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Applying STAMP/STPA to Analyze the Causes of the Unexpected Fire Happening at the Heat Treatment Process

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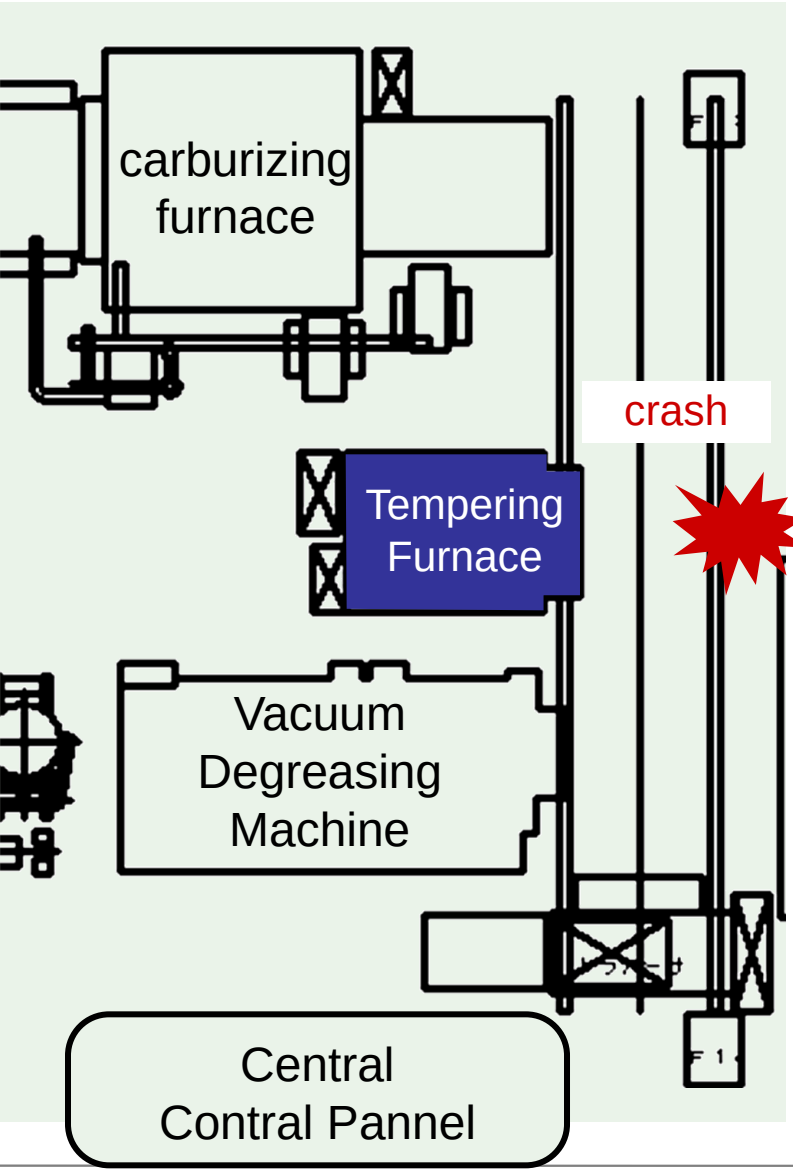
Unexpected Fire

It's the 1st time after the equipment was adopted 10 years ago



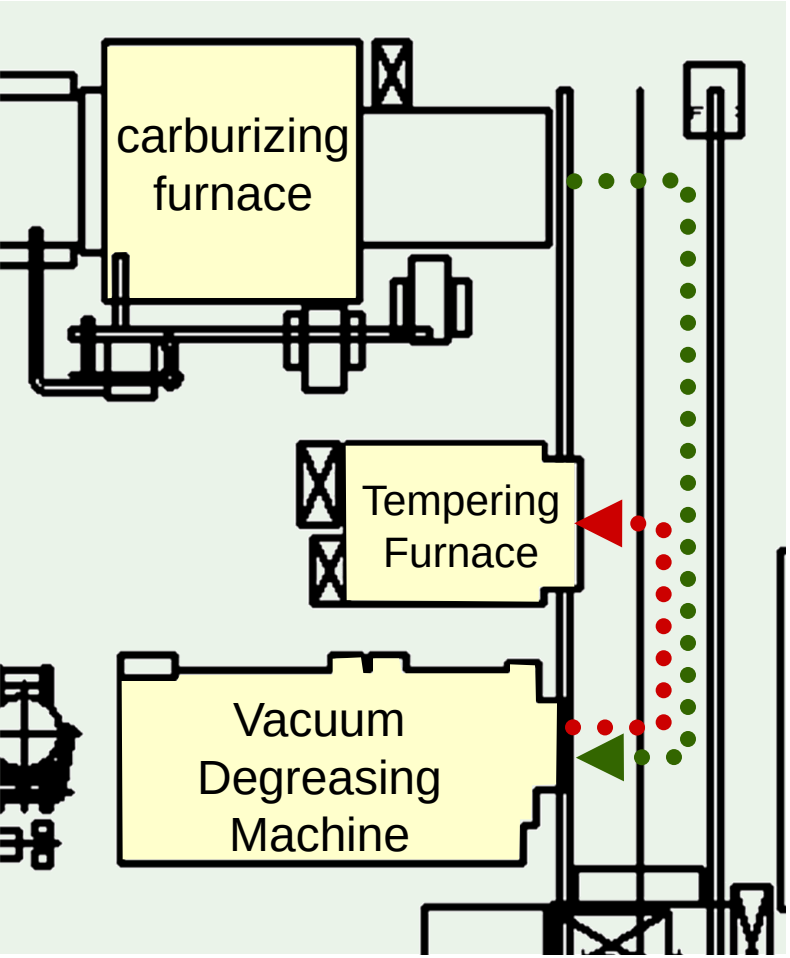
AFTER

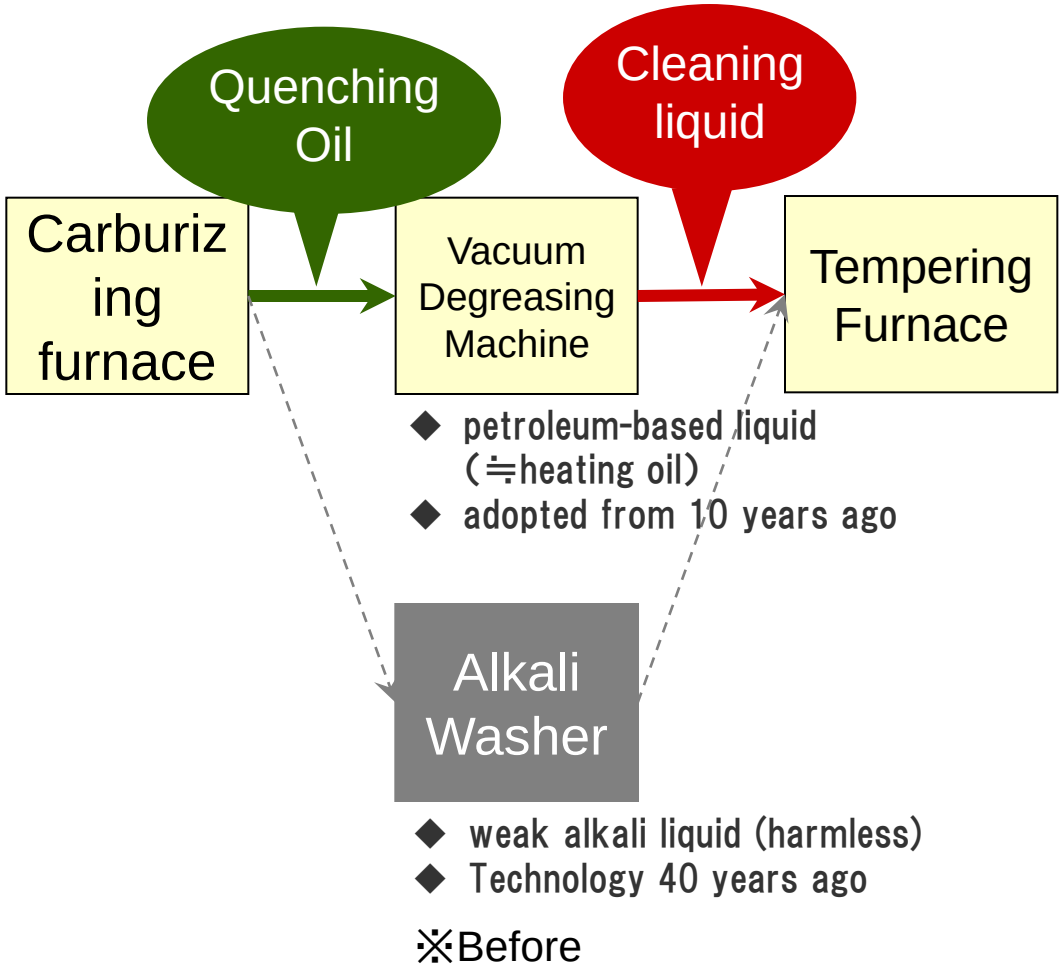
Before

Size of the door
W 1,500
L 220
H 1,300

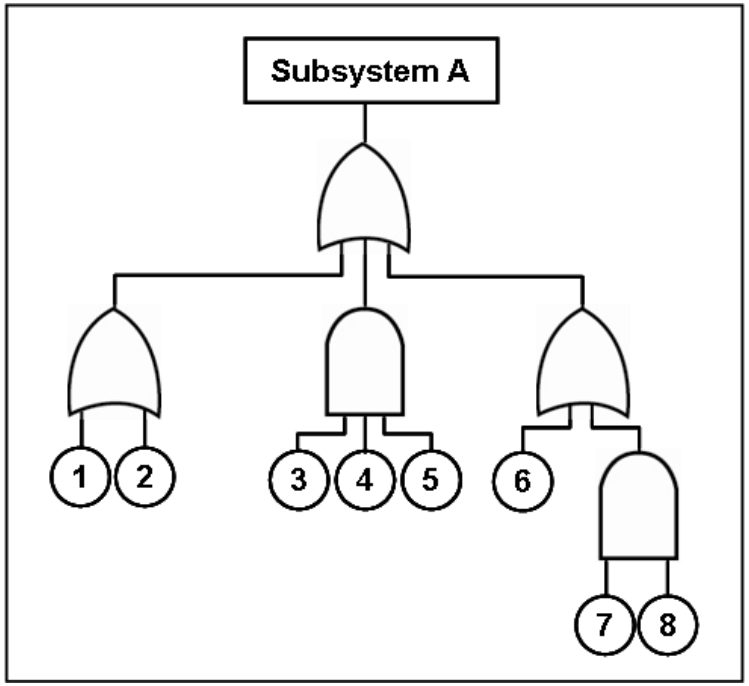
Last year, there is an unexpected fire happening in the tempering furnace at our plant. According to the FTA analysis, we understand the cause is that the cleaning liquid, which is flammable, was brought into the furnace together with the work-pieces. And, when the volatilized flammable gas was close to the heater and heated up to the firing point, the fire was caused.

Stations of the production line





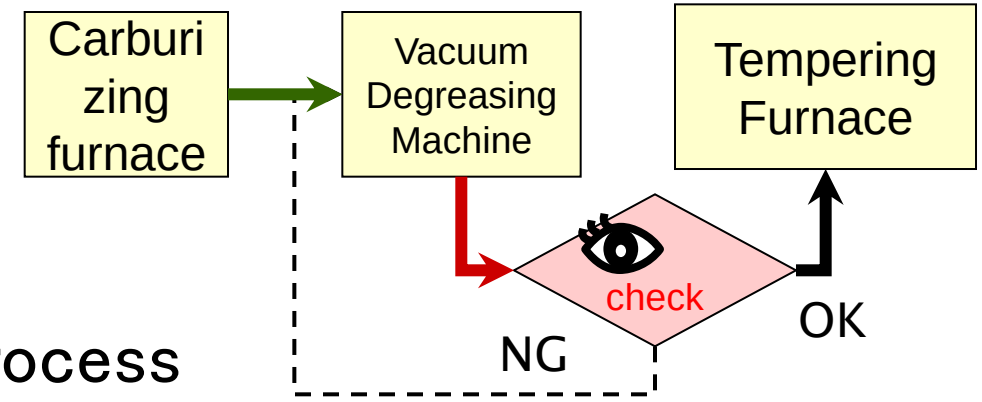
Here is the production line. After carburization, the quenching oil will stay on the work-piece. In order to remove the quenching liquid, the work-piece needs to be sent into the Vacuum Washer before it gets into the furnace.



Concept of FTA
(http://en.wikipedia.org/wiki/Fault_tree_analysis)

Cause Analysis

The flammable cleaning liquid was heated up at the Carburizing Furnace



Countermeasure

Adding a Visual Check Process

After the FTA analysis, we found the main cause of the unexpected fire is that the flammable cleaning liquid was heated up at the Tempering Furnace. Therefore, as our countermeasure, we added an operator into the process, to check if there is any liquid left on the work piece or not.
To prevent the recurrence completely, we recently applied STAMP/STPA to review the countermeasure again.

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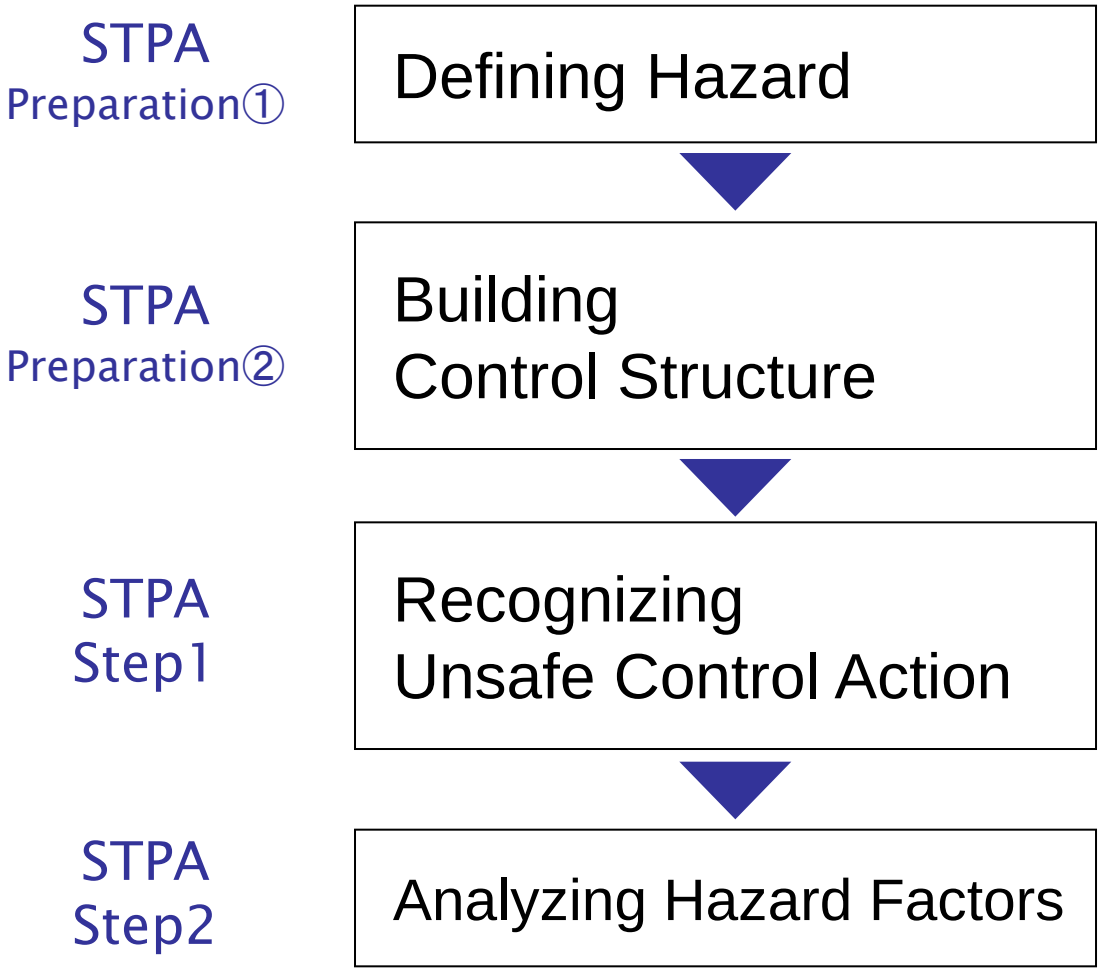
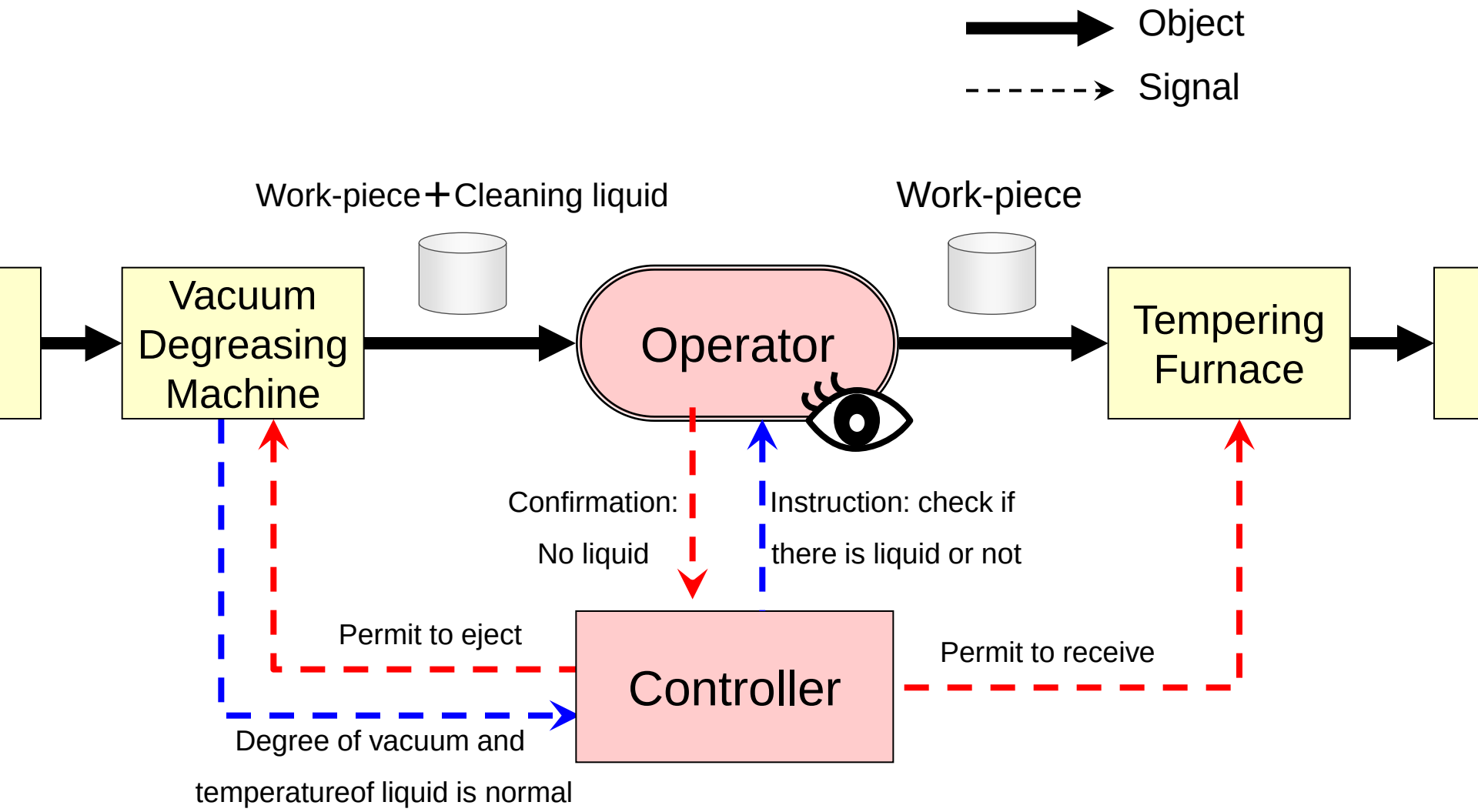
Process of STAMP/STPA



According to the process of STPA, we tried to build the Control Structure.

Control Structure



First, before the work-piece goes out from the Vacuum Degreasing Machine, The Degreasing Machine will send signal to the Controller to report the degree of vacuum and temperature of the liquid is normal or not. If everything is normal, the Controller will then send the signal to permit the The Degreasing Machine to eject the work piece out. And then, the Controller will ask the operator the check if the liquid has been removed or not. If everything is ok, the operator will push the button to send feedback to the Controller. Then, the Controller will permit the Tempering Furnace to receive the work-piece.

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Recognition of Unsafe Control Action

Command	Not provided	Incorrectly provided	Provided too early/late, out of sequence	Stopped too soon
It's OK to receive the work-piece	No hazard	No hazard	No hazard	No hazard
It's NG to receive the work-piece	No hazard	**If OK signal is inputted when there is liquid left, Hazard happens.**	No hazard	No hazard

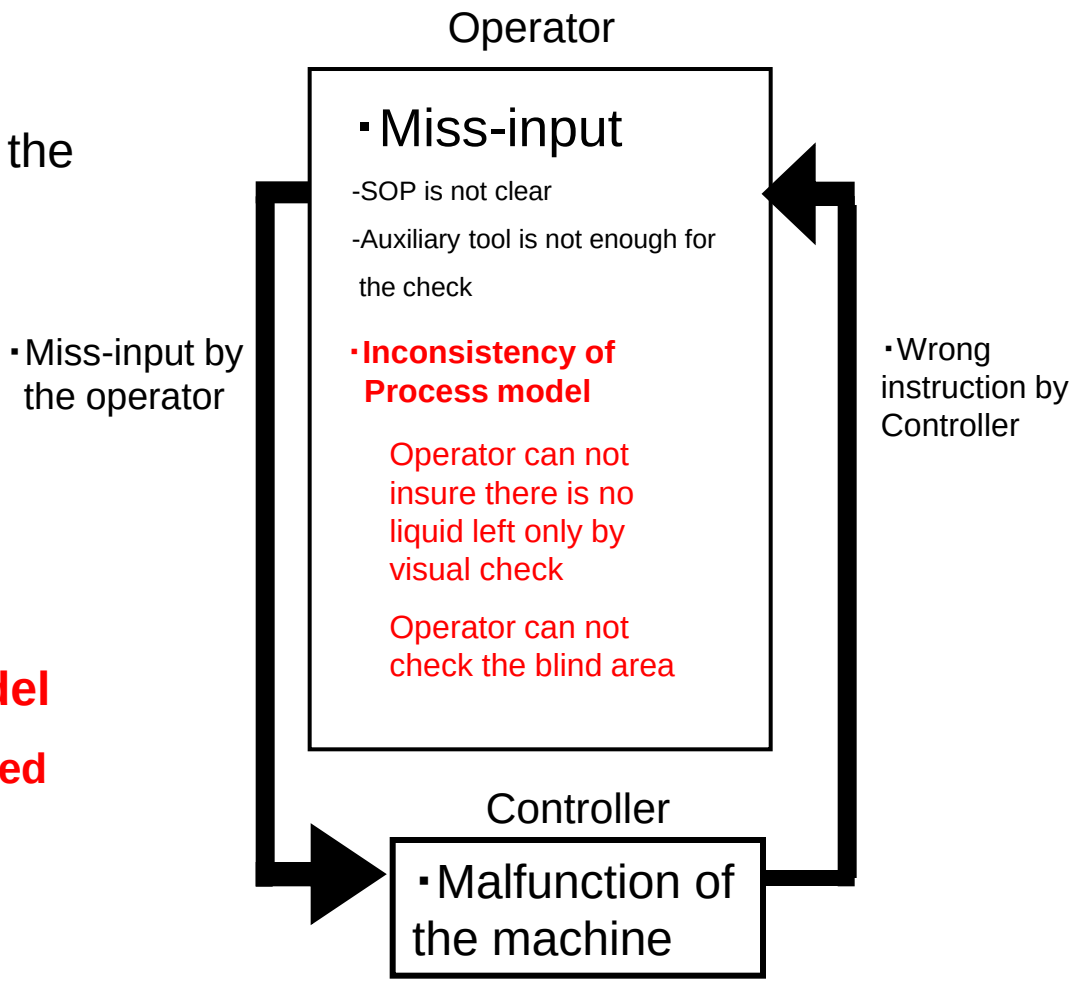
	Much	Little	Observable	NOT Observable
Condition: Liquid stays on the work-piece	identifiable	**Not identifiable** ↓ **Because of it is a tiny amount, effect is little** ↓ **Once accumulated in the furnace, Hazard happens**	identifiable	**Not identifiable** ↓ **Because of it is a tiny amount, effect is little** ↓ **Once accumulated in the furnace, Hazard happens**

And next, we tried to find out the Unsafe Control Actions. For example, if the operator considers that the work piece shall not be thrown into the furnace, BUT he just pushes the wrong button. And then the hazard will happen.
Or, if the quantity of the liquid is too little to see, it will accumulate in the furnace gradually and leads to the hazard finally.

Whole picture of the hazard recognized

- Malfunction of Controller
- OK signal is miss-inputted while the ituation is NG
- Miss-input by the operator
  - -SOP is not clear
  - - Auxiliary tool is not enough for the check

- **Inconsistency of Process model**
  - **The ability of visual check is limited**
  - **The existence of the blind area**
- Wrong instruction by Controller



After the STAMP analysis, we can see that there are some inconsistency of the Process Model that the current FTA cannot find out, such as “the ability of visual check is limited” or “the existence of the blind area”…etc.

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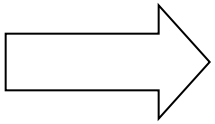
Risks we analyzed by STAMP/STPA

FTA FMEA	The cleaning liquid should not be brought into the furnace.
STAMP /STPA	It is unavoidable that the cleaning liquid gets into the furnace.



To prevent the liquid from accumulating, a periodical burn-out is adopted.

As a conclusion, we found that the FTA or FMEA will only try to prevent the cleaning liquid from getting into the furnace. However, on the other hand, the STAMP analysis shows us that it is unavoidable that the cleaning liquid gets into the furnace.
Therefore, according to the result of STAMP/STPA, we did some modification on our countermeasures. For example, to prevent the liquid from accumulating, a periodical burn-out is adopted.