Preventing Strategy of External Disturbances of Glass Furnace

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Abstract

In this study, first, we show that the furnace process which requires maintaining high temperature is effected grievously by the temperature of surrounding air. Second, an alternative which maintains the relatively constant temperature dispersion surrounding the furnace and at the same time has economical advantages will be proposed.

1. Introduction

The high degree of viscosity and non-Newtonian fluid dynamics are involved to describe the characteristics of the inside of the glass furnace. It is not easy to measure some characteristics like temperature, and build the statistical models for process analysis. Because the temperature is fluctuating in the short time interval and its fluctuation is autocorrelated, it is difficult to determine the status of its fluctuation, and/or verify the existence of some statistical relations among the variables. To illustrate the situation, we select the temperature of the crown as the quality characteristics.

Data that have an autocorrelation like the variables of glass furnace cannot adopt $X\text{-}R_S$ chart, because independent and identical error distribution is being assumed to implement the control chart. Therefore we use ARIMA model for diagnosis of process stability.

We only use first step, identification, for diagnosis of process stability. The main tool used in this step is SACF(sample autocorrelation function) which is employed to check process stability. The stability, so called 'white noise', is defined as the acceptance of Ho : ρ=0, which means ACF=0. The white noise of the temperatures of the main crown that is the temperature of main crown in glass furnace is shown in Figure 1.

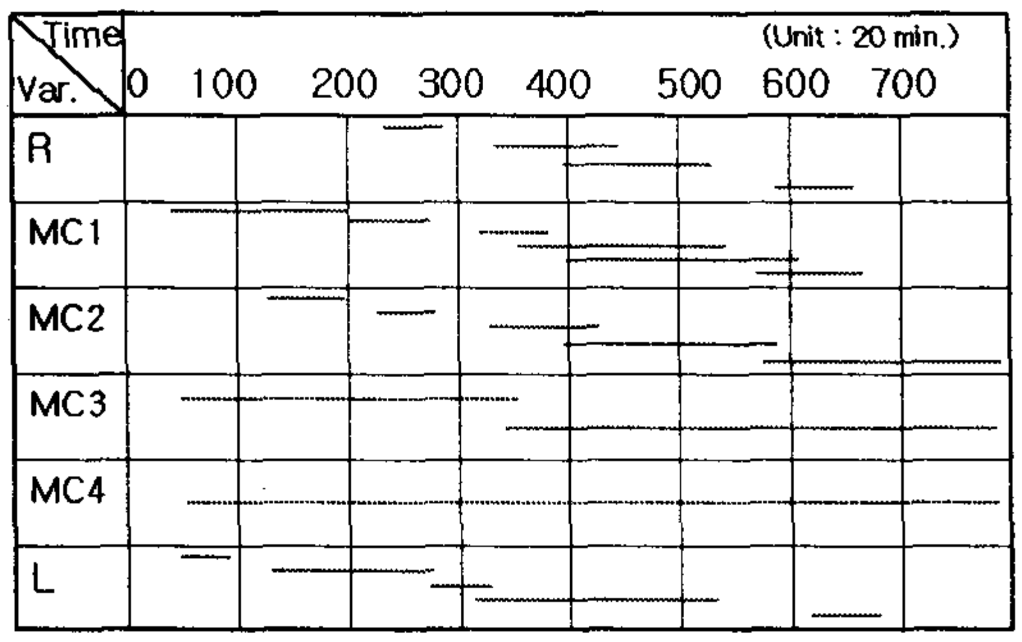


Figure 1. White noise of process variables(MC3: 3rd thermo couple in main crown)

Figure 1. shows that the glass furnace doesn't have the stability time-serially. Why doesn't the glass furnace have the stability? There could be only one single reason; operators are changing continually the setting values in furnace operation in order to get spec-in. Why are operators changing the setting values? The reasons are primarily as follows; the fluctuations in the characteristics of incoming materials, the fluctuations in the environments surrounding the furnace such as temperature, moisture and pressure.

2. External Disturbances

We know that the quality characteristic like the temperature of the furnace is affected by the constantly changing dispersion of the air in the instrumental industry. In order to virtually get rid of this kind of fluctuation, for example, products produced by injection molding such as light guide panel of LCD, exterior parts of cellular phones are made in the clean room which has virtually constant temperature and moisture.

The effect of the surrounding air has been ignored in less precision product. But the precision products requiring 5~10μ standard deviation needs certain constant environment-condition.

Table 1. shows that in Korea the standard deviation of the air temperature in the rainy weather is lower than that in the clean day. And in the case of furnace process the non-conforming rate in the rainy weather is lower than that in the clean day. (see Table 2.)

	Raining	Clean	P-value
Temperature SD / day (℃)	6.10	14.11	0.000

Table 1. The comparison of the temperature dispersion

	Raining		Clean		P-value
	Mean	SD	Mean	SD	
A Line	16.44	4.81	16.81	6.55	0.742
B Line	18.75	6.80	21.23	9.04	0.108
C Line	32.00	10.40	33.81	6.74	0.269
D Line	23.10	14.70	29.40	16.40	0.040
E Line	19.47	9.02	23.80	15.10	0.073
F Line	24.52	6.17	28.17	8.13	0.009

Table 2. The comparison of the non-conforming rate

3. Experiments

The injection molding process, which often happens in relatively small-size shops could more often afford to have the clean room. But the furnace process of the big volume is impossible to be placed in the clean room lacking an economically compelling reason.

In this study, first, we show that the furnace process which requires maintaining high temperature is very much effected by the cool and changing surrounding air. Second, an alternative, which has relatively constant temperature dispersion surrounding furnace, while still be economically feasible will be proposed.

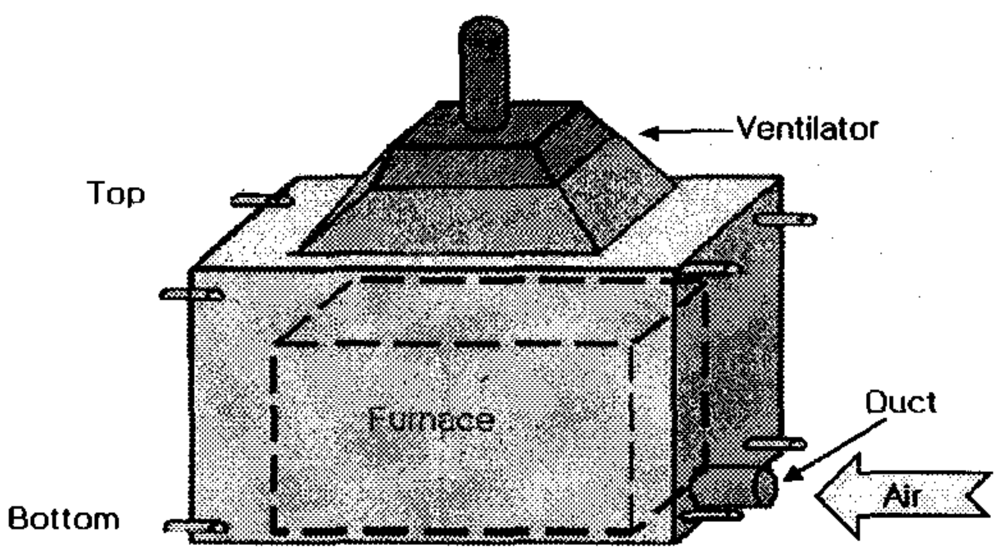
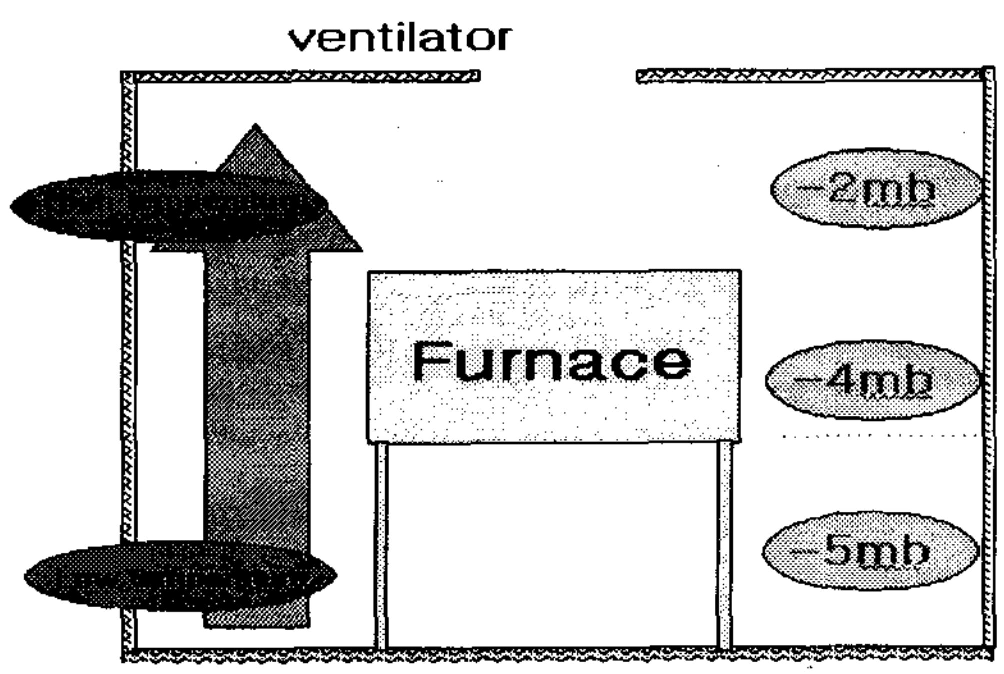


Figure 2. Experimental model

Figure 2. is the experimental model for the effect test by the environment condition like air temperature. By Taguchi method the result shows that when the standard deviation of the temperature(20° ~ 30°) surrounding the furnace is small then that of the inside of the furnace is small. And in the furnace process which is of high temperature placed in the big volumed house, the management of air current inside the house is important.

The air current should be smoothly flowing from the bottom to the top of the furnace house. Figure 3. shows that the air temperature on the top of the house is higher than that at the bottom. But the air pressure on the top is higher, the air current tend to flow from the top to the bottom.



<Figure 3> The status of the temperature and the pressure in the furnace house.

This fact indicates that for the smooth air-current to happen, we must get rid of the variation in the air pressure of the external air along with the variation in the moisture level.

4. Conclusion

In precision processes that require μ-level standard deviation the environmental factors like temperature, moisture and air pressure are very crucial for stabilizing the processes. It is economically viable that the relatively small volumed processes such as injection molding process be operated in a clean room. But the furnace process of relative large volume is not a candidate to be housed in a clean room due to economical reasons.

Therefore in the furnace process the control of the air current, to stabilize the moisture and air pressure level as well as the inflowing air temperature level must be considered for the good operating condition of the glass furnace.

5. References

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