

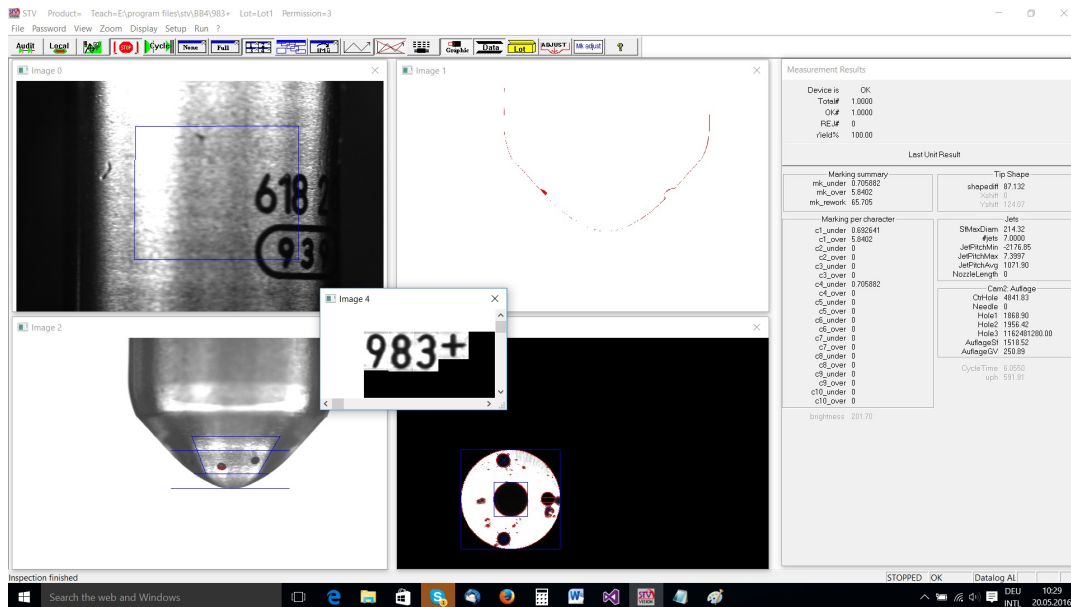
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100% Inspection of Diesel Injection Nozzles in the Production Line May 2016



Diesel injection nozzles are the core of every Diesel engine. The production requires extremely high definition standards for durability, precision, and zero tolerances. Hundreds of different types are produced. And they must last a lifetime cycle, which often is over a million kilometer.

Quality inspection of these nozzles is due to three topics:

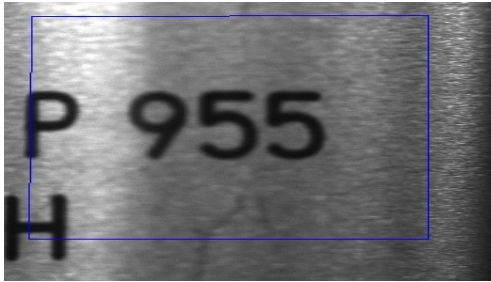
- Nozzle tip shape measurement. The tip is tested for any false deformation in 3D.
- Jet holes measurement: The number, position, and diameter are measured. False jets cause motor damage.
- Marking inspection of the nozzle type. Almost 1000 different types

are produced, and a mix of different types is extremely dangerous.

- The back surface must be perfectly clean, polished, and without damage. It is the encapsulation and must close the 2000 bar inside without leaking of oil.
- In the production process, the nozzles are embedded in oil. This makes inspection extremely difficult. The system includes an oil removal unit, to allow safe measurement.
- The system communicates with a robot for automatic handling.

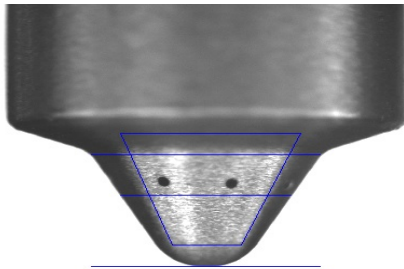
Nozzle Shape

The nozzle tip is measured during rotation in 10 different orientations. The whole 3D contour of the tip is scanned. Any deviation of the reference tip is accurately measured and tested against tolerance.



Jets

The jet holes are inspected, the hole size is measured in surface light, the position is tested, and they are counted for exclusion of excess holes. A sequence of 20 images are taken while the nozzle rotates 360 degrees, so every 18 degree increment the nozzle is tested. The jets are measured in every image, then they are all classified to exclude double measurement. Any missing, excess or misaligned hole is monitored.

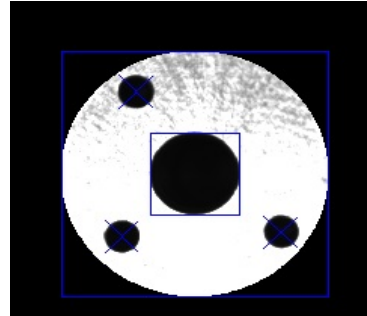


Surface Damages

The nozzle surface can be damaged. The system detects each irregular damage parallel to the jet hole measurement. The user defines tolerances for maximum tolerated damage size.

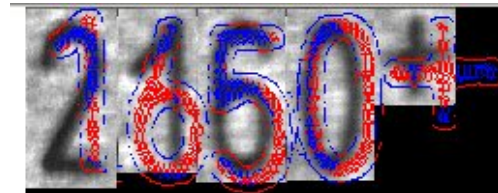
Back Surface Inspection

The 3rd camera is used for back surface test. This surface is critical for safe encapsulation of the nozzle, and to avoid leakage of the 2000 bar pressure of the common rail system. The surface must be polished, clean, without damage or scratch, and with the needle inside. All this is checked in one image.



MK2 Marking Inspection

The laser marking on the nozzle perimeter is inspected for good readability, and false marking or the wrong type nozzle is rejected. This avoids product mix of over 1000 different nozzle types. Today the production line is made very flexible and allows fast product change between lots. As a result, the user must make sure that every machine unit in the line is carefully cleaned from old nozzle types after changeover. The marking inspection at the final end of the line assures that there are no false nozzles in the production output.



| Camera type | low | medium | high | |
|--------------------------|-------------|-----------|-----------|--------------|
| Camera resolution | 1388 x 1038 | 1900x1200 | 2500x2000 | Pixel |
| Camera speed | 15 | 50 | 25 | Images /sec |
| Image size | 12 x 10 | 12x7.6 | 12x10 | Mm |
| Pixel size | 8.6 | 6.3 | 4.8 | micron |
| Shape measurement | + - 6 | + - 4 | + - 2 | micron |
| Nozzle length | + - 6 | + - 4 | + - 2 | Micron |
| Jet hole position | + - 20 | + - 15 | + - 10 | micron |
| Surface defects | >= 25 | >= 18 | >= 14 | micron |
| Marking defect | 10% | 10% | 10% | Of character |
| Back surface | 50 | 35 | 24 | micron |
| Max # of images / device | 59 | | | frames |
| Throughput per device | 3 | | | Sec |
| Robot interface | 24V PLC | | | |
| Industrial PC | Win10-64 | | | |
| Illumination | Strobed-LED | | | |