NitroJet's Basic Characteristics and Decontamination Performance for Concrete Scabbling - 17025

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ABSTRACT

The nuclear decontamination and decommissioning (D&D) market is much growing all over the world. Especially many Japanese NPPs are determined to be shut down. Then, IHI Corporation (hereinafter, IHI) have NitroJet® technology to scabble concrete, remove paint, and cut metals by spraying liquid nitrogen to be applied to such D&D operations. As spoken at WM2016 [2], NitroJet®'s decontamination performance for painted metal plate was verified quite high. Then, IHI tried verifying NitroJet®'s basic characteristics to scabble bare and painted concrete, and its decontamination performance by comparing water jet.

INTRODUCTION OF NITROJET®

NitroJet® is an "Ultra-High Pressure Cryogenic Decontaminating System" by using liquid nitrogen. IHI is the licensee to promote NitroJet® in Japanese nuclear business. NitroJet® sprays liquid nitrogen and it can scabble concrete without generating secondary liquid waste. (See Fig. 1.) Liquid nitrogen combines 3 effects as below.

1. Low temperature (-150°C) makes the material to be removed fragile.
2. Blast effect of the cryogenic fluid expands 700 times during vaporization.
3. Ejection speed of the fluid provides the kinetic energy to lift the material from the substrate

NitroJet® skid　　Concrete scabbling　　Coating removal

Fig. 1. NitroJet®

NitroJet® system includes a liquid nitrogen storage tank, a main skid, a cooling chiller, a jet nozzle that sprays liquid nitrogen, a shroud cover, and a vacuumed collector. (See Fig. 2.) When the level of contamination is low, NitroJet® can be operated directly by workers wearing protective clothing, and when the level of contamination is high, the jet nozzle can be operated remotely by a robot. In order to prevent scattering contaminated material to the surrounding areas, the jet nozzle is covered by a shroud cover and it is connected into a vacuumed collector. The collected material is handled as solid waste, so handling is quite simple. It is also possible to mount NitroJet® together with the liquid nitrogen storage tank onto a trailer.

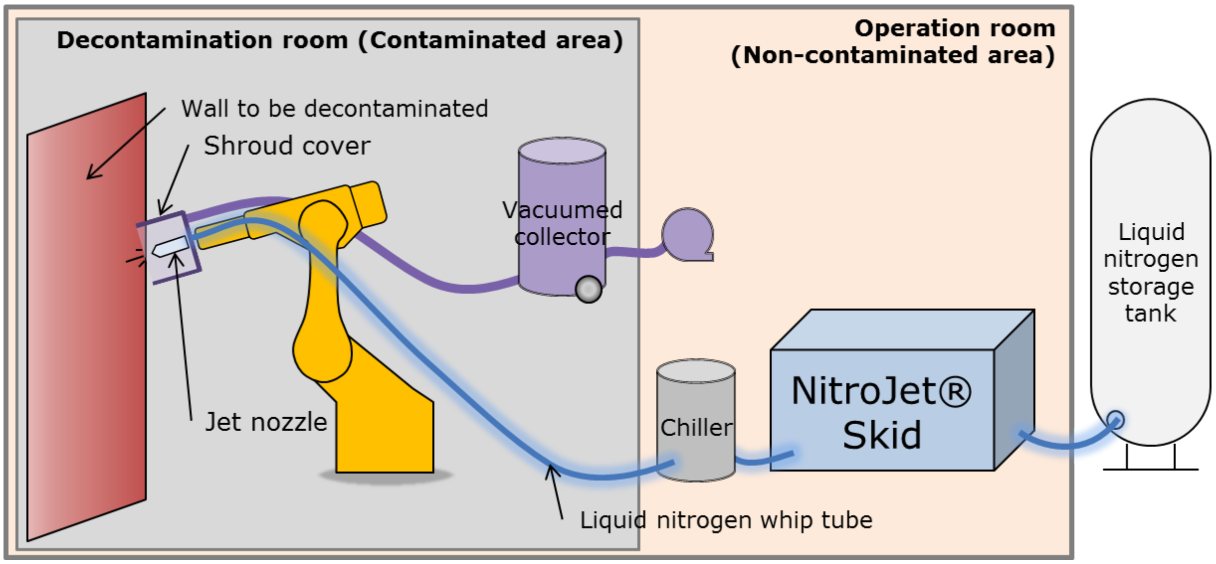

Fig. 2. NitroJet® process

OBJECTIVES

The objectives focused here were as below.

1. Verify NitroJet®'s basic characteristics to scabble concrete (both bare and painted)
2. Verify NitroJet®'s decontamination performance by comparing water jet

To achieve them, concrete test pieces (size: 200 x 300 x t50mm) were prepared, which had the same specification as concrete walls and floors in general nuclear power plants in Japan.

BASIC CHARACTERISTICS TO SCABBLE CONCRETE

Acquiring basic characteristics is very important to know how NitroJet® can work and what kind of work is suitable to be applied. Then, we evaluated its scabbling depths (mm) for bare concrete from each combination of setting parameters.
Additionally, some concrete structures or buildings to be decontaminated may be painted, so we also evaluated NitroJet®'s scabbling depth for painted concrete.

Bare Concrete Scabbling

At first, we verified for bare concrete with controllable parameters, which are intensifier pressure (220-315MPa), scanning speed (50-315cm/min). And others

were optimized in advance.
Fig. 3. is the result of scabbled depth of bare concrete. NitroJet® could scabble concrete more than 40mm depth at maximum in one scanning, so it's quite powerful. Therefore, scabbled depth is mostly depending on scanning speed. (Bending arrow) So we can control scabbled depth from deep to shallow by scanning speed. In the case that scanning speed was fixed, scabbled depth depends on intensifier pressure. (Dashed arrows)

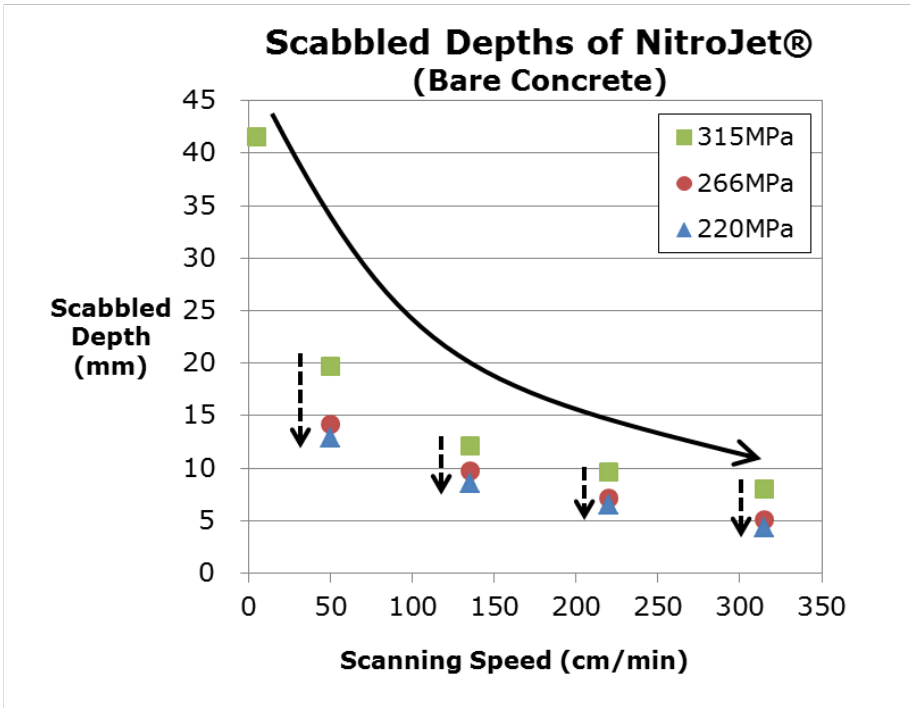

Fig. 3. Scabbled Depth of NitroJet® (Bare Concrete)

Painted Concrete Scabbling

Secondly, we verified scabbling for painted concrete. This paint specification is a simulated wall of buildings in some nuclear power plants in Japan.
Fig. 4. is a scabbled pass of painted concrete. Its scabbling depth is about 20mm.

Fig. 4. Scabbled Pass of Painted Concrete

Fig. 5. is a plot of scabbled depths for painted concrete. Open squares are painted and filled circles are the same data as Fig. 3. (Only 220 and 315MPa) As the result, NitroJet® basic characteristics for painted concrete are as well as bare concrete.

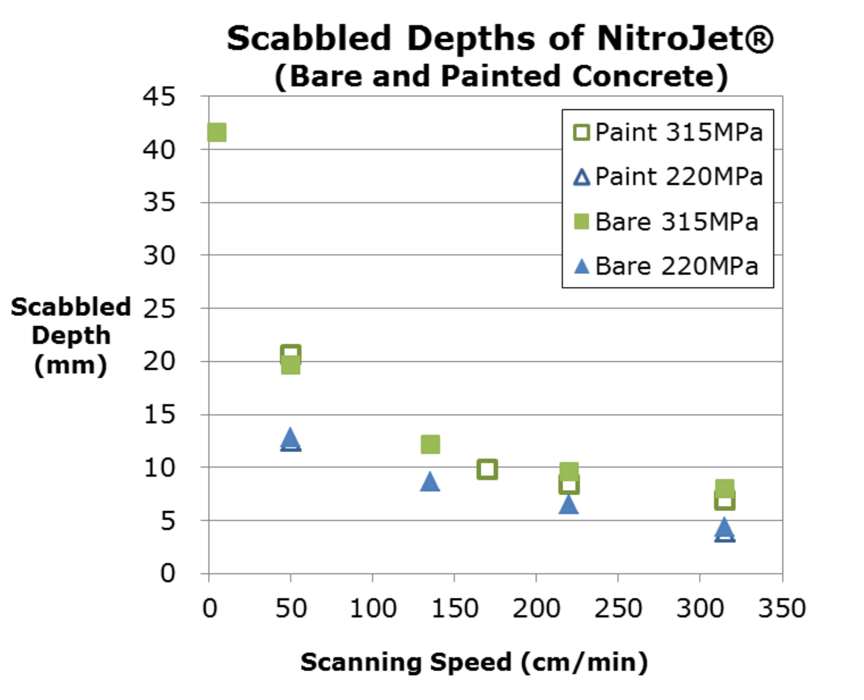

Fig. 5. Scabbled Depth of NitroJet® (Bare and Painted Concrete)

DECONTAMINATION PERFORMANCE

It is also important to know NitroJet®'s decontamination performance to apply it in the nuclear D&D market. IHI approached this objective by 2 methods as below.

Observing Residue Contamination

We tried observing residue contamination after scabbling by NitroJet®. Water jet scabbling was observed as well.
To achieve it, bare scabbling test pieces where fluorescent paint was adhered, were prepared to observe simulated residue contamination. Fig. 6. is shown as an example. This is a concrete block which is cracked by a hammer after adhering fluorescent paint. The left image is taken under room light and the right one is under black light in a dark room. Fluorescent adhered part and even cracked concrete powder are seen brightly in the right image. Then, it can help to observe residue contamination.

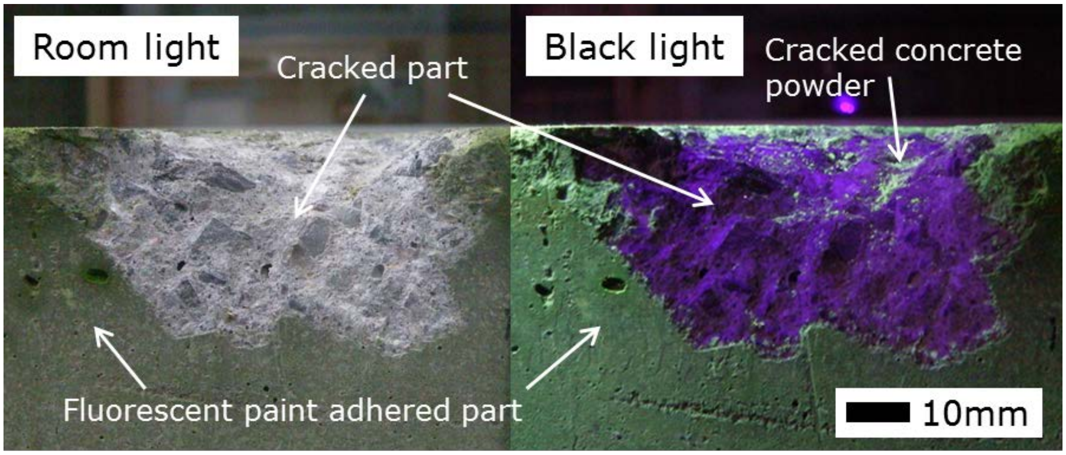

Fig. 6. Fluorescent Paint Adhered and Cracked Test Piece (By a Hammer)

Fig. 7. is a scabbled pass by NitroJet®. The image above is taken under room light and the one below is under black light. Despite plain area is bright, scabbled area is totally dark in black light. This means that contamination on the surface have disappeared after scabbling by NitroJet®.

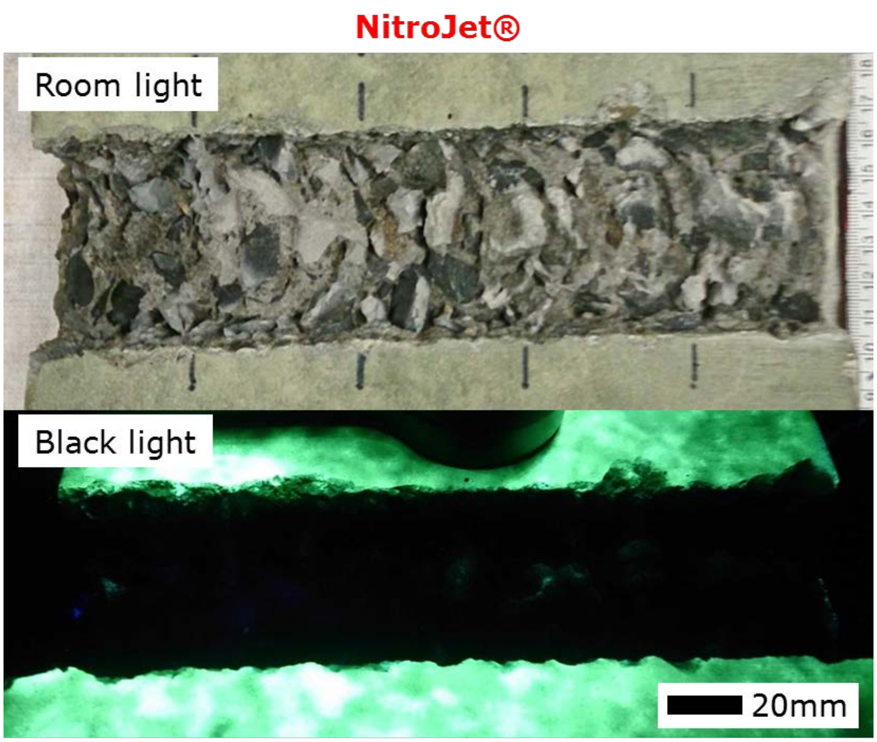

Fig. 7. NitroJet®'s Scabbled Part

Fig. 8. is another scabbled pass by water jet. Its scabbled depth is as deep as NitroJet®'s, and black light brightness of both methods is controlled to be the same. Scabbled area is much darker than plain area, but some bright parts are left there. This means that a little of residue contamination stays after scabbling by water jet.

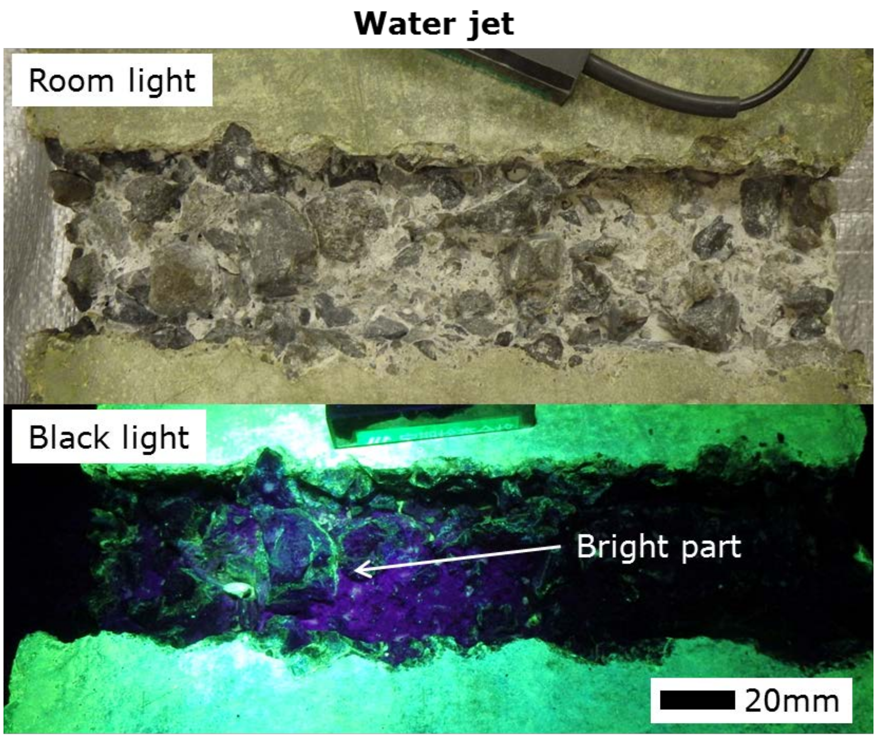

Fig. 8. Water jet's Scabbled Part

As the result, NitroJet® could remove most of contamination by scabbling concrete without cross contamination. Therefore, its decontamination performance may be higher than water jet.

Acquiring Decontamination Factor

According to observing residue contamination as above, NitroJet® can be expected to have high decontamination performance. However it was difficult to be counted how high it is. Then, we tried verifying it by acquiring DF (Decontamination Factor). DF is a ratio of physical quantity prior to and after the decontamination. (See Eq. 1)

$$\mathbf{DF} = \frac{\mathbf{D_0}}{\mathbf{D_1}} \qquad \text{(Eq. 1)}$$

Here, D_0 stands for the amount prior to decontamination, and D_1 is the one after decontamination.
At this verification, a kind of non-radioactive tracer was used. We prepared other test pieces with this tracer and tried scabbling on them. And the samples of them both before and after scabbling were analyzed to acquire the masses of the tracer, and then we calculated DFs. At this scabbling, scabbled depths were controlled from 8 to 16mm to know the differences of DF up to scabbled depths.
Fig. 9. is a plot of acquired DFs. NitroJet®'s DF was more than 100. This is quite high decontamination performance. And it tends to increase along scabbled depth. On the other hand, water jet's DF does not have a relationship with scabbled depth. It may be because of cross contamination seen as Fig. 8.

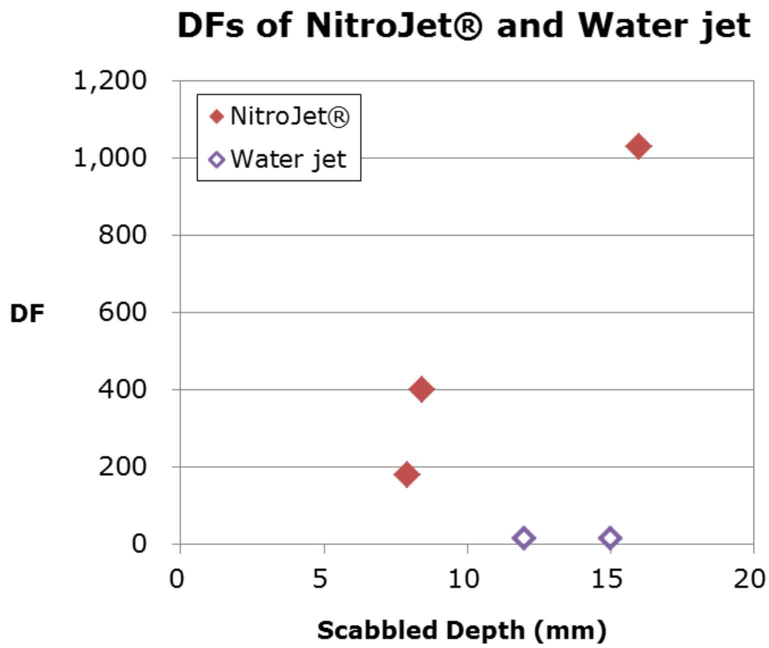

Fig. 9. DFs of NitroJet® and Water jet

CONCLUSIONS

At first, we tried verifying NitroJet®'s basic characteristics to scabble concrete of both bare and painted. Its scabbled depth was 40mm at maximum and it can be controlled with scanning speed.
Secondly, we tried verifying NitroJet®'s decontamination performance by comparing water jet. Then, Fluorescent paint as a simulated contamination was used to observe cross contamination. And non-radioactive tracer was analyzed to acquire DF. As the results, NitroJet®'s DF was more than 100 and quite high. Moreover it doesn't remain cross contamination.

REFERENCES

1. Lettie Chilson (2011) "Decontamination Using Remote-Deployed Nitrocision® Technology," Proceedings of the Waste Management 2011 Symposia.

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3. Yuichi Takahama (2016) "NitroJet®'s Decontamination Performance for Concrete Scabbling," Proceeding of the Asian Nuclear Prospects (ANUP) 2016.