Replica Molding Technique – Quick and Accurate

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Abstract
In most industries, reduced outage time is of major importance. Hence, it is essential to have an NDE method that allows quick and accurate analysis of surface indications and anomalies.

The Replica Molding Technique (RMT) used by WesDyne has been developed to deliver fast and accurate surface inspections, both submerged and in open air. The technique enables detection, characterization and length sizing of surface breaking defects with very high accuracy. In the Swedish nuclear industry, RMT is a validated and qualified method for detection, characterization and length sizing of 3 µm wide and 1.5 mm long surface breaking defects. Additionally, the technique is used for profile measurements and modelling of the resulting replica using 3D laser scanning.

Unlike other surface inspection techniques, RMT is not affected by complex object geometries, under water challenges or radiation levels. However, a major benefit is the rather short preparation and mobilization time required for the complete RMT system to be ready for inspection.

Introduction
The basic principle of replica molding is to make a rubber imprint of a surface. This is done by applying a silicone based molding compound on the surface where it hardens – resulting in a highly accurate inverted copy of the surface.

![Figure 1: Replica mold with defect.](image)

The replica molding compound consists of two parts, a base material and a hardener, which are mixed together by a mixing nozzle. The compound can be applied manually or remotely using compressed air.
The RMT used by WesDyne originates from forensic science. In Swedish nuclear industry, the RMT started in 2004. Since then, WesDyne has furthermore evolved the technique.

The RMT is a validated and qualified technique within the Swedish nuclear industry. The technique is controlled by the general procedure AVT01 [1], which states that surface breaking defects as small as 1.5 mm in length and 3 µm in width can be detected, length sized and characterized. RMT can be performed in open air but also under water at depths down to 30 m, at a temperature interval of 15 °C – 50 °C.

**Remote RMT**

To perform remote RMT a molding frame is used. The frame has an inlet where the molding compound enters and an outlet where air/water is evacuated. Both the frame and the inlet/outlet channel are made of transparent material to facilitate camera surveillance of the remote RMT process. The frame also has a specially designed foam strip that seals off the area of interest.

![Figure 2 Molding frame designed by WesDyne to perform remote RMT on control rod extensions.](image)

The frame is equipped with a standardized reference block containing defects corresponding to half the width of the detection target. The purpose of the reference block is to ensure the replica molding compound quality is satisfactory, i.e. that it can replicate the actual defect size.

![Figure 3 Replica mold of a standardized reference block with defect lines (1.5 µm width).](image)

Temperature is an important parameter to consider during remote RMT since it affects the working and curing time of the replica molding compound. Hence, the frame can be equipped with a temperature sensor which enables temperature measurement in the immediate vicinity of the object.
Each specific RMT object requires its own molding frame design. First a molding frame CAD model is created based on object drawings. Then the CAD model is transferred into the WesDyne 3D printer which creates a molding frame prototype. The printed prototype is used for experimental trials to find the optimal frame design for the specific object. This work requires a fast manufacturing process where new frame designs can easily be created. The WesDyne 3D printer makes it possible to manufacture molding frames with complex geometries for various purposes in a short amount of time.

**Detection**
RMT can be used as a standalone NDE technique for detection and characterization of surface breaking defects. The technique is suitable for inspection of objects with complex geometries. For example, RMT has been used in boat sample excavations after defect removal to verify that no defect remains in the bottom of the excavation.

**Characterization**
RMT can be used as a complementary NDE technique for characterization of surface breaking indications detected using other NDE techniques. For example, RMT has been used to characterize indications detected with Visual Technique (VT) and Eddy Current Technique (ET).

![Figure 4: An ET indication characterized as a crack on replica mold. The crack location is marked with thin needle tips for 3D modelling purposes.](image)

**Microscopic Analysis**
The RMT analysis is performed with a calibrated microscope that enables defect detection with very high accuracy. Defect images are grabbed using special computer software which is compatible with the microscope. The software enables length sizing of defects, area measurement, image stitching etc.

![Figure 5: Microscopic analysis of replica mold – length sizing of defect using image stitching.](image)
Profile Measurement
The replica can be used for profile measurement by importing a surface geometry picture of the mold, as seen in Figure 7, into a CAD program. In picture a reference grid is needed to scale the mold correctly in the CAD program.

3D Laser Scanning
The replica mold can be screened using a 3D laser scanning technique where the scanner has a resolution of 0.04 mm. Then the scanned data can be transferred into a CAD model presenting the object geometry, which can be used for wear extent measurements, object dimension measurements etc.

Summary
RMT is used for:

- Detection, characterization and length sizing of surface breaking defects.
- Profile measurement.
- Modelling of the replica using 3D laser scanning.

RMT is a fast and accurate NDE method which allows outage time savings. The method is not affected by complex object geometries, under water challenges or radiation levels.

References