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NON-DESTRUCTIVE TESTING OF PRESSURE VESSELS – APPLICATION OF SolidWorks

Vujadin Aleksić[1], Bojana Aleksić[2], Dejan Momčilović[3], Ljubica Milović[4], Aleksandar Sedmak[5]

Summary: *This paper describes application of parametric software for drawing and modelling on testing of pressure vessels. The used software, SolidWorks, is used to demonstrate all phases of testing: preparation of non-destructive testing (NDT) and report generation regarding test results.*

Key words: SolidWorks, pressure vessel, non-destructive testing (NDT)

1. INTRODUCTION

The analysis of present situation in domestic market shows that the thorough preparation of non-destructive testing is almost absent. The good preparation enables better qualty of NDT as well as to quality of test reports. The one of major requrements for NDT test report is traceability and repeatebility, which is not general practice. One of aspects of preparation is drawing of test sheets, 2D or axonometric, with test subjects with spatial definition of expected test areas, and detail unique definition of position of flaws and other geometric irregularities.

Good pereparation of NDT, as a main goal, can be enhanced by use of commercial software of fast 3D drawing of test subjects and definition of one or more pivot points for accurate spatial definition of flaws or irregularities [1].

Direct 3D drawing enable us to define view position which save time and reduce the number of complicated 2D drawnings extracted from 3D model.

Embeding obtained 3D drawings in text processor generate quality test reports with unique definition of revealed flaws and irregularities which is the very basis of traceability and repetability requred by SRPS ISO 17025 [2].

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2. METHODS OF NDT AND DEFECTS

Non-Destructive Testing (NDT) is related to identifying the presence of those defects, imperfections and discontinuities in the finished product which impair the performance level. Testing is direct on test objects without sampling and destruction.

Application of NDT is closely related with historical development of engineering, and it can be said that the failure analysis initiated the development of NDT. The biggest flaws ca be detected since the beginiing od 20th century, by descovery of X-rays by Wilhelm Konrad Roentgen. Significant step was introducing of ultrasonic testing in 1929. and magnenetic flux in 1934. Krautkrammer introduced DGS diagram for determination of flaw size and enables application of practical principles of fracture mechanics [3].

Application of NDT, historically analysed, can be roughly divided as an age of railway, age of cars, age of airplanes, life with flaws, informatic age and age of monitoring.

Common characteristic of first three ages is that flaws was not allowed, despite of knowledge of flaws influence, based on experimental results and theory. This is result of numerous catastrophic failures, and steep development of NDT methods. Last few decades, two engineering disciples share same field: NDT and fracture mechanics, creating the new age, living with flaws. [3]

Informatic age and th age of monitoring are periods that covers last two decades and where, in all phases – testing and analysis, the key role plays the computer. [4,5]

Despite of previous noted, the key questions emerges: What is reliability of NDT? What is probability of flaw revealing? What is the value of repeatability of testing? If we kons most of these answers than is possible to apply fracture mechanics principles to flaw influence assessment. Unfortunately, o some of these answers is very difficult to answer. [3]

Continous introduction of modern methods enbles smaller and smaller defect with enhanced repeatability and increase of threshold sensitivity of NDT.

These methods includes testing, check-inspection and control, which share simmilar basis of observation and measurement.

During inspection control of pressure vessel the key questions are: Which section may have flaws? What is most dangerous flaw? What is the best method for flaw severity evaluation? What is the influence of pressure and temperature on critical flaw?

In general, there is two types of flaws: volumetric and planar. Volumetric flaws or indications can be described with three dimensions or volume and planar flaws have two dimensions much greater than third. Planar flaws are more significant for reliability assessment which lead to conclusion that discovery and evaluatiion of such indications the key problem. In other words finding such planar indications trigger answers related with sanation, and risk assessment of vessel. Safe operation of pressure vessels can be achieved with cooperation of specialist for NDT, mechanical testing and fracture mechanics.

3. PROGRAM AND PLAN OF ND TESTING

Program and plan of testing is writing acording to client requirements with basic client data that covers also acceptance criteria, test standards, test equipment, qualified personel and testing schedule.

Program and plan writes chief engineer trained by standard SRPS EN 437 level 2 – test manager. [6]

When the test subject is complex object as hydro and coal power plant, at the same time the chief engineer while writing the detail program plan, at the same time must write test plan, too. Test plan defines list and schedule of teams, time plan for using the equipmeent, as well as duty plan for each memeber of test personel.

The form of test plan can be in free form, however it must be compatible with Term plans of client and mast have all neccessary details regarding NDT of complex subject, with emphasize on traceability.

4. GROUNDWORK FOR NDT OF PRESSURE VESSELS

Prior to NDT, the groundwork activities should be doone. The very first step is preparation by reading technical documentation and drawing the models and sketches for presseure vessels, preparation of vessel surfaces for testing and calibration of test equipment.

Due to the fact that NDT methods deos not require separaton of tested parts, the key action is unique defined marking by NDT team leader in cooperation with client.

Marking of parts is based on pressure vessel data, by number and letter.

Preparation of parts for testing is according by standard defined procedure, it the method requires preparation of surface.

As regular part of groundwork, prior to every testing the NDT operator is checking the test equipment, based on standard requirements and procedures defined by equipment manufacturer.

5. MAKING THE PRESSURE VESSEL MODEL

5.1 SolidWorks SOFTWARE PACKAGE [7]

SolidWorks is software for parametric and direct modelling of various shape of bodies based on elements, with the linking of 3D parametric elements with 2D elements. This software also cover all phases of design from skratch to numerical calculation by use of finite lement method (FEM). [8,9] This characteristic make SolidWorks very suitable to report generation of NDT reports and fast integrity calculation with the vessel with a flaw. Also, this software is useful for failure analysis, too. [10]

2D technical drawings can be easy generated in Drawing mode, where all sorts of drawings and sections can be presented. The useful feature is adding different marks and clouds for notes on present drawings.

Any change in basic drawing trigger automatic update to reference box on drawing.

This update means that will be applied on drawings linked with the base model.

Main modes in solidworks are mode for parts so called PART, assembliesnamed ASSEMBLY and drawing mode DRAWING. As illustration, of Fig 1. is presented 3D model and 2D drawings used in preparation and generation of reports for pressure vessels.

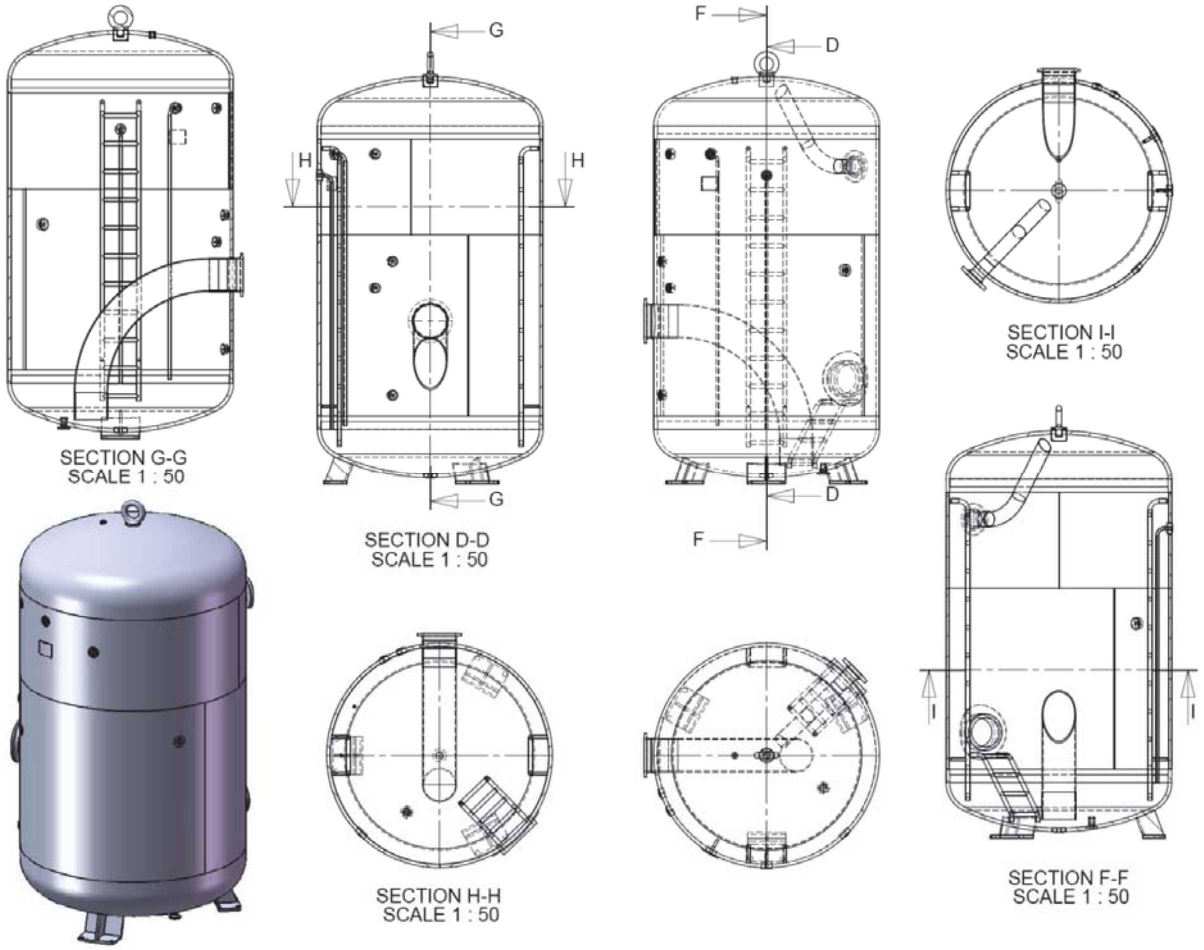
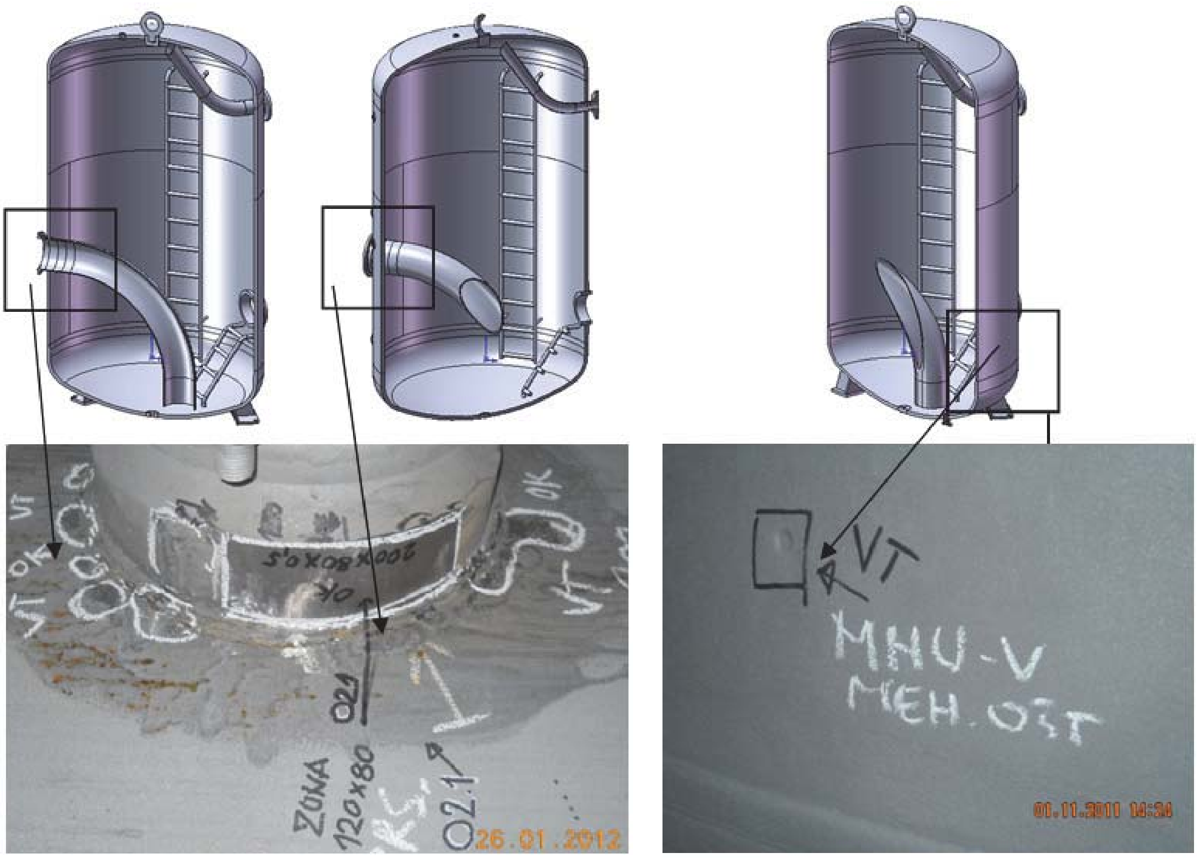


Fig. 1 *3D, 2D drawing and different sections of pressure vessel*

5.2 USE OF PRESSURE VESSEL MODEL FOR LOCATION OF DEFECTS

By combination of found flaw or irregularity on pressure vessel obtained by photography and Solid Works model it is possible to uniquely defined the position, size and shape of flaw or irregularity, Fig 2. This enable positioning the founded flaw in endless number of different viewpoint which is limited by use even with digital photography.

After founding the flaw, no matter of the type of flaw, SolidWorks model can be upgraded with the model of flaw and used for FEA numerical calculation which will lead to integrity assessment.



a) Founded flaws *c) Mechanical damage*

Fig. 2 *NDT of base material and welded joints of pressure vessel*

6. RESULTS SORTING AND ANALYSIS

Results sorting and analysis of measurement is achieved by procedures for data processing defined by NDT method. During sorting, and particulary during analysis and interpretation of results, the theoretic beckground and knowledge of the operator is the leverage which contributes to the quality of results.

After testing the memo about testing is signed by th client.

Memo, in free form must have: data about test subject, test method, test conditions, apllied equipment, used parameters and other details which enables traceability and repeatability of testing.

Test report and findings of the test subject is write according to memo and standard SRPS ISO IEC 17025 requirements. [1] as well as by standard which defines test method in all steps.

7. CONCLUSION

The use of comercial software as an prepair activity, particulary the software for parametric and direct modelling, enables fast 3D modeling and unique spatial definition of all key points on test object and possible flaws, too.

The huge number of different 3D views on pressure vessel as well as great number of sections reduce the number of generating unwanted 2D drawings.

By the linking with the other sowtware packages, like text processors, all can be linked in system for generating test reports, on the basis of traceability and repeatabilty requirements defined by 17025 standard. [1]

The model of pressure vessel can be upgraded with the model of flaw and used for FEA numerical calculation which will lead to integrity assessment.

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