessary to compensate the stretching stress as one of the manufacture conditions in order to maintain stable film quality.
Compensation of stretching stress changed with the rise of cooling water temperature was attempted by adjusting the preset temperature of preheating process. WCF, PHF (preheated film) and SF (stretched film) produced under various cooling water temperature were sampled. In addition, PHF and SF with which the stretching stress change by cooling water temperature

change was compensated were also sampled. The relationship among the cooling water temperature, stretching process condition, film superstructure and film physical properties were investigated.
From these investigations, it was found that it is very important that the stretching stress is kept constant in order to maintain the product quality. Because the factor which determines product quality is stretching stress. It isn't necessary that cooling water temperature is kept at low temperature in order to obtain the good film stretchability or good film transparency. It is important that the stretching stress is compensated by controlling the preset temperature of preheating process in order to maintain the product quality.

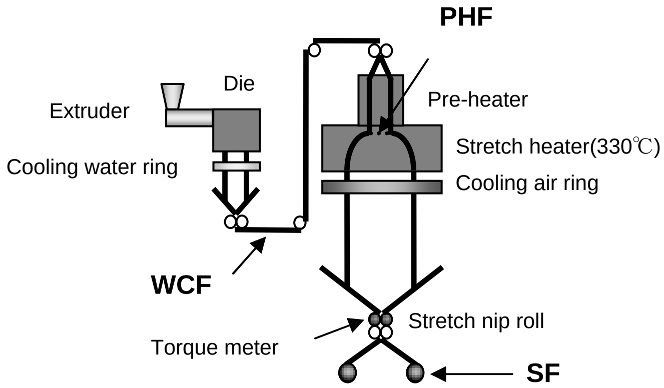

Figure 1: Schematic drawing of the double bubble tubular process

Table 1: Relationship between the cooling water temperature and stretching stress

Sample	1	2	3	4	5	6	7
Water cooling temperature(°C)	15	25	←	35	←	52	←
Film surface temperature before the preheating process(°C)	26	27	←	31	←	31	←
Ave. temp. of preheaters(°C)	275	275	272	275	271	275	270
Film temperature after preheating(°C)	112	112	112	113	112	113	112
Stretching stress σ_{MD}(MPa)	18.1	17.2	18.3	15.2	18.3	15.4	18.1
Film quality	good	good	good	bad	good	bad	good
Shrinkage (%, 110℃, MD/TD)	37/46	33/44	36/45	32/43	34/46	30/43	35/45

3 Conclusion

The rise of cooling water temperature leads to film temperature rising at the entrance of preheating process and stretch start point. As a result, since stretching stress becomes low, stretchability and shrinkage property become bad. As the stretching stress is important factor for controlling the film physical properties and the processability, it is necessary to compensate the stretching stress change when the cooling water temperature is changed by seasons factor and so on. It became clear that it is possible to produce the stretched film of same physical properties by controlling the preset temperature of the preheating process and controlling the stretching stress, even if the cooling water temperature varies. It is possible to produce a stretched film having good quality by adjusting the preset temperature of the preheating process and controlling stretching stress, even if cooling water temperature is high.

4 References

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