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The Effect of Foam in Surface Molten Glass and Use of TNBT for the Combustion Process in Furnace to Temperature and Produced Glass Quality

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Abstract

In the process of making glass with the Float Process can be divided into several stages of the production process such as preparation of raw materials, mixing, melting, forming, cutting, and packing. From this process that becomes a benchmark of glass quality is the type and number of defects in the glass caused by the processes that occur in making glass. The glass defect can be from the existing production process stage. In the smelting process occurs in the furnace area, where in the combustion process, the fusion that occurs there is foam that can interfere with the combustion process in the furnace. This can occur due to foam can prevent the entry of radiant heat into the liquid glass. So that with the foam that is formed will be analyzed what effects and variables can occur and the application of tetra n-butyl titanate to the foam formed. With the use of TNBT can eliminate the foam that occurs and can directly reduce the temperature of the crown furnace that results in a decrease in glass defects that occur and increase production efficiency.

Keywords : Furnace, Glass, Foam, TNBT

INTRODUCTION

The industrial process must be seen as a cycle that strives continuously or continuously to achieve the expected goals. In the industrial process there is a production process that makes a cycle [1].

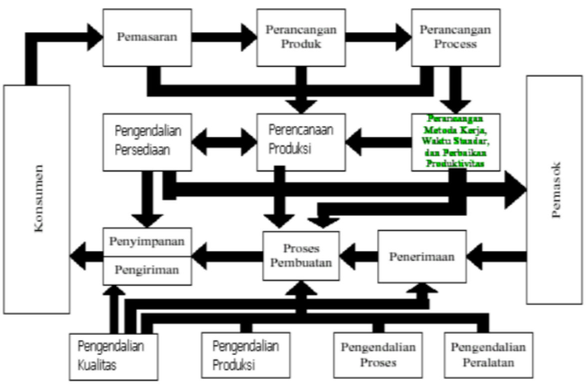

Figure 1.1 Production Cycle [1]

In the process of making glass with Float Process can be divided into several processes such as preparation of raw materials, mixing, smelting, forming, cutting, and packing [2]. Broadly speaking, the process flow of the production process includes the diagram below.

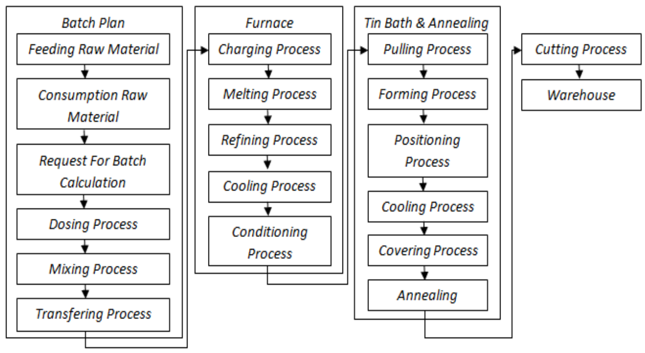

Figure 1.2 Flow of Glass Making Process

In the process of making glass which is a benchmark of glass quality is the type and number of defects in the glass caused by the processes that occur in making glass. These glass defects can be from the process of mixing raw materials or materials, the smelting process, the formation process, and from the cutting and packing process. In the smelting process occurs in the furnace area, where the combustion process uses gas fuel and residue. In the smelting process there is foam that can interfere with the combustion process in the furnace. This happens because the foam can block the entry of radiant heat into the liquid glass.

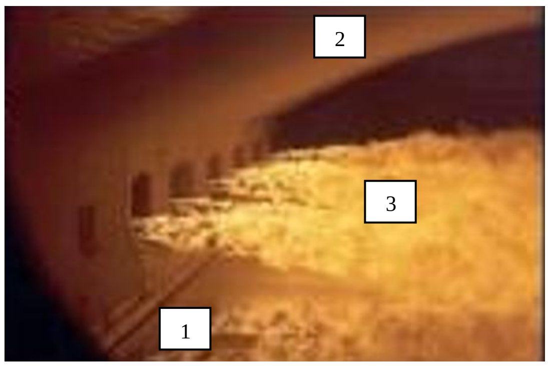

Figure 1.3 Combustion in the furnace: 1:Molten Glass; 2:Crown; 3:Flame

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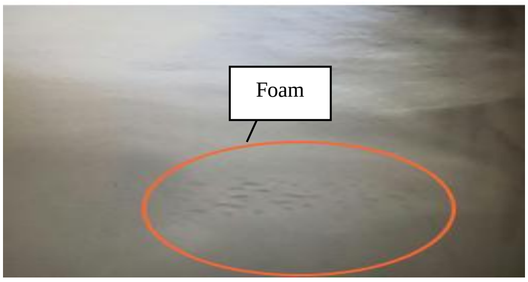

Figure 1.4 surface covered with foam

BASIC THEORY

Furnaces are an important part of the glass making process. The glass industry is currently facing major challenges, one of the most important topics is the energy balance of the glass production process. Aspects such as the concept of insulation for furnaces, efficiency of regenerators, increased use of cullet and the latest technologies such as pre-batch heating are increasingly becoming a focus so that this will affect the performance of refractories in the furnace structure [3]. In the figure below describes the parts of the furnace [4].

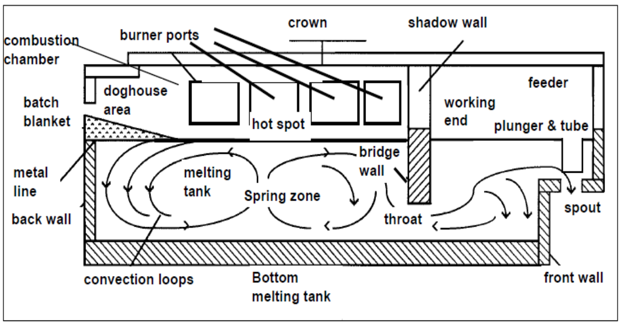

Figure 2.1 Section in a furnace [4]

The combustion process that occurs in the furnace is a process of heat transfer from a burning flame that can heat the furnace crown, so it is necessary to pay attention to the temperature limit produced because it can make refractory corrosion from the furnace crown

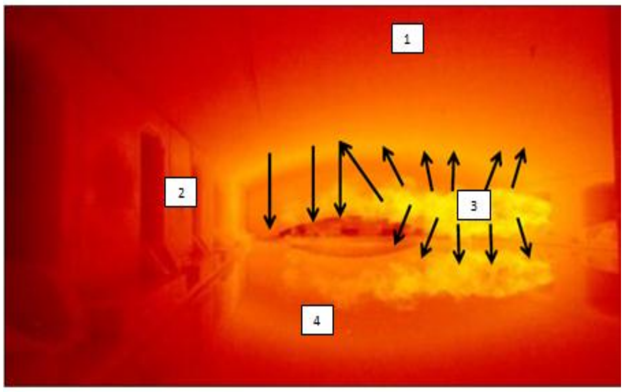

Figure 2.2 The inside of the furnace: 1: Crown; 2: sidewall; 3: Fire burning; 4: Molten Glass [4]

In the furnace operational process, froth can occur in conditions of several things, following an explanation of the occurrence of foam that can impact the furnace's operations [4]:

1. Due to the release of gas bubbles and the length of the gas bubble at the surface of the liquid glass.
2. Foam can be caused by the process of releasing gas in the smelting process from a batch of blankets (primary foam) and / or during the finishing process (secondary foam).

Foam has a negative impact to the end of the process in the furnace, along with the effects of foam on the furnace [4]:

1. Froth has a strong insulation effect.
2. Can prevent the penetration of heat radiation from the combustion chamber to molten glass.
3. Increase the temperature.

RESEARCH METHODS

The following are the stages of the research stages that are made in the methodology below.

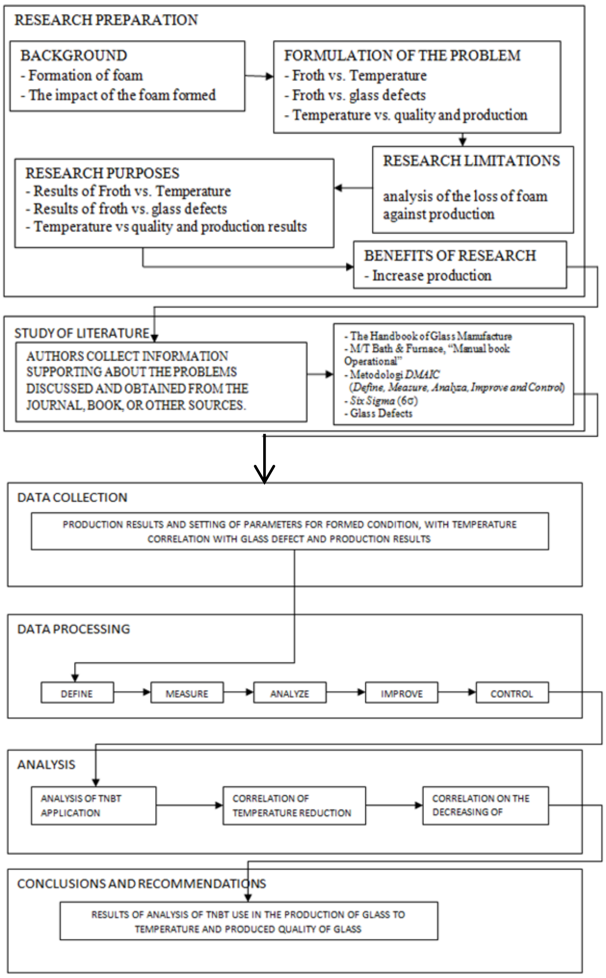

Figure 3.1 Research Methodology

RESULTS AND DISCUSSION

Define

At this stage the researcher will carry out the process of decomposing the process that can be carried out before the next stage of the process. In the smelting process some of the processes that become obstacles are the occurrence of foam which can become a barrier so that the heat from the fire generated from the burner can not penetrate the surface of the liquid glass contained in the furnace. In the smelting process the foam that is formed can make an increase in seed that occurs in the smelting process because the combustion process is not perfect due to the foam position that blocks the combustion process against the surface of the liquid glass. So that several alternatives must be made to anticipate the process. Some alternatives are the selection process for the above problems, namely by continuously increasing combustion so that the radiant heat from the combustion process can enter the liquid glass, besides that it can minimize the occurrence of foam on the surface of the liquid glass so that the radiant heat can be more focused again. The following temperature occurs due to the formation of foam on the smelting process.

Table 4.1 Temperature conditions for foam

	Position	T_{min}	T_{Max}	$T_{rata-rata}$
T_{Crown}	1	1456	1463	1459.82
	2	1519	1524	1521.73
	3	1557	1573	1563.09
	6	1593	1600	1596.64
	7	1559	1566	1562.55
	8	1513	1519	1516.64
T_{Bottom}	1	901	919	911.18
	2	894	915	906.27
	3	892	914	905.55
	6	906	924	916
	7	924	943	935.18
	8	923	943	935

Increasing combustion can result in an increase in temperature, especially temperature, in the condition of the crown in the furnace so that it can make the life of the furnace shorter. So the researchers tried to eliminate the foam that formed. From the results of the define process the researcher takes a process that can be processed at the next stage. Here are the results of the define process:

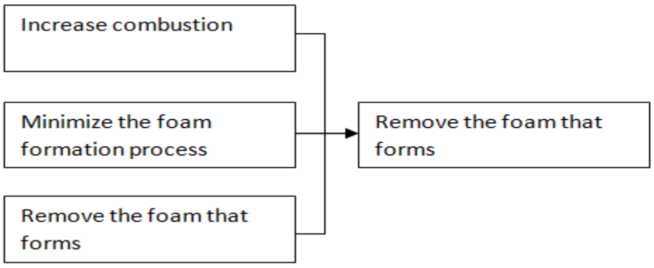

Figure 4.1 The results of the define process

Broadly speaking to see the process of the furnace so that it is needed in the process of defining the problem then using the SIPOC diagram, through this diagram we can see the general processes that occur in the furnace process as well as the suppliers, inputs, outputs, customers presented in the following figure.

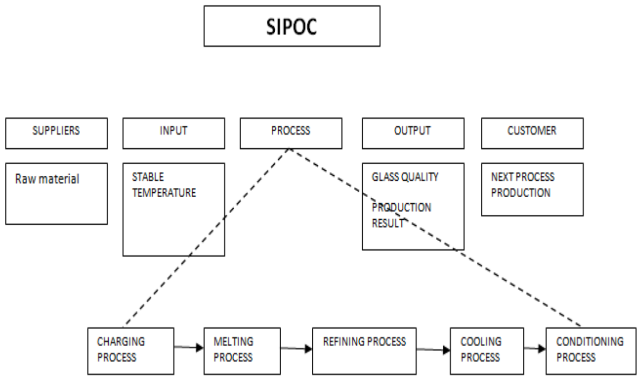

Figure 4.2 SIPOC Furnace

Measure

In the measure phase is the advanced stage after the define process which is the process of measuring the current level of performance. Previously researchers conducted the determination of critical to quality, in this study the determination of critical to quality was determined through a selection process carried out in the define stage. For this reason, the calculation of the number of glass defects is caused by the formation of foam. Here are some glass defects that have been classified according to their type

Table 4.2 Glass defects

KIND OF DEFECT	PCS
INCL	24075
KNOT	43108
DRIPS	915
BUBBLE	33287
LOBB	23
TOTAL	101408

Based on the sampling classification of types of glass defects that can occur is done by grouping using pareto. The following pareto chart of the types of glass defects that have been classified.

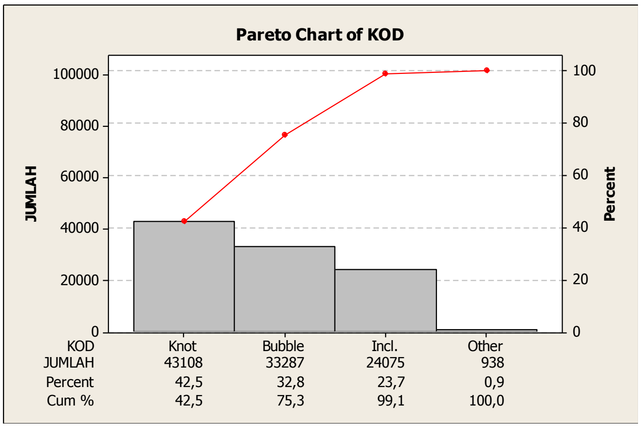

Figure 4.3 Pareto Diagram of glass defects

Based on the Pareto diagram, the biggest potential defects in glass is for defects in glass types of knots, then the defective glass type of bubble is also potentially large enough to affect quality. Production results are a target that is also a benchmark in the success of achieving production targets. In determining the success of a production can be seen from the quality obtained which is seen from the type of quality that has been produced and high production efficiency. The following is for production based on the presence of foam in the smelting process.

Table 4.3 Production Results

Pull	13648,8
Glazing	4807,0
Tarc	6256,4
Total	11063,4
Eff	81,06

Based on the table of production results, the pull value is the total production capacity that can be produced in total production, where for production with glazing and Tarc quality with a total efficiency obtained is 81.06%

Analyze

At this stage is the next stage of the DMAIC process. Phase Analyze is the phase of finding and determining the root or cause of this research. In the previous stage, researchers have conducted Define and Measure stages so that problems have been obtained that will later be resolved and some are not resolved so that it needs to analyze in more detail at this stage. Analysis by using why analysis to get a root cause. Where by using why analysis researchers can find out the causes of glass defects that occur and how to deal with certain process processes carried out. The following types of glass defects such as knots, bubbles, inclus, so that the method of analysis will be done for the glass defects above. The following is why the analysis for glass defects with types of knots can be seen in the picture below.

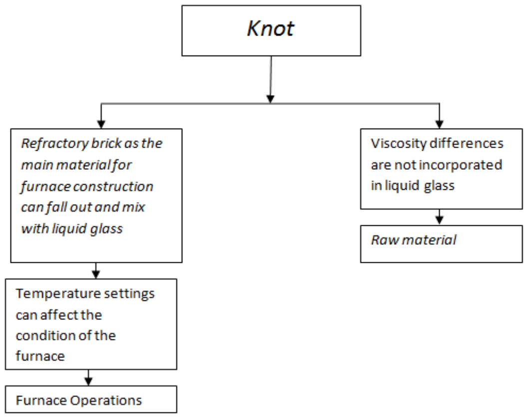

Figure 4.4 Why analysis for defect knots

Why analysis is used to find out the root cause of the process of the occurrence of knots with the root of the problem:

1. Operational furnaces that can affect the process of knots in the furnace process.
2. Raw material that enters the melting process, there is a difference in viscosity so that knots can occur.

After using why analysis researchers used fishbone diagrams. Fishbone diagram is used to identify the cause of the problem. By using why analysis above the researcher then divides the cause of the problem into several factors such as human, method, machine, environment, material. From this fishbone diagram processing, we will get the root causes of the problems from these factors. In this fishbone, the root causes will only be written, which is obtained from the results of the previous why analysis. The first Fishbone diagram is about defects that occur. The following can be seen in the picture below.

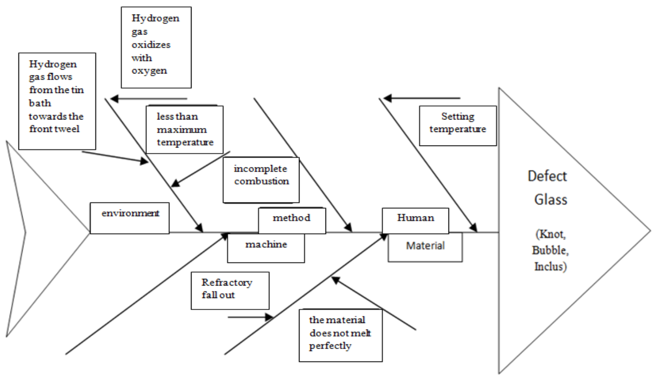

Figure 4.5 Fishbone diagram for glass defects

From the cause and effect diagram that has been made, it can be seen that the process that has the potential to cause glass defects is grouped with factors of material, environment, and humans. In addition to using fishbone diagrams, researchers also use FMEA namely Failure Mode Effect Analysis which is used to determine the possibility of deviations from the steps for the existing process. The FMEA table can be seen below.

Table 4.4. Failure Mode and Effect defects in glass

Proses Step / Input	Potential Failure Mode	Potential Failure Effects	S	Potential Causes	O	Current Controls	D	RPN
Pengaturan temperatur	Low/high temperature	Furnace risk	10	High Temperature	3	Control temperature	2	60
Material tidak melt dengan sempurna	Material source	Material unmelt	5	Low temperature	2	Control temperature	2	20
Temperatur kurang maksimal	Foam terbentuk	Crown high temperature	7	High Temperature	6	Control temperature	4	168
Pembakaran tidak maksimal	Low temperature	Defect potential	7	Energy usable	2	Control temperature	2	28
Oksidasi hidrogen dengan oksigen	Banyaknya kandungan gas	Bubble potential	6	Air contamination	2	Sealing	2	24
Gas hidrogen mengalir dari tin bath ke arah front tweel	Banyaknya kandungan gas	Bubble potential	6	Air contamination	2	Sealing	2	24

Improve

In the improve phase is to choose ideas that can be done to improve the existing system based on the results of previous analyzes. In the previous stage, researchers have analyzed the existing processes. Some things that make it possible to do an improvement process based on the process that occurs. By applying the use of TNBT, it is expected to eliminate foam so that the combustion process becomes more optimal and the temperature can be maintained more. For installation it can be seen in the following picture.

Figure 4.6 TNBT Installation Process

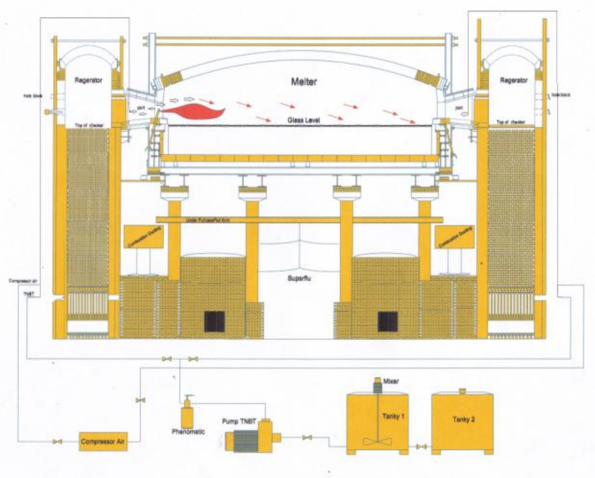

Figure 4.7 Flow Process TNBT

By installing the TNBT in the furnace, it can be observed the conditions in the furnace, where there are conditions when there is foam when not using TNBT and the condition is no foam due to the use of TNBT in the furnace, here is a picture of the difference in conditions in the furnace.

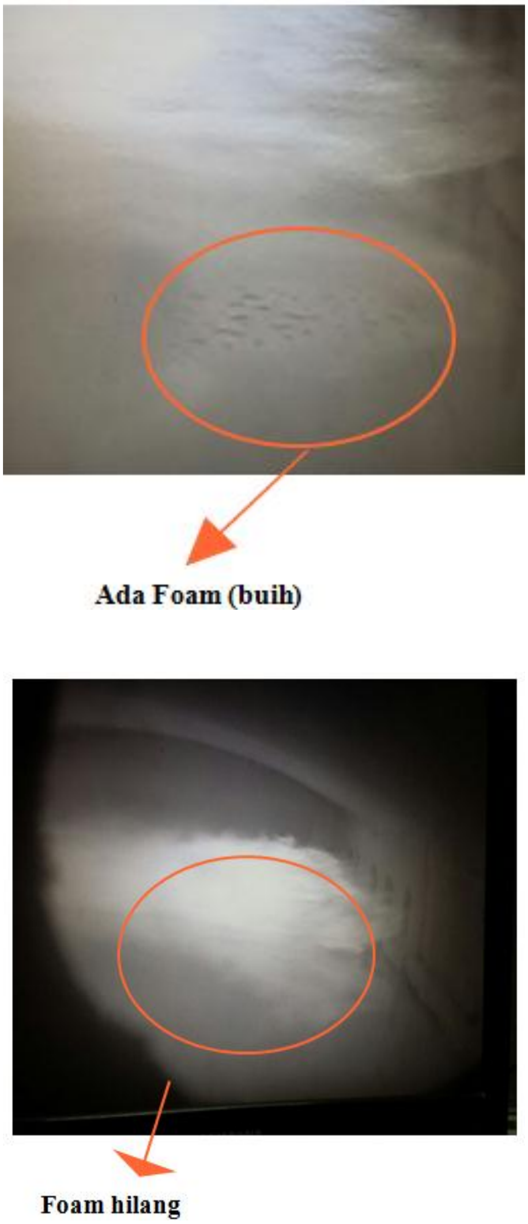

Figure 4.8 conditions before using TNBT (above) conditions after using TNBT (below)

In the picture of the condition before using TNBT looks foam on the surface of the molten glass, while in the conditions after using TNBT there is no visible foam on the surface of the molten glass. This can make radiant heat more focused and can reduce crown temperature in the furnace. Based on the improvements we have, we will compare several variables that become a benchmark for the success of the application of TNBT use in the furnace. The following is the temperature comparison before and after installing TNBT.

Table 4.5. Temperature Comparison

	T_{before}	T_{after}	ΔT
Temp Crown	1.459,82	1.458,83	-0,98
	1.521,73	1.518,92	-2,81
	1.563,09	1.555,25	-7,84
	1.596,64	1.589,42	-7,22
	1.562,55	1.551,75	-10,80
	1.516,64	1.499,75	-16,89
Temp Bottom	911,18	911,33	0,15
	906,27	909,17	2,89
	905,55	908,67	3,12
	916,00	916,92	0,92
	935,18	937,25	2,07
	935,00	937,83	2,83

Table 4.6. Comparison of defects in glass

KOD	TNBT %		Deviasi
	Before	After	
Incl.	24075	20610	3465
Knot	43108	37602	5506
Drips	915	507	408
Bubble	33287	17569	15718
LOBB	23	3	20
Total	101408	76291	25117

Table 4.5. Comparison of production results

	Before	After
Pull	13648,82	12365,58
Glazing	4807,012	5771,042
Mirr	-	24,64
Tarc	6256,47	4785,901
Total	11063,48	10581,58
Eff	81,1	85,6

Initially before the application of TNBT was used, there was a temperature difference which affected the construction of the furnace, this could be seen by the greater temperature at the crown of the furnace before the application of TNBT usage with a lower temperature after applying the TNBT usage. This difference can be clearly seen by comparing the temperature of the bottom of the furnace which is inversely proportional to the temperature of the crown of the furnace so that with a decrease in the temperature of the crown the furnace has an impact on increasing the bottom temperature where the radiant heat from the combustion process can directly hit the liquid glass without being blocked by foam that can form on the surface liquid glass. In the application of the use of TNBT in the furnace, the existing temperature is more awake which indirectly affects the number of defects in the glass that occur. This also has an impact on the amount of production efficiency obtained for each day. So that indirectly with the process conditions that exist in the furnace and obtain the existing temperature can produce good glass quality with better production efficiency results.

Control

At this stage it is necessary to control the results of the TNBT implementation. It is intended that the implementation has been controlled. Some points that must be controlled are whether foam still appears when TNBT is still used, conditions and temperature recap.

CONCLUSION

Based on the results of the research that has been done, it can be concluded that:

1. With the application of the use of TNBT it is proven that it can eliminate foam that is on the surface of liquid glass.
2. The impact of loss of foam then the radiation from direct combustion of the surface of the liquid glass without being obstructed by foam so that the crown temperature can be lower than before the use of TNBT, with different temperature differences for each port for the temperature of the crown the temperature difference is about 0.98 ^{o}c - 16.89 ^{o}c more low before using TNBT, while for bottom temperatures around 0.15 ^{o}c - 3.12 ^{o}c higher before using TNBT.
3. With a good smelting process and a decrease in defects that occur, the production results become better by getting better efficiency than before. For the reduction of glass defects from 101408 pcs to 76291 pcs or around 24.77% and indirectly can increase efficiency from 81.1% to 85.6%.

REFERENCE

[1] Ali. 2011. Desain Produk dan Proses Industri. (online).http://staff.uny.ac.id/sites/default/files/Modul%206%202011.pdf. (Accessed 11 November 2017)

[2] V. Tooley, Fay., 1984, "The Handbook of Glass Manufacture"

[3] Roland Heidrich, Stefan Postrach, Rongxing Bei., 2013, "Refractory Solutions For The New Challenges In Glass Furnace Construction".

[4] Hubert., 2015, "Basics of industrial glass melting furnaces," Celsian Glass & Solar Eindhoven, The Netherland.