**Analysis on the Relationship between**

**the Cooldown Time and the Temperature of the Steam Transfer Pipes**

During the ironing process of our product, the pipe is heated up due to the hot steam traversing in the pipes. For our product, a cooldown time should be designated in order to have the hot pipes cool down to an acceptable temperature for user to take off the clothes from the pipe frame without getting burnt. Therefore, the mathematical relationship between the cooldown time and the temperature of the pipes at the end of ironing should be analysed and integrated into our electronic controlling system.

The chamber of our product is connected with the atmosphere environment by the two fans ventilating the hot steam. Thus it can be inferred that the pressure inside the chamber is close to the atmospheric pressure. Given this natural convection of heat transfer, it can be assumed that Newton’s Law of Cooling is valid in this scenario. It is also assumed that 30 degree Celsius is an acceptable temperature for human hands to bear.

The temperature of the pipe at the end of the ironing process is and the accepted temperature is . The Newton’s Law of Cooling expression is , where is the heat transfer coefficient (assumed independent of here) (SI unit: ) and is the heat transfer surface area (SI unit: ). It is pointed out earlier that the fans ventilate the hot steam out of the chamber. Therefore, the fans also assist in cooling down the pipes and should be reflected in the expression:

where , is a positive constant characteristic of the system, which must be in units of , and is the sum of the constant power of the two fans.

The solution of this first order, linear ODE, by standard methods of integration and substitution of boundary conditions, gives

Equate the solution to , there is

As a result of the heating process, the ending temperature is always greater than and thus the anti-logarithm is always smaller than 1. Therefore, the expression of time is a monotonous decreasing function. As such, it can be concluded that the higher the ending temperature is (the smaller the anti-logarithm is), the longer it takes to cooldown.

In order to integrate this conclusion into our design product, we first test with the highest steaming power level and the testing results shows that 30 second is sufficient to cool the pipes down to the acceptable temperature range. Therefore, we set 30 seconds to be the cooldown time in the electronic controlling system in safety purpose.