# THREAD INSPECTION MANIPULATOR for PRIMARY LOOP COMPONENTS of VVER 1000/1200 NUCLEAR POWER PLANTS

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***ABSTRACT*** - HRID developed special manipulator for inspection of different size of threads (M36, M48, M52, M60, M64, M100) on nuclear power plant (VVER 1000/1200) components with eddy current and ultrasonic methods. Manipulator is extremely easy to use reducing personnel time in radiation zone significantly. 95% of all assembling and disassembling activities can be performed manually without use of any tool. It allows quick inspection of threads with both methods in fully automatic mode.

***Keywords***: threads, manipulator, nuclear power plants, inspection, eddy current, ultrasonic

## 1. INTRODUCTION

This article describes HRID Ltd. manipulator for inspection of threads (M36, M48, M52, M60, M64, M100) on various components of VVER 1000/1200 nuclear power plant using eddy current and ultrasonic inspection methods.

## 2. INSPECTION EQUIPMENT PURPOSES

The developed manipulator is intended for automated remote pre-service and periodic in-service inspections of the threaded holes (M36, M48, M52, M60, M64, M100) which are located on various nuclear power plant components flanges.

Inspection of the threads is performed in order to:

- acquire input data about a condition of the components of the threads before start of operation;
- acquire data about a condition of the same threads during nuclear power plant operation (periodic inspections).

## 3. GENERAL TECHNICAL CHARACTERISTICS of THREAD INSPECTION MANIPULATORS

### 3.1 DESIGN REQUIREMENTS

3.1.1 Thread inspection system manipulators are remote controlled and consist of two integrated modules mounted as follows:

- Eddy current testing (ET) module is used for thread inspection (M36, M48, M52, M60, M64, M100). This module when eddy current probe is replaced with brushes becomes cleaning module.
- Ultrasonic testing (UT) control module is used for examination of areas around threaded holes;

3.1.2 The inspection system provides possibility of recording indications/ defects in digital form including their coordinates which will be stored on computer hard disc or external hard disc in tolerance of ±1.5 mm.

### 3.2 INSPECTION SYSTEM MAIN COMPONENTS

Thread inspection system includes the following main components:

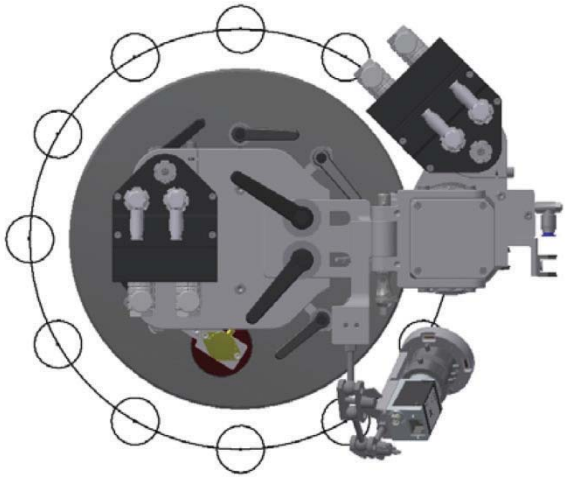


***Figure 1.*** *Manipulator M1 for M36 threaded holes*

1. Manipulator for inspection of M36 threaded holes. See Figure 1. This manipulator will be in further text designated as M1.
2. Manipulator for inspection of M48, M52, M60, M64 and M100 threaded holes. See Figure 2. This manipulator will be in further text designated as M2.

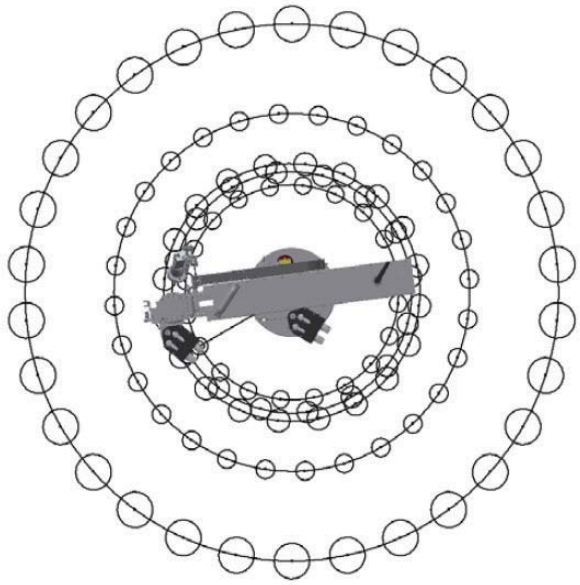


***Figure 2.*** *Manipulator M2 for M48, M52, M60, M64, M100 threaded holes*

Thread manipulators are used for cleaning flange surfaces and threaded holes, UT inspection of base material and ET inspection of threaded holes in range of M36 to M100 mm. Manipulator is conceptually organized in modular meaning and all modules can easily be removed or replaced.

Geometrical flexibility and performance of the manipulators enable them to be used in the areas that require inspection with high speed, multi probe inspection with larger or smaller strokes of movement. Both manipulators have also camera for monitoring of all movements.

3. Module for cleaning threaded holes with plastic brush.
4. Modules for eddy current inspection of threads.
5. Modules for UT inspection of base material between and around the threads.
6. Two controllers (one controller integrated on M1 manipulator and the second integrated on M2 manipulator)
7. CoreStar OMNI 200R eddy current instrument;
8. Eddy current probes for inspection of threaded holes (one probe for each size of threaded hole);
9. HRID Software packages for eddy current:
   - Data acquisition
   - Data analysis
10. ZETEC ZIRCON UT instrument with Ultravision 3.5 software package
11. System for supply of water (contact media) to ultrasonic probe during inspection
12. Ultrasonic transducers.
13. Laptop computers, printer, server disk etc.

See for details ***Figure 3.*** with picture of whole system.

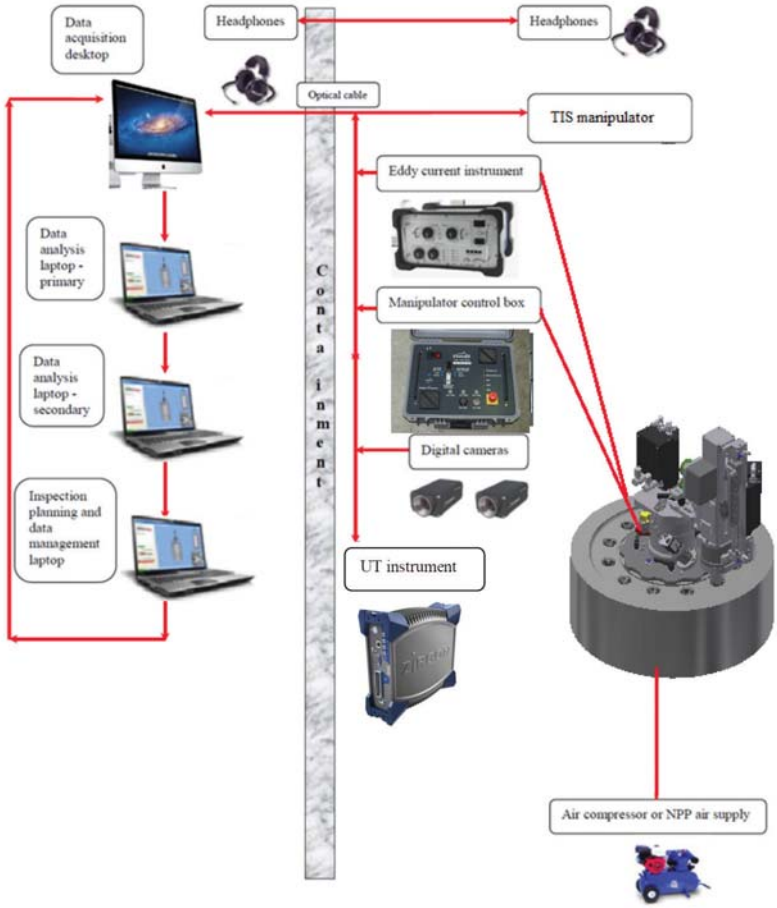
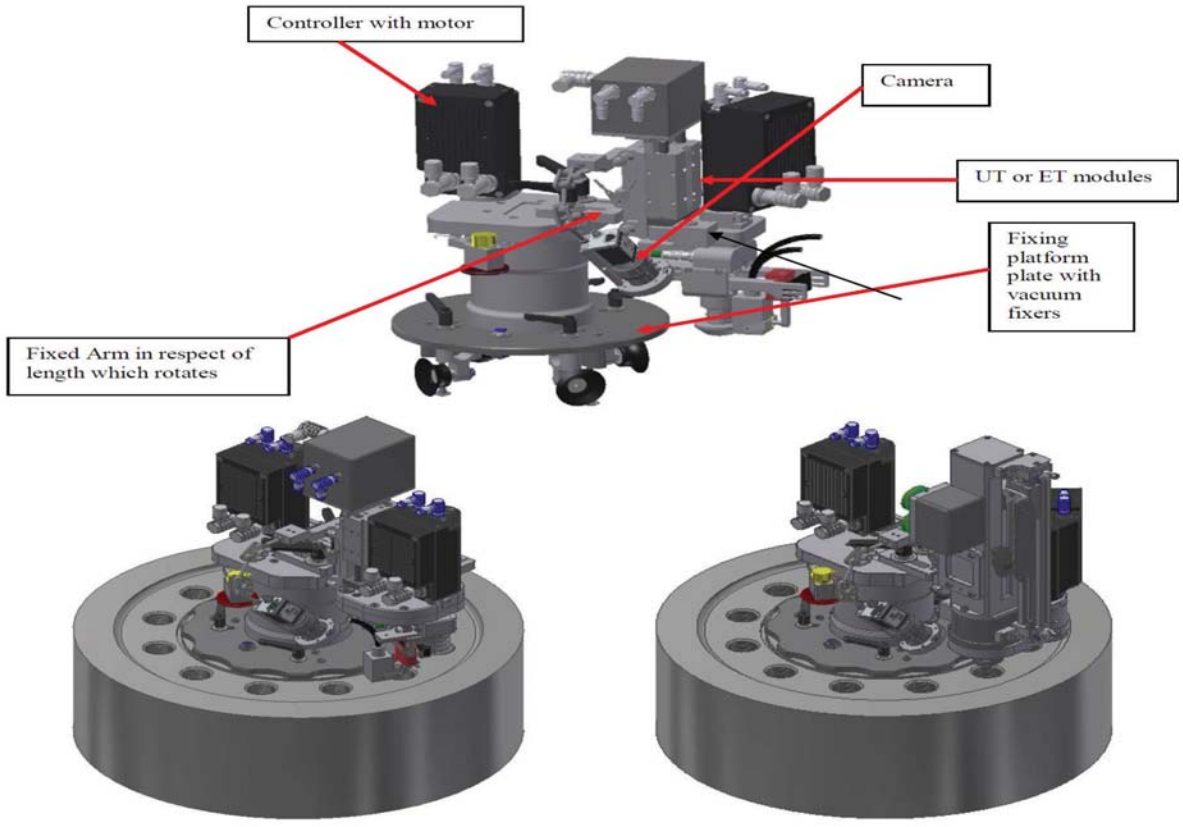



***Figure 3.*** *Thread inspection system*




*a) M1 with UT inspection module;* *b) M1 with Cleaning / ET module*

***Figure 4.*** *M1 manipulator and its modules*

### 3.2.1 M1 manipulator description

Main parts of the M1 manipulator are: fixed legs, with motor module for manipulator rotation, EC module with pneumatic cylinder and motor and UT module with motor and controller, ***Figure 4.***

### 3.2.2 M2 manipulator description

Main parts of the M2 manipulator are: adjustable legs, telescopic arm with motor module for rotation, EC module with motor, pneumatic cylinder and different types of EC probes, UT module with motor and controller. See ***Figure 5.***

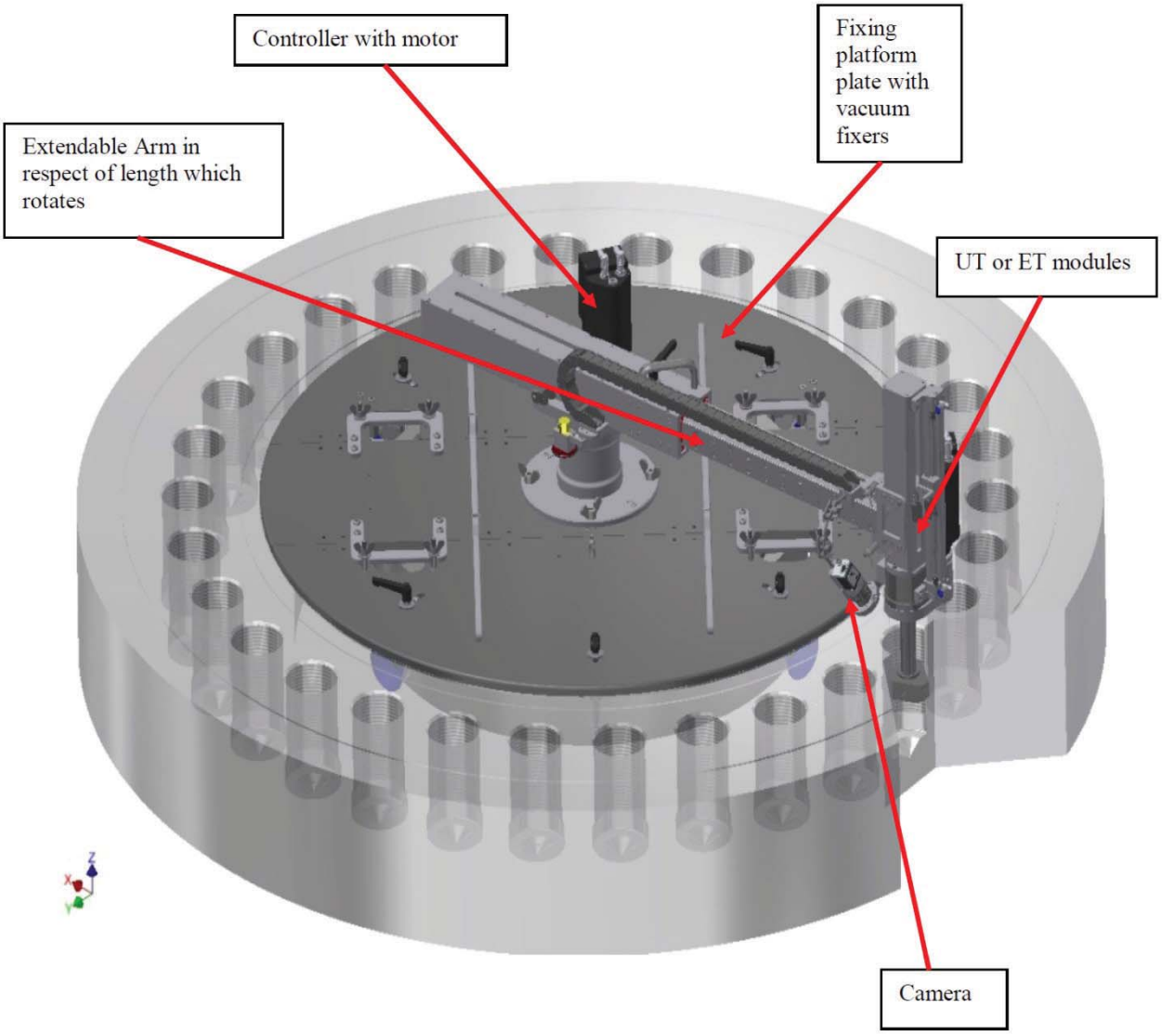


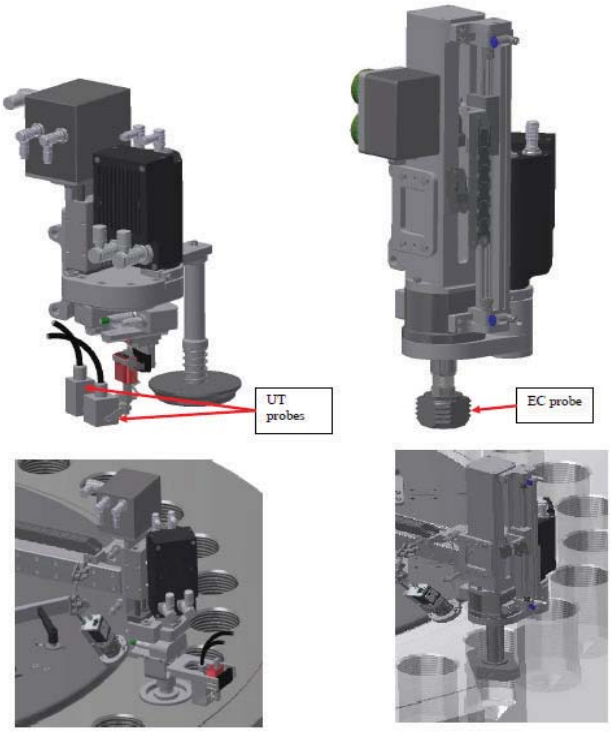

***Figure 5***. *M2 manipulator*

### 3.2.3 Inspection Modules

HRID thread inspection system has 3 inspection modules:

1. Eddy Current module for inspection of threads
2. Ultrasonic module for inspection of base metal around and between threads.
3. Cleaning module for threads and flange surface around thread. This module is basically the same module as EC module where eddy current probe is replaced with different cleaning brushes.

For more details see in ***Figures 6*** and ***7*** see EC, UT and cleaning modules:




a) UT module b) ET module

***Figure 6.*** *UT and EC inspection modules*

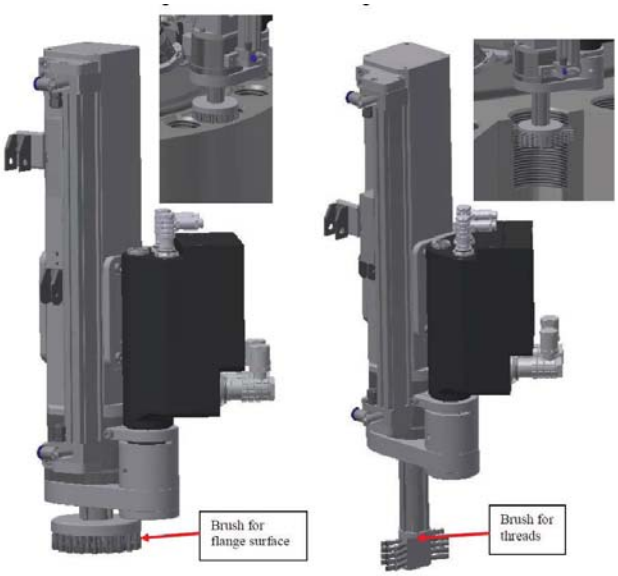
M1 and M2 manipulators are designed with ease of operation and maintenance in mind. Mechanical and electrical components have been carefully selected for safe and accurate operation in the given conditions. Most of the surfaces were anodized to prevent pitting. Electronics is further isolated and protected to work under conditions in elevated ionizing radiation. The tools required for maintenance are standard.

Manipulators offer four motion axis independent control for UT inspection, and three motion axis for ET inspection and cleaning purposes.

DC electrical motors are used along with encoders to provide precise positioning. Calibration of manipulator is preformed on mock up with pre mounted calibration blocks which differs dependently of testing method. Following the calibration, manipulator can be used for automated UT and ET data acquisition.

See picture of manipulator stand for calibration purposes in ***Figure 8.***

(a) (b)




a) Flange surface cleaning tool
b) Threaded holes cleaning tool

***Figure 7.*** *Cleaning module for threads and flange surface*

***Figure 8.*** *Stand for M1 and M2 manipulators*

3.2.4 Manipulator main characteristics

M1 and M2 basic characteristics are the following:

- Four axis of motion:

1) Rotation; used for over threaded hole positioning and flange surface cleaning
2) Rotation; used for rotating (scanning) with probes/brushes around (UT and cleaning) and in threaded holes (ET and cleaning)

3) Translation; used for approaching with probes/brushes to the object of control

4) Translation; used for incremental (index) UT probe movement

- Index - axis maximum speed for UT; 30 mm/s
- Scan - axis maximum speed:

a) for ET; 165 mm/s for M36 and 455 mm/s for M100, based on 87 rpm

b) for UT; 50 mm/s for M36 and 200 mm/s for M100, based on 26 rpm

- Probe(s) Positioning Accuracy ±1,5 mm
- Scanner is equipped with encoders to monitor the position of probes in the rotational and, for UT probes, also in translational direction
- Regarding to the geometry, possibility of testing threaded holes from M36 till M100
- Regarding to test material, possibility of testing ferrite steel threads, as well as stainless austenitic steel threads
- Testing and calibration are preformed with scanner mounted on stand.
- Protection against dust and water: according to IP54 standard
- Allowed characteristics of the working environment are given in Table 1

***Table 1 Allowed working conditions***

| *DESCRIPTION* | *VALUE* |
|---|---|
| *Working temperature, °C* | *to 50* |
| *Temperature of testing surface, not more than °C:* | *60* |
| *Relative humidity at 30°C, %, not more than:* | *90* |
| *The radiation at the surface of the flange (mean), not more than mGr/hour:* | *2,6* |

- Mass of the scanner: approx. 15 kg for M36 configuration, approx. 35 kg for M48 to M64 configuration and approx. 55 kg for M100 configuration

## *4. CONCLUSIONS*

Described HRID manipulators for inspection of different threads (M36, M48, M52, M60, M64, M100) in VVER 1000/1200 nuclear power plants has been demonstrated as excellent tool for performance of UT and EC inspections of threads and base material. The main advantages are the following:

1. User friendly design with minimal use of standard tools.
2. Fully automated operation.
3. Practically no maintenance activities;
4. Speed installation and speed dismounting operations.
5. Easy decontamination.
6. Resistance on water and dirt.