SYSTEM DESCRIPTION

The Magnetic Defectoscope System DEF-1C-IH2 allows users to perform a fast, high resolution inspection of permanent magnet assemblies. The Magnetic Defectoscope is equipped with inductive sensors and magnetic Hall sensors. A system of inductive sensors for eddy current measurement efficiently detects the mechanical cracks and inhomogeneity in the magnetic materials and even non-magnetized parts. The 3-axis Hall probes are used for the high-spatial measurement of the magnetic flux density and magnetic field polarity of permanent magnets. The combination of inductive and Hall sensors is embedded in a software-controlled linear moving system allowing a fast inspection of magnetic assemblies in production lines. Magnet assemblies are manually inserted in the system, which than automatically transports the parts over the sensor system. The transport mechanism is pneumatically driven and fully computer-controlled. Based on the inspection results and user-given parameters tolerances, the Defectoscope automatically sorts-out bad parts and marks the good parts with an ink-stamping system.

DEF-1C-IH2 Defectoscope consists of:

1. **Mechanical module with sensor system**
2. **Electronic box**
3. **Control panel**
4. **Industrial PC**
5. **Software**

1. MECHANICAL MODULE

The mechanical system is aluminum made, anodized and black dyed device box. The size of the mechanical module is 600mm x 500mm x 380mm. It is equipped with the protective cover that prevents users the access to the moving parts and electrical contacts. The electrical connector panel is on the back side of the device. On the right side of the box there is the air connection and regulation system that is required for the pneumatic drive system.

Fig.1. Mechanical module with the protective cover

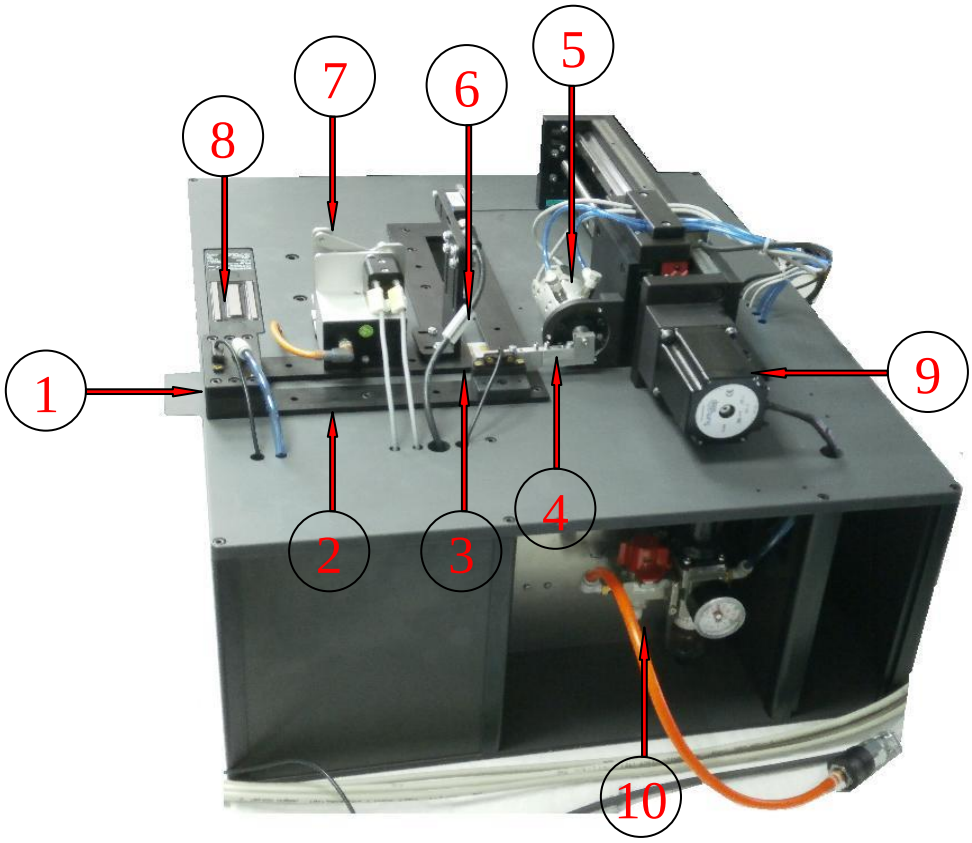

Fig. 2. Main parts of the mechanical module

The main parts of the mechanical module shown on the Fig. 2 are:

1. Magnet launcher
2. Magnet rail
3. Inductive and Hall sensor module
4. Mechanic arm
5. Rotary actuator
6. Bad magnets container lid
7. Automatic ink-marker
8. Magnetic lock for protective cover
9. Linear module
10. Air connection and regulator

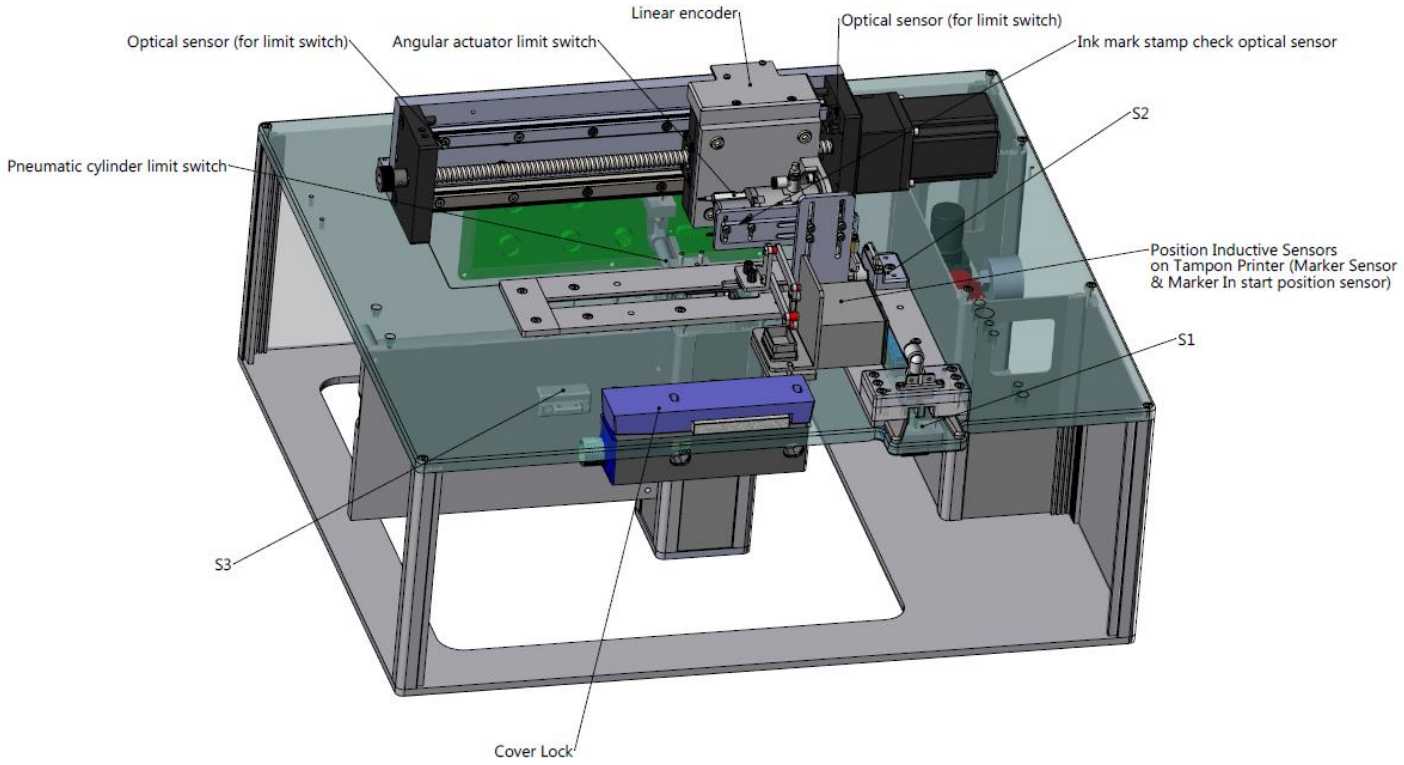

Fig. 3. Main sensors and detectors with optical sensors S1, S2 and S3 for sensing the magnet position

2. ELECTRONIC BOX

The electronic box is housing for several electronic modules. The size of the box is (Width x Depth x Height) 449mm x 315mm x 132mm.

Fig. 4. Electronic Box

The Electronic Box contains:

1. Two single-axis Magnetic Field Transducers type F3A-0ZK.5D-S.2T2K5 with axial Hall Probes and the measurement accuracy of <1%. This is a high accuracy magnetic flux density-to-analogue-voltage transducer with a high-level and temperature compensated output signal of axial (Bz) component of the measured magnetic field.

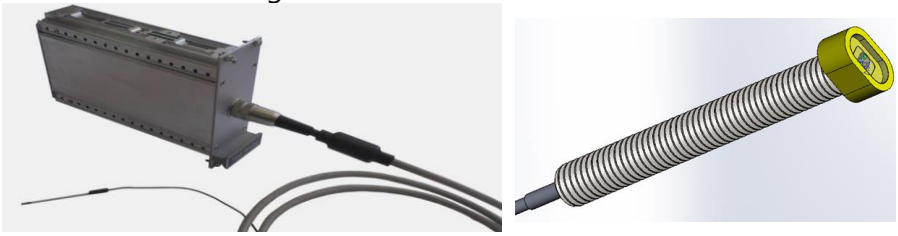

Fig. 5. Magnetic transducer and Hall probes mounted in a probe holder

2. Defectoscope electronic module with inductive sensors. The two inductive sensor consists of the primary coil with AC current that generates AC magnetic field. This AC magnetic field generates eddy currents in the material of the objects under test, which are detected by the secondary, pick-up coils. A crack or inhomogeneity in the material reduces the signal amplitude in the secondary coil. The coil type, size and the current frequency are selected according to the material and the size of cracks and inhomogeneity that need to be detected.

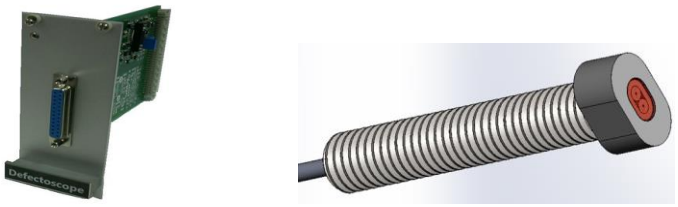

Fig. 6. Defectoscope electronic module and inductive probes mounted in the probe holder

3. Connection to the Motion Control Card NI PCI-7354 is the 4-axis individually programmable controller that is used for a wide variety of both simple and complex motion applications. It includes eight 16-bit analog-to-digital converters for onboard data acquisition, as well as a host of advanced motion trajectory and triggering features. It is equipped with the 64 digital I/O lines and the high-speed 4 MHz position triggers.

Fig. 7. Motion Control Unit

4. Connection to the Data Acquisition Card (DAQ) NI PCIe-6321. The NI multifunction data acquisition (DAQ) devices provide a new level of performance with the high-throughput PCI Express bus, NI-STC3 timing and synchronization technology, and multicore-optimized driver and application software. It provides 16 analog inputs (250kS/s), two analog outputs, 24 digital I/O lines and four 32-bit counter/timers for PWM, encoder, frequency, event counting, etc.

Fig. 8. Data Acquisition Card

5. Stepper motor drivers STP-DRV-4850 controls the movements of the linear module. It is a 5A, 24-48VDC 2-phase micro-stepping motor drive.

Fig. 9. Stepper motor driver

6. Sensor Control Unit processes the signals from optical positioning sensors used for magnet transportation and ink-marking system.

Fig. 10. Computer controlled ink-marking system

7. Linear encoder control. The resolution of the linear encoders is ±2μm.

Fig. 11. Optical linear encoder

8. Single output Switching Power Supply 75W RS-75 with the universal AC input and short-circuit, overload and over-voltage protection.

Fig. 12. RS-75 Switching Power Supply

3. CONTROL PANEL

The control panel serves as Defectoscope user interface. It houses the Emergency Stop switch that can prevent the mechanical damage and enhance the user's safety. In addition there are three buttons and three indicator lamps:

- Measurement start button (green)
- Measurement continuation button (yellow)
- Measurement stop button (red)

Fig. 13. Control panel

4. INDUSTRIAL PC

The DSM Infinity® I4 Industrial PC system is used to control the Defectoscope mechanic (motors, encoders, sensors and switches) through the installed motion control card NI PCI-735X and to acquire the inductive and Hall sensor signals trough the installed DAQ NI PCI-6321:

-Dimensions W/D/H: 430 x 508 x 177 mm / 600 Watt Power Supply, ATX
-4 U, Slot CPU, 12 slots / 6x USB 2.0 (2x on the front side)
-DSM Slot - CPU Intel® Core I7-620M 2.66GHz / QM57 Chipset / OEM MS Windows 7 Prof. 32 bit, English
-Equipped with 4GB DDR3 SDRAM PC1600 (max. 8 GB) / SATA Controller for 4 SATA II devices, Raid 0,1,5,10
-Onboard Dual LAN 10/100/1000Base-T / VGA / Audio Controller
-1000GB quality hard disc 3.5" 7200rpm SATA2, 24x7 / 3x PCIe x1, 1x PCIe x16, 8x PCI

Fig. 14. Front- and back panel of the DSM Industrial PC

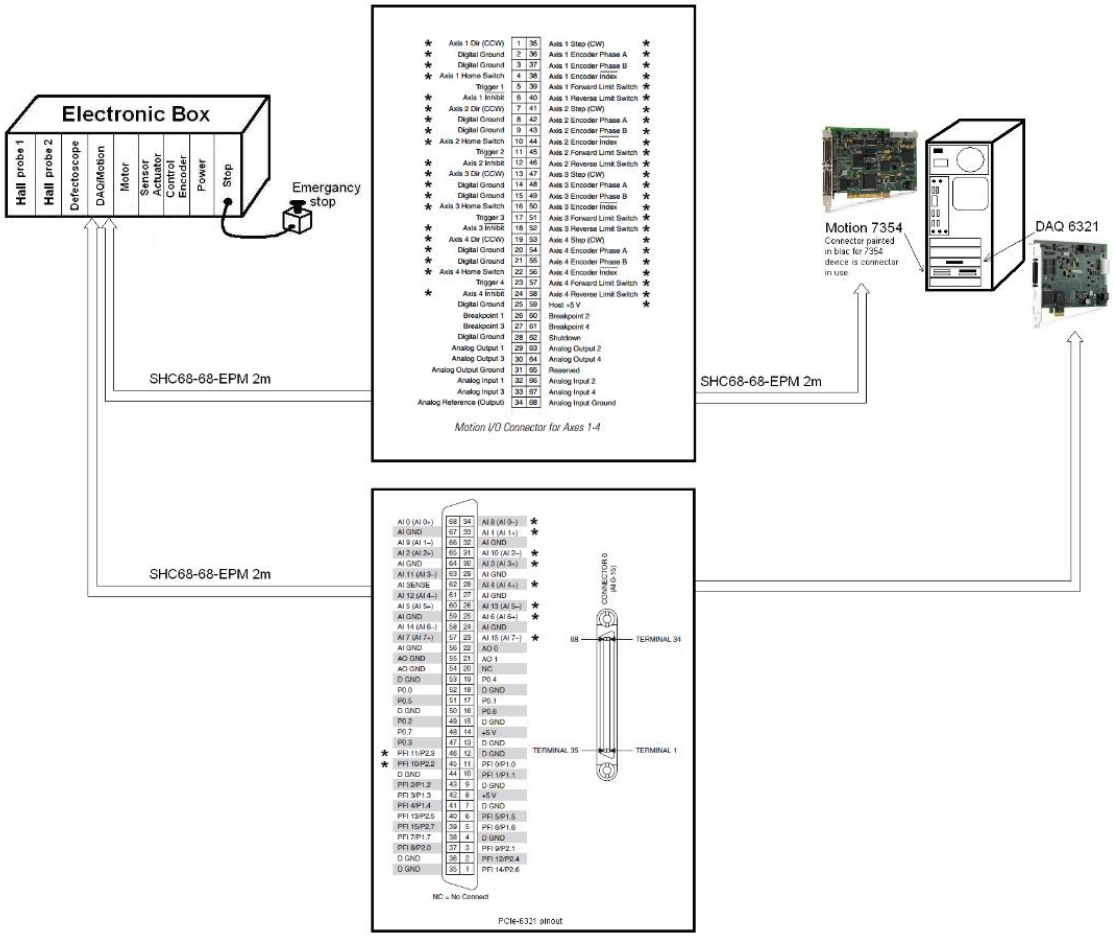

Fig. 15. Connection diagram- Electronic box to PC

5. DEFECTOSCOPE SOFTWARE

The Defectoscope software is developed in LabView and runs on MS Windows 7 installed. It controls the measurement algorithms, acquires, analyses and visualizes the measured data.

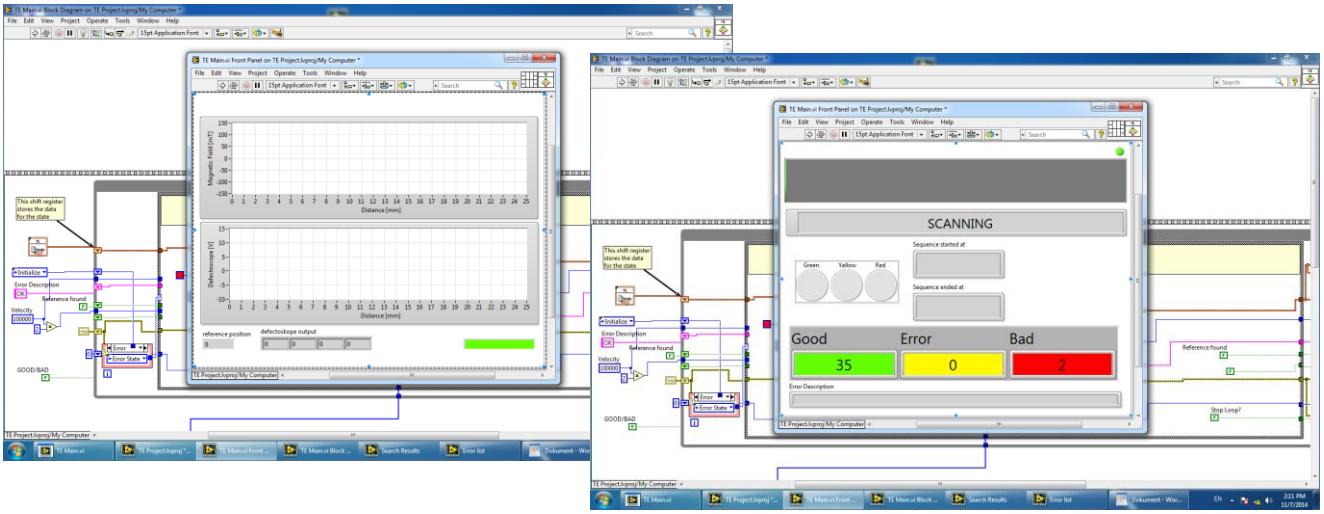

Fig. 16. LabView Defectoscope Software

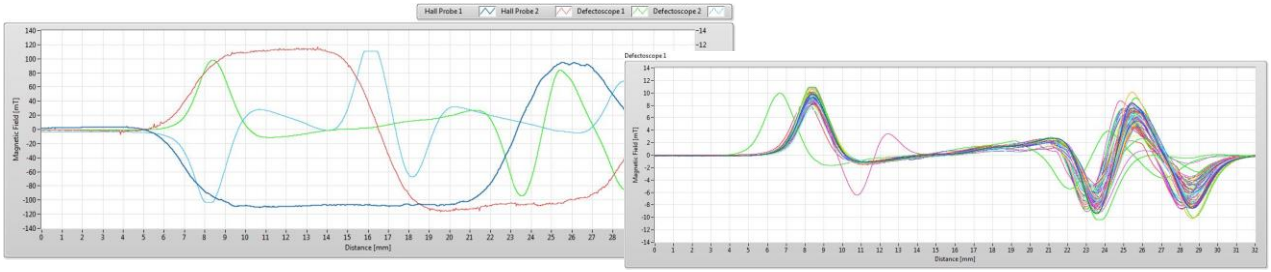

Fig. 17. Data Analysis and Visualization

OPERATION INSTRUCTION

1. The operator presses the "START" button for the measurement/lot start.
2. The "START" message appears on the screen for 5 seconds and the ORANGE lamp blinks.
3. The operator takes the magnet from the input container and puts it in the notch on the Defectoscope.
4. The magnet part is identified (optical sensor) and the air jet pushes forward the magnet.
5. Magnet stops in the position, which is identified by the optical sensor.
6. The rotary actuator lowers-down the mechanic arm.
7. An optical sensor identifies the end-position of the mechanic arm.
8. The linear module moves the magnet part towards the Defectoscope sensors.
9. The two Hall sensors and then the two inductive sensors check the magnetic field strength and the polarity, as well as the presence of cracks in the magnet part.
10. The magnet part stops at is validation position, which is defined by the linear encoder.
11. If magnet ok, the part is stamped/marked by an "●" character (the stamper has the optical sensor to confirm the completed stamping). The magnet is moved further to the "OK container". The GREEN lamp is on. While moving towards the ramp, an optical sensor checks the visibility of the stamped character.
12. If the stamped character (mark) is not visible, the ORANGE lamp is on and the warning message "REPLACE THE INK" appears on the screen; The Defectoscope protective cover lock is automatically unlocked. The operator replaces the ink, closes the protection cover and presses the button "CONTINUE". The ORANGE lamp and the warning message disappear and the process is ready for further measurements.
13. If magnet is not ok, a container lid is opened and the magnet part falls into the "NOT OK container", which is mounted under the table with Defectoscope. The RED lamp is on.
14. The Defectoscope counts the OK / NOT OK parts.
15. If the number of OK parts is higher than the defined amount (program parameter in the config file), the ORANGE lamp is on, the warning message "OK Container FULL" appears on the screen and the process is stopped until confirmed by operator with the "CONTINUE" button. The ORANGE lamp and the warning message disappear.
16. If the number of NOT OK parts is higher than the defined amount (program parameter in the config file), the ORANGE lamp is on, the warning message "NOT OK Container FULL" appears on the screen and the process stops until confirmed by operator with the "CONTINUE" button. The ORANGE lamp and the warning message disappear.
17. If three parts are NOT OK three times in the raw, the ORANGE lamp is on and the warning message "THREE NOT OK PARTS" appears and the process stops until confirmed by operator with the "CONTINUE" button. The ORANGE lamp and the warning message disappear.
18. The measurement sequence is completed by pressing the "STOP" button.
19. The software stores all measured data and warning messages with the date/tamp stamp.
20. A separate emergency stop button will be provided to break the measurement process if needed.
21. The Defectoscope DEF-1C-IH2 is designed for the continuous operation over the whole day. The measurement time is max. 8 seconds per one tested magnet, or less than 12 seconds including handling.