DECONTAMINATION AND DECOMMISSIONING

R. A. Langley, Chairman
R. Ramsey, Co-Chairman

DECONTAMINATION OF STEEL PIPE WASTE BY HONING

M. TAKEUCHI[1], T. MORISUE[2], Y. HASEGAWA[2], T. TAKAHARA[2]
A. ISHIHAMA[3]

(1) The Chubu Electric Power Co., Inc., (2) Toshiba Corporation
(3) Niigata Engineering Co., Ltd.

INTRODUCTION

The operation of nuclear power stations will generate large quantities of surface contaminated metallic waste. This metallic waste will require expensive handling and storage. The ability to remove this surface contamination would eliminate both the expense of radioactive storage and disposal and any associated risk of environmental contamination.

The most part of the surface contaminated metallic waste is steel pipes. The steel pipe interior is contaminated by the crud. The method applied in the present work was mechanical decontamination by honing, rotating a hone (a kind of whetstone) in the pipe to remove the contaminated surface. Features of this honing decontamination method are as follow.

(1) Metallic waste contamination levels can be reduced to below the background level.
(2) This method can be easily applied to a long pipe using an arm extension attachment.
(3) Waste generated by this method is less than that in the chemical decontamination method using acid and is easily treated.

This paper discribes the results of steel pipe decontamination test by honing and the honing decontamination equipment concept.

HONING DEVICE

Several hone categories were researched, and Flex-hone was selected for the experiment. The name Flex-hone is a BRUSH RESEARCH MANUFACTURING Co., Inc. trade mark. As shown in Fig. 1, instead of two or three rigid stones, the hone has hundreds of smaller stones, which are formed on the ends of high density nylon strands forming a brush which is fed through the pipe while being rotated. There is very little pressure against the pipe wall —— only that pressure caused by centrifugal force of the rotation. Due to this centrifugal action, the whole hone is self-centering and self-aligning. The metal surface is removed by the hone rotation inside the pipe during honing cycle.

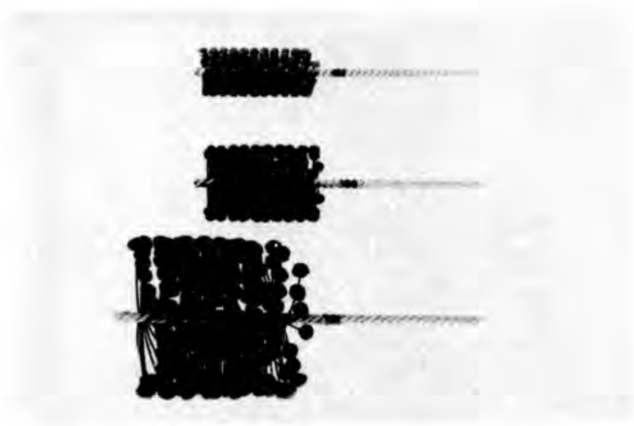

Fig. 1 Flexible honing device (Flex-hone)

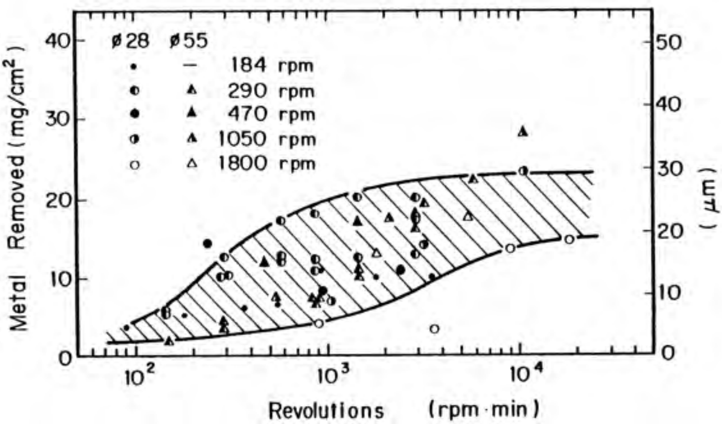

Fig. 2 Metal removal from stainless steel pipe interior by honing

FUNDAMENTAL TEST

Specimen and Procedure

Some fundamental data, such as metal layer thickness removed by honing, were obtained by small specimens of carbon and stainless steel pipes:

JIS STPG 38 carbon	27mmID x 50mm 57mmID x 50mm 102mmID x 50mm
JIS SUS 304 stainless steel	28mmID x 50mm 55mmID x 50mm

Metal surface was removed by the hone with a 60 grit aluminum oxide. It was need that the hone diameter was 1.1$\sim$1.2 times larger than the pipe inner diameter for contacting the inside of the pipe. The actuation and the rotation of the hone were carried out by a drilling machine (SKD-13, SEIKO-SHA Co.). The hone rotation speed was adjustable in a wide range (470$\sim$1800 rpm), and monitored by a tachometer. Honing time was maximum 10 minutes. Each specimen was weighed on a chemical balance (LU-T1200D, SHIMADZU Co.) before and after honing with a precision of ±10 mg.

Metal Removal

The metal removed by honing is a function of hone revolution speed (ϕ) and honing time (t). Metal removal data as a function of the number of revolutions (ϕt) are shown in Figs. 2 and 3. Metal removal thickness (δ) was calculated using the following equation,

$$\delta = w / \rho_0$$

where w is the metal removal amount per unit surface area, and ρ_0 is metal density. The 13$\sim$25µm (10$\sim$20mg/cm^2) thickness could be removed within about 3$\sim$5 minutes. Metal removal amount did not increase infinitely with increasing both hone revolution speed and honing time. The prefered hone revolution speed was in the range from 500 to 1000 rpm, and the honing time from 3 to 5 minutes for especially removing the base metal from the steel pipe inner surface. Metal removal rates for carbon and stainless steel pipes were almost the same. The difference in pipe diameter in the 27 to 102 mm range hardly effected the thickness of metal removed by honing.

Moreover, the honing method applicability to a long pipe, about 2 meters in length, was confirmed experimentally using an arm extension attachment.

Surface Analysis

Some carbon and stainless steel pipe specimens were immersed in sea water for 40 days. About 15mm x 30mm sections were cut out of the specimens before and after honing for pipe interior surface analysis. The interior surface roughness was

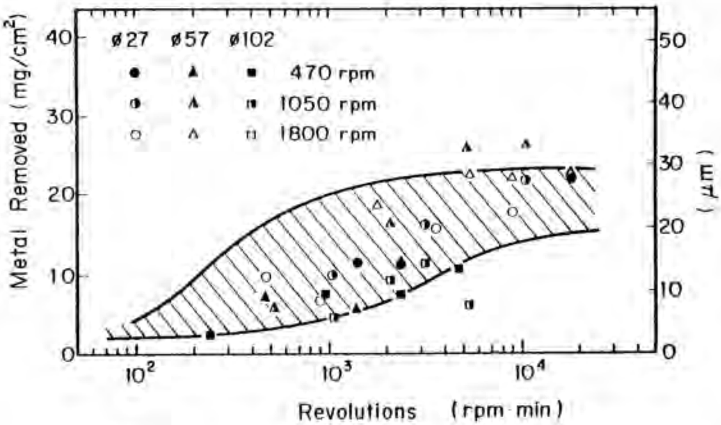

Fig. 3 Metal removal from carbon steel pipe interior by honing

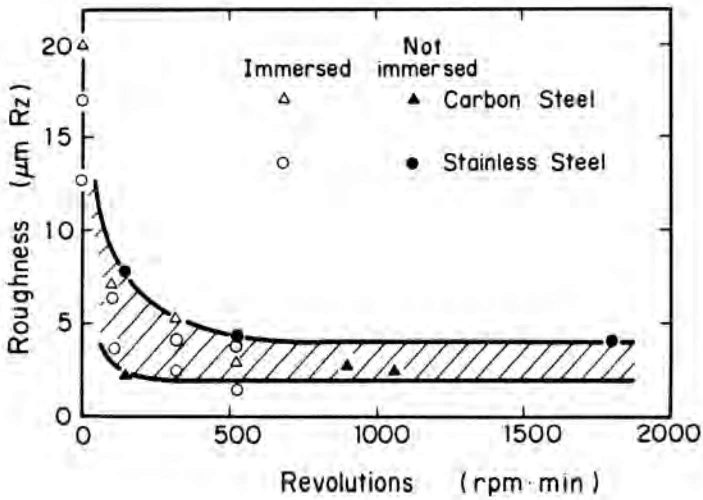

Fig. 4 Surface roughness caused by honing

measured by a surface analyzer with a diamond stylus at 0.01μm accuracy (SE-3, KOSAKA LAB. Co.). Results are shown in Fig. 4. The final quality ranged from 2 to 4μm R_Z (ten point roughness).

Microscopic observation of the pipe interior surface was carried out with a scanning electron microscope (JXA-733, JEOL Co.). Figure 5 compares the specimens surface before and after honing. Although scratches were introduced, the processed surface was very flat and free of macroscopic irregularities.

DECONTAMINATION TEST

Specimen and Procedure

Specimens were sampled from the Radioactive Waste Disposal System (RW) and the Reactor Water Cleanup System (CUW), SUS 304 stainless steel, at the Hamaoka Nuclear Power Station Unit 1 (BWR 540MW), operated by the CHUBU ELECTRIC POWER Co., Inc. Small specimens were used for the honing decontamination test:

RW specimens	32mmID x 60mm
CUW specimens	50mmID x 40mm

Hone rotation was driven by a lathe (LEQ·G-125A, WASHINO MACHINE Co.) instead of the drilling machine used for the fundamental test. Hone revolution speeds were 290 rpm, and 184 rpm in part. Honing time was 20 minutes at maximum. The metal removal amount was weighed on a chemical balance. The radioactivity of the specimens was measured before and after honing by a GM counter and a Ge(Li) detector to determine the decontamination factor (DF).

Decontamination

The decontamination factor for the honed specimens is shown in Fig. 6 as a function of metal removal amount. A constant 100∿300 decontamination factor was obtained with 10mg/cm^2 or more metal removal. The background radiation level could be reached in the case of the specimens sampled from the Radioactive Waste Disposal System. However, it was difficult to decontaminate the specimens sampled from the Reactor Water Cleanup System with deep depression (up to ∿200μm).

Major contaminant nuclides were cobalt-60, manganese-54 and zinc-65. As shown in Fig. 7, the decontamination factor values for each nuclide were mostly similar to each other.

Figure 8 shows contamination of the hone used. The hone contamination level is defined by ratio of the amount of contaminant transfered to the hone and the amount of contaminant removed from the surface of the specimen by honing. Contamination of the hone decreased with an increase in honing time. Water supply against the inside of the pipe during rotation of the hone to cool the hone carried away the contaminated

100 μm

Original specimen

100 μm

After 5 min honing

Fig. 5 SEM micrographs of specimen surface (stainless steel immersed in sea water for 40 days)

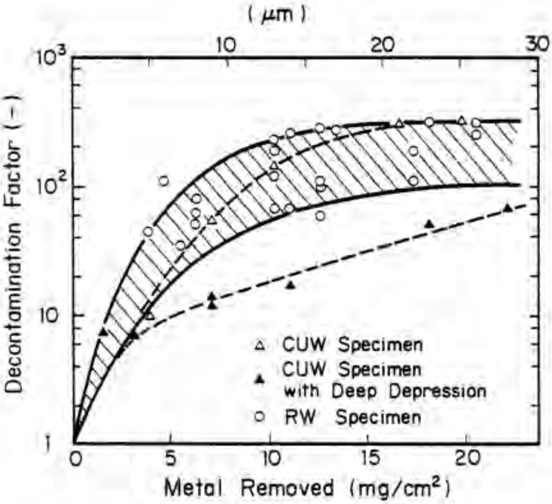

Fig. 6 Decontamination factor caused by honing

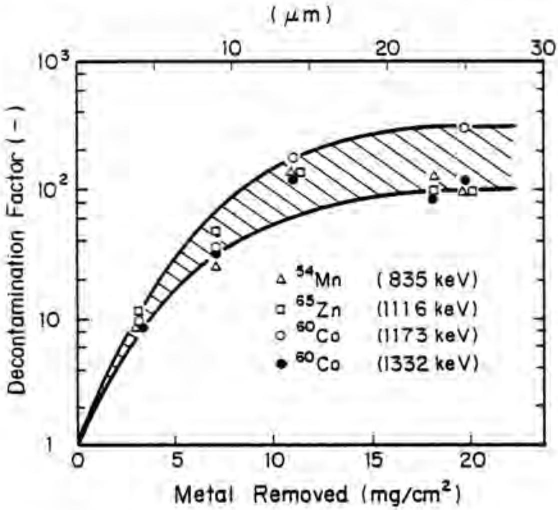

Fig. 7 Decontamination factor for each nuclide through honing

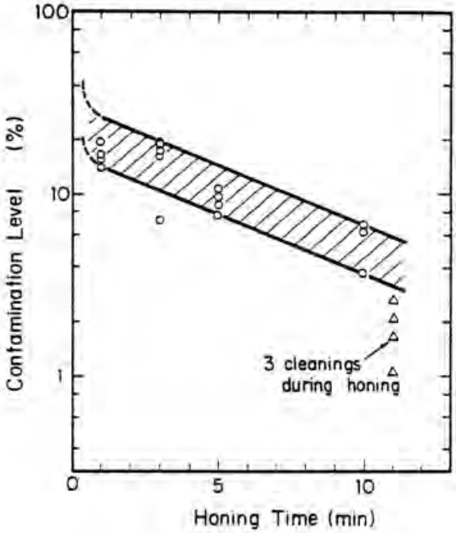

Fig. 8 Contamination of hone used

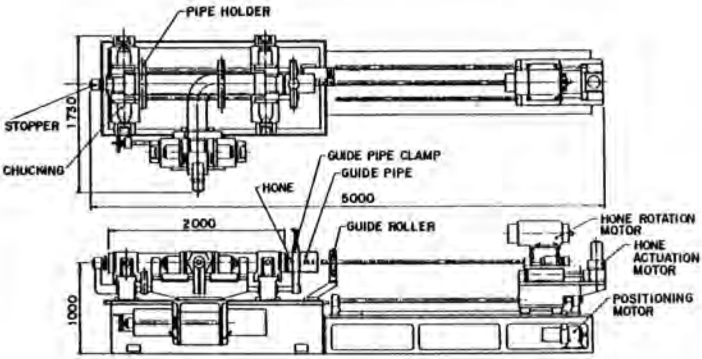

Fig. 9 Mechanical decontamination equipment concept

particles that have been removed. Especially, cleaning the hone was effective to prevent hone contamination.

DECONTAMINATION EQUIPMENT DESIGN

On the basis of the above results, mechanical decontamination equipment using honing was designed as shown in Fig. 9. The decontamination equipment comprises a rotatable hone, hone drive mechanisms and pipe chuckings. The hone is connected to a hone rotation motor by a flexible shaft. Hone rotation motor may be a 3.7 kW DC motor chosen. The hone is inserted into pipe through a guide pipe, and contacts the inside of the pipe. The pipe surface is removed by rotation and actuation forward and backward of the hone. The positioning motor is used for remotely advancing and retracting the rotatable hone. Water used to cool the hone is processed for the contaminated particles by filtration, and reused. Equipment is $1730mm^W \times 5900mm^L \times 1450mm^H$, and its weight is about 1000kg. Processing time is 30 ∿ 120 minutes/2000mm long pipe.

Equipment features are as follow,

—— Operation by remove control,
—— Auto-chucking for a contaminated pipe,
—— Decontamination of both carbon and stainless steel pipes (27 ∿ 216mm OD x 2000mm long),
—— Decontamination of 90° elbows pipe.

CONCLUSION

The following conclusions were obtained experimentally.

(1) Steel pipe inner surface decontamination by honing is possible within a short period of time for a pipe without deep depression.
(2) Honing can be applied for a long pipe using an arm extension attachment.

On the basis of the above results and conclusion, a remote operational equipment for decontamination was designed.