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Analysis of The Causes of Failure to Blow 600 ml Bottles on Blow Molding Machine with The Fishbone Diagram

Syahlan NurSalam[1], Erwin Erwin[1*], Bahrul Ilmi[2]

[1]*Department of Mechanical Engineering, Universitas Sultan Ageng Tirtayasa, Jendral Sudirman Sreet, Cilegon City, Indonesia.*
[2]*Department of Mechanical Engineering, Universitas Tamansiswa Palembang, Tamansiswa Street No.261, Palembang City, Indonesia.*

*Corresponding author: *erwin@untirta.ac.id*

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ABSTRACT

Failing Blowing is an imperfect preform blowing process. The defective form can be a puckered preform, a leaking bottle or a puckered bottle. Blowing failure is influenced by three main parameters, namely preform, preblow and blowing temperatures [1]. Then data was taken with variations of the material used, namely preform materials from internal and external. This is not intended to assess the effectiveness of the amount of production using a particular material, but makes a reference in analyzing the problem of failed blowing with different material variations. The analysis stage is carried out using the fishbone diagram method. The results of the analysis found the cause of blowing failure and a significant difference in numbers from the blowing failure data taken on internal and external preforms. The main possible causes of failure to blow settings are inappropriate parameters. The number of blowing failures in internal materials was obtained as many as 23 and in external materials as many as 8 bottles. Then the main parameter settings used in internal materials with a preform temperature of 107oC, a preblow pressure of 6.7 bar and a blowing pressure of 22 bar. While in external materials the preform temperature is 106oC, the preblow pressure is 6.7 bar and the blowing pressure is 22 bar. Looking at the type of material alloy of internal and external preform, this has a difference where the external preform is a preform with 100% PET (virgin) resin while the internal preform is a combination of 25% Recycle PET and 75% PET. This will obviously greatly affect the characteristic properties of the material.

Keywords: *Blowing, Blowing Failing , Material, Preform, Temperatur and Pressure.*

1. PENDAHULUAN

Plastic bottles are derivative products of plastic pellets. Plastic bottles are very practical in use and carry during activities. The characteristics of plastic bottles vary, so knowledge is needed regarding which type is suitable for its use function [2]. The types of plastic bottles are as follows.

1. PETE or PET (polyethylene terephthalate) is commonly used for translucent/transparent plastic bottles such as mineral water bottles, beverage bottles, juice bottles, cooking oil bottles, soy sauce bottles, chili sauce bottles, medicine bottles, and cosmetic bottles and almost all other beverage bottles [3].
2. HDPE (high-density polyethylene) has the properties of a stronger, harder, opaque material and is more resistant to high temperatures. HDPE is commonly used for cosmetic bottles, medicine bottles, beverage bottles, milky white milk bottles, Tupperware, gallons of drinking water, folding chairs, jerry cans, lubricants, and others [4].
3. PVC (polyvinyl chloride), which is the most difficult type of plastic to recycle. This type of PVC plastic can be found in plastic wrap (cling wrap) for toys, hoses, pipe building, plastic tablecloth, soy sauce bottles, chili sauce bottles, and shampoo bottles [2].

4. LDPE (low density polyethylene) is a brown type plastic (thermoplastic / made from petroleum), commonly used for food containers, plastic packaging, and soft bottles. LDPE is used for plastic lids, crackle bags / bags and other thin plastics. Although good for food, LDPE-based items are difficult to destroy. In addition, at temperatures below 600C it is highly resistant to chemical compounds [2].
5. This type of PP (polypropylene) plastic is the best choice of plastic material, especially for food and beverage places such as food storage, bottle caps, plastic cups, children's toys, drinking bottles and most importantly, making drinking bottles for babies. Materials made of PP have elastic properties, which when pressed will return to their original shape. The characteristics of this type of plastic are transparent and tend to be cloudy (cloudy) [5].
6. PS (polystyrene) is commonly used as a material for eating Styrofoam, disposable drinking places such as spoons, glass forks, and others. Polystyrene can release Styrene material into food when the food comes into contact. This material should be avoided, because it is harmful to health, besides this material is difficult to recycle [5].

Blow molding machine is a machine that has the working principle of printing bottle preform by blowing. The preform bottle that has been heated and then inserted into a mold cavity and then injected with a certain air pressure so that the bottle preform can expand and form a profile or desired product [6]. There are several types of blow molding, namely :

1. Stretch blow molding machine is the main machine of the blowing process. That is the blowing of the preform into a bottle according to the mold made. This machine basically consists of two parts, namely bottle blowing unit and prefrom heating unit. Infrared prefrom heating (oven), is part of the stretch blow molding machine where in this section there is a preform heating process as the initial form of the bottle [7].

   While the bottle blowing unit is a continuation of the preform heating unit (oven) process, namely the blowing process. After heating and still in high temperature (so that the PET becomes soft) then the preform is put by the machine into the mold (mold), and then the blowing process is carried out into bottles [7].

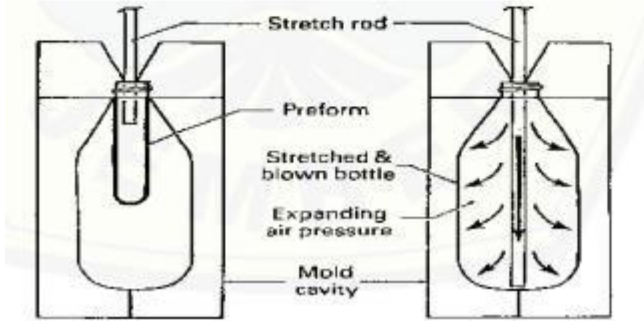


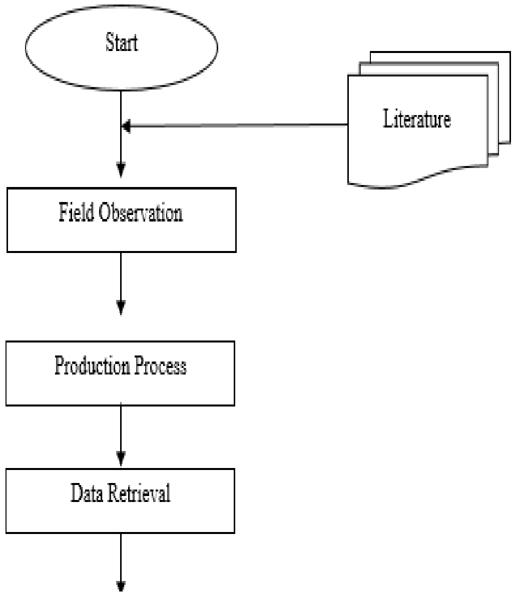
Figure 1. ***Stretch Blow Molding*** **[7]**.

2. *Extrusion Blow Molding* This process is referred to as a plastic material helper by dripping from the extruder. The method that uses an extruder and blow is the simplest method in the blow mold process. This principle can be used for products that vary from size, shape, neck opening on bottles, and handle formations the types of plastic used are HDPE, PVC, PP, PC, and PETG [8].
3. Injection blow molding is the process of forming plastic products by injecting the first for the plastic that will be blown. In general, this machine is used for containers with a relatitively small size and absolutely no lever. Usually used for the production process of bottles that have a thread formatuin on the neck[9].

2. METHODOLOGY

2.1. Flow Chart

The following is a flow chart in the analysis of the causes of failed blowing of 600 ml bottle production on blow molding machines in this practical work is as follows.



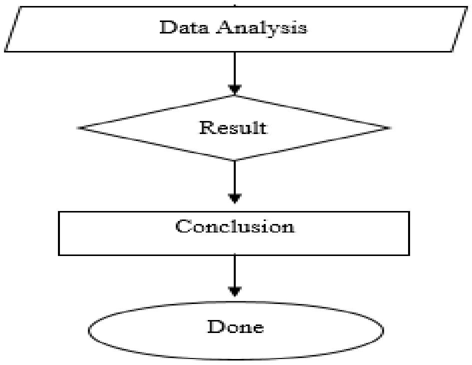


Figure 2. Diagram Alir

2.2. Production Process

The production process in the industrial world does not always get good results as desired. There could be defects in each product (reject product). The process of making a 600 ml bottle uses stretch blow molding techniques. Stretch blow molding is a molding technique by blowing the preform into a bottle according to the mold made. Here is the flow process of making a 600 ml bottle.

The bottle making process using the SBO 14 machine is a molding machine with a bottle blowing model with an average nominal production of 18,200 bottles/hour with oven module number 14 and mold 14. The principle of this bottle blowing machine operates using the concept that the preform is heated, the preform is stretched axially and the preform is expanded by preblowing and blowing (Sidel, 1997)

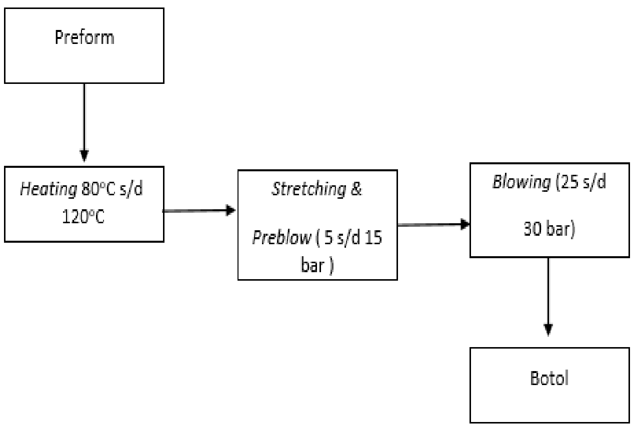


Figure 3. Flow Process

Data was collected on February 1, 2023 and February 3, 2023, by recording the number of production in 1 hour and the number of blowing failures in shift 1 production in 1 hour. On February 1, 2023, production data was taken using materials from external parties and on February 3, data was taken using internal materials, so that they could find out the comparison of the type of material in the process production. This is not intended to assess the effectiveness of the amount of production using a particular material, but makes a reference in analyzing the problem of failed blowing with different material variations.

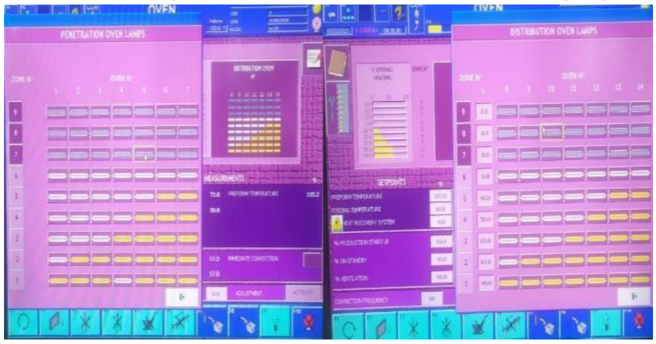
2.3 Setting Parameter

In maintaining production efficiency, it is necessary to set parameters that are in accordance with the material. These parameters also affect the failure of blowing. However, it is narrowed down to 3 main parameters whose impact is very large on blowing failure, namely preform temperature, preblow and blowing. The following are the parameter settings used on February 1 and 3, 2023.

Table 1. Parameter on PLC

material	*Preform temp*	*preblow*	*blowing*
Eksternal (1/2/2023)	107°C	6,7 bar	22 bar
Internal (3/2/20203)	106°C	6,7 bar	22 bar

Then there are settings for heat penetration and distribution lamps in the oven that also need to be considered because these lamps determine different heating levels in the preform parts. Penetration and distribution lights can be seen in the following figure.



Gambar 4. Penetrant and Distribution lamp Setting (Internal Material)

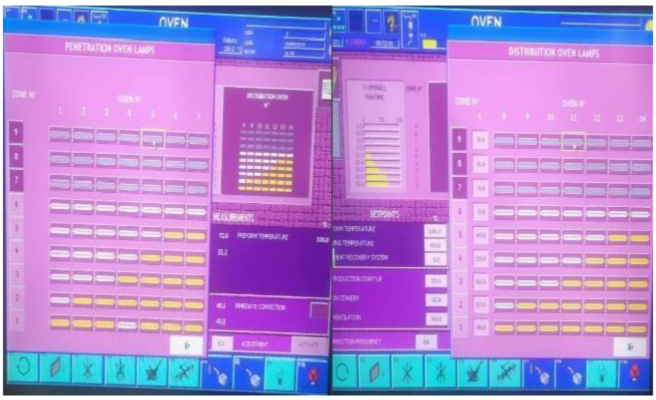


Figure 5. . Penetrant and Distribution lamp Setting (External Material)

3. RESULT AND DISCUSSION

3.1. Production Quantity Data

Table 2. Production Quantity Data

Date	Hours/Shift	Materials	Production Quantity	Failure Quantity
1/2/2023	Shift 1 (09.00-10.00 WIB)	Internal	20.000	23
3/2/2023	Shift 1 (09.00-10.00 WIB)	eksternal	19.000	8

Looking at the table above, there is a significant difference in the number of defects produced, but when looking at the amount of internal material production is more in 1 hour. This is because in shift 1 on February 1, 2023, there has been downtime due to problems with the infeed rail, the preform concerns the rail that will be transferred to the infeed wheel so action needs to be taken by operators and technicians. The problem takes about 10 minutes. So if the production capacity is 21,000 bottles / hour, then in 10 minutes about 3500 bottles ration at that hour.

3.2. Identification of failed blowing failures on bottles

Then data collection is carried out for each bottle that explodes or fails in the blowing process which can be seen the data on the PLC alarm. Identification of defects in bottles is classified into 3, namely failure to blow at the bottom, failing to blow at the body, and flat bottom. As can be seen in table 3 and table 4 below.

Table 3. Clasification of Blowing Failures

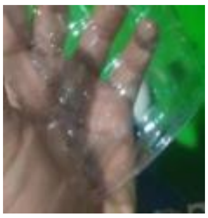
Type of blowing failures	Figure
bottom	
body	
Flat Bottom	

Table 4. Klasifikasi gagal Blowing

Internal Preform Materials			
No Mold	Type of failures	Part of bottle	Quantity of failure
2	Bocor	*Body*	1
3	Bocor	*Bottom*	2
4	Bocor	*Bottom*	2
6	Bocor	*Body*	1
7	Bocor	*Bottom*	3
8	Bocor	*Bottom*	2
9	Bocor	*Bottom*	1
11	Bocor	*Bottom*	1
12	Bocor	*Body*	1
	Bocor	*Bottom*	1
13	Bocor	*Bottom*	4
14	*Flat Bottom*	Bottom	3
	Bocor	Body	1
External Preform Materials			
No Mold	Type of failures	Part of bottle	Quantity of failure
1	Bocor	Bottom	2
4	Bocor	Bottom	2
5	Bocor	Bottom	1
9	Bocor	Bottom	1
14	Bocor	Bottom	2

3.3. Discussion

The cause of blowing failure has many factors both from machines, parameters, materials and so on. So it is necessary to identify the problem by categorizing the main cause of the problem so that it makes sense with the situation. Identification of problems needs to be done from the root to facilitate improvement actions. The method used in identifying the problem is the fishbone diagram method. Here is a fishbone diagram of the problem identification in failed blowing.

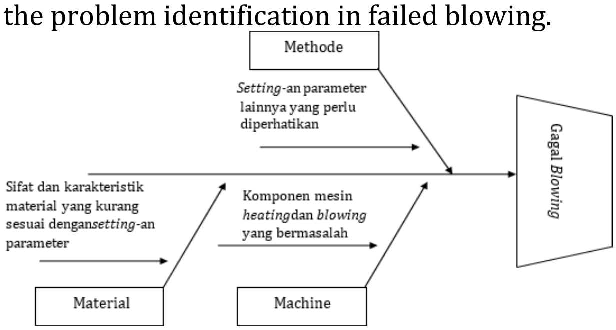


Figure 6. *Diagram Fishbone*

From the fishbone diagram above, the cause of blowing failure is obtained and a significant difference in numbers from the blowing failure data taken on internal and external preforms. The main possible causes of blowing failure inappropriate parameter settings. From the data taken on February 1, 2023 and February 3, 2023 using internal and external preforms.

Referring to table 1, the blowing failure rate in internal material is more than external material with a difference of 15 bottles. Looking at the type of material alloy of internal and external preform, this has a difference where the external preform is a preform with 100% PET (virgin) resin while the internal preform is a combination of 25% Recycle PET and 75% PET. This will obviously greatly affect the characteristic properties of the material.

Furthermore, the method factor is setting parameters that refer to table 1, figure 4 and figure 5. The parameter settings on the two materials are different, only the preform temperature parameters are made differently, namely external with preform temperature parameter settings of 107oC and internal, namely 106oC. This variation clearly affects when referring to the material alloy, when the internal preform is heated to a temperature of 107oC which is not much different from the external, then the preblow and blowing treatment is carried out with the same pressure, then the internal preform is not strong enough to accommodate that much pressure with such hot preform conditions, this is why the number of blowing failures in the internal preform is more than the external preform.

Then if you look at the form of failed blowing, the dominant failure to blow is leaking at the bottom. When looking at the settings of penetration and distribution lamps in a row of 5 lamps on penetration lamps, the lights that light up are 2 with a lamp capacity of 2000 watts. Then in the distribution lamp, the lights that light up are 2 lamps with a given heat efficiency of 40%. When looking at the data taken on external and internal materials, it turns out that there is no difference in the settings of the penetration and distribution lamps, this causes failure to blow the dominant internal and external materials, namely leaking at the bottom. Then heating the lamps in row 5 is to heat the bottom at the penetration and distribution of 2 lamps with a distribution heat efficiency of 40%, this means that the setting is too hot because the average blowing failure produced is located at the bottom.

When the bottom preform is too hot then preblow with a pressure of 6.7 bar and blowing 22 bar. The bottom preform cannot accommodate that much pressure, the thickness of the bottom is thinning along with the increasing pressure exerted so that finally the bottom preform explodes. The alarm monitor on the PLC also shows the mold number that is problematic because there is a bottle ejector sensor that also reads the mold number. In table 4, it is recorded that the mold number that often fails to blow is number 13, which is 4 times in 23 failed blowing. Mold 14 3 times in 23 failed blowing. The position of the mold can be seen as follows.

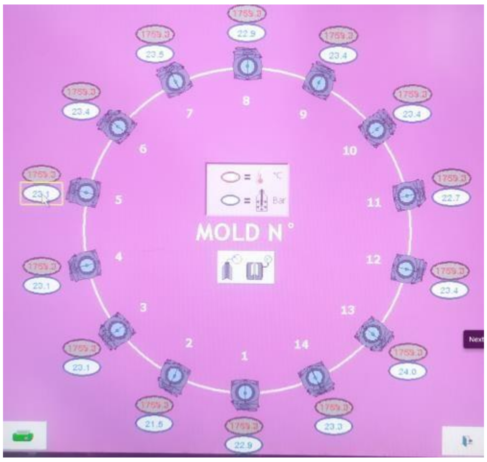


Figure 7. ***Mold Information*** **pada PLC**

This is a small indication that there is a problem with station molds no. 13 and 14. On Monday, January 30, 2023, maintenance will be carried out on shift 1. At the time of maintenance, the replacement of stretching units no. 13 & 14 was carried out because the cylinder was jammed so that the stretching shaft did not move up and down properly. This will certainly affect the stretching process later, where this process is done with 1 movement and in a very short time of 0.08 seconds. The illustration can be seen in the following image.

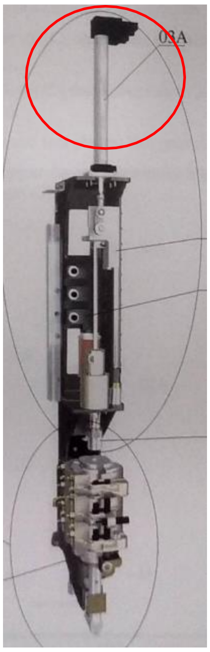


Figure 8. ***Stretching Unit***

A change of stretching unit has been made but it seems that the installation of the part is not good or maybe the spare parts are running less than optimal. Then there is mold no. 4 in table 4.2 recorded 2 times in 8 blowing-failures and in table 4.3 recorded 2 times in 23 blowing-failures.

Then in mold number 4, there was a chiller leak at the base so that the cooling was not perfect, but on January 31, 2023, a mold support unit change was made.

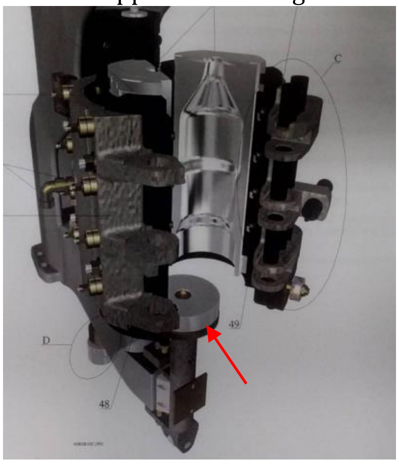


Figure 9. ***Base Mold***

But if there is a leak again, it means that the trouble is in the chiller channel, this will affect the blowing process where when the blowing process when it reaches the base mold with cooling that is outside the setting, the blowing process will not expand because the bottom bottle is not soft because the temperature has been cooled, automatically with the bottle blowing pressure is not strong enough to withstand and eventually a leak occurs in the area.

4. CONCLUSION

Based on the results of the analysis that has been carried out, it can be concluded that:

1. 600 ml bottles are produced from the preform or semi-finished material of the bottle which then the preform is heated evenly with a temperature of 80oC to 120oC. Furthermore, the preform is stretched by stretching and preblow with a pressure of 5 to 15 bar to form corn. Then blow with a pressure of 25 to 30 bar after the preform forms a bottle then the pressure on the bottle is discarded.
2. The type of molding used in the production process of 600 ml packaging bottles is stretch blow molding, blowing preform into bottles according to the mold made. This machine basically consists of two parts, namely bottle blowing unit and prefrom heating unit.
3. From the analysis of the causes of blowing failure using fishbone diagrams, they are categorized into 4 factors, where method and material factors are correlated which is the cause of the significant difference in blowing failure between internal and external materials with a difference in blowing failure of 15 bottles in 1 hour production. The cause is parameter settings that are not adjusted to the alloy of preform material. Where the parameter settings only have differences in preform temperature with a temperature difference of 1oC, namely external = 107 oC and internal = 106oC. So that husky material is not able to withstand the same amount of pressure as ITA preform material because the temperature is too high for husky preform material. Then the machine and maintenance factors are correlated, where when looking at mold number data that often fails to blow. Recorded numbers 4, 7, 13 and 14 this explains the occurrence of trouble in the mold unit. Then the pressure on the bottle is discarded.

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