FAILURE PREVENTION AND SERVICE LIFE EXTENSION OF WELDED PIPES IN OIL INDUSTRY

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1 Introduction

Oil and gas well piping and pipelines for the transport of oil and gas are regarded as highly responsible structures, quite susceptible to corrosion and occurrence of cracks. Therefore, it is very important to know the pipe's residual strength, in the case that any of aforementioned types of damage occur [1, 2].

Steels meant for the production of protective seam welded pipes, which are used in wells are specified in the API 5CT standard [3]. Automatic or semi-automatic production of welded pipes enables the continuing production of longitudinal-seam welded pipes and the basic intention is to achieve the welding speed, which would be equal to the speed of pipe-forming. Machines for the continuing production of longitudinal-seam welded pipes are mainly designed for the automatic high frequency contact welding [4].

Based on the precise examination regarding the defect type and size, as well as based on the calculation of operating ability of the welded joint, the decision, which refers to the possibility of reintegrating the pipe into the system, can be made [5].

Steel pipes in oil industry are continuously exposed to corrosive effects, enhanced by pressures and temperatures, which exist within the well. Corrosion can lead to decrease of mechanical properties of steel, which can, in combination with the effect of unfavorable conditions, lead to occurrence of the initial crack and, subsequently, failure. Failure of protective pipes can be caused and accelerated by various corrosion mechanisms [6, 7].

Fig. 1 General corrosion of well pipes and pipeline failure [1]

2 Failure analysis of welded pipes in oil industry

It is very difficult to analyze production systems, such as oil wells, because of the structure complexity, operating conditions and inaccessibility of pipes. In these cases, the fault tree analysis is very successfully used, with a few minor simplifications. The fault tree is suitable for analyses of the complex systems, which are consisting of functionally related or dependable subsystems with different performances. The fault tree analysis is regularly used when the nuclear power plants, aircraft, communication systems, chemical and other industrial processes are concerned, but that does not apply to processes in oil industry. Through the analysis of singular influences, the fault tree provides the conclusion, which refers to the causes and singular contributions to failure [8].

Results of the fault tree analysis are used for failure prevention, failure analysis or in other words influence on reliability, clearer definition and quantifying of certain influences that affect reliability, ensuring the conditions that provide good reliability.

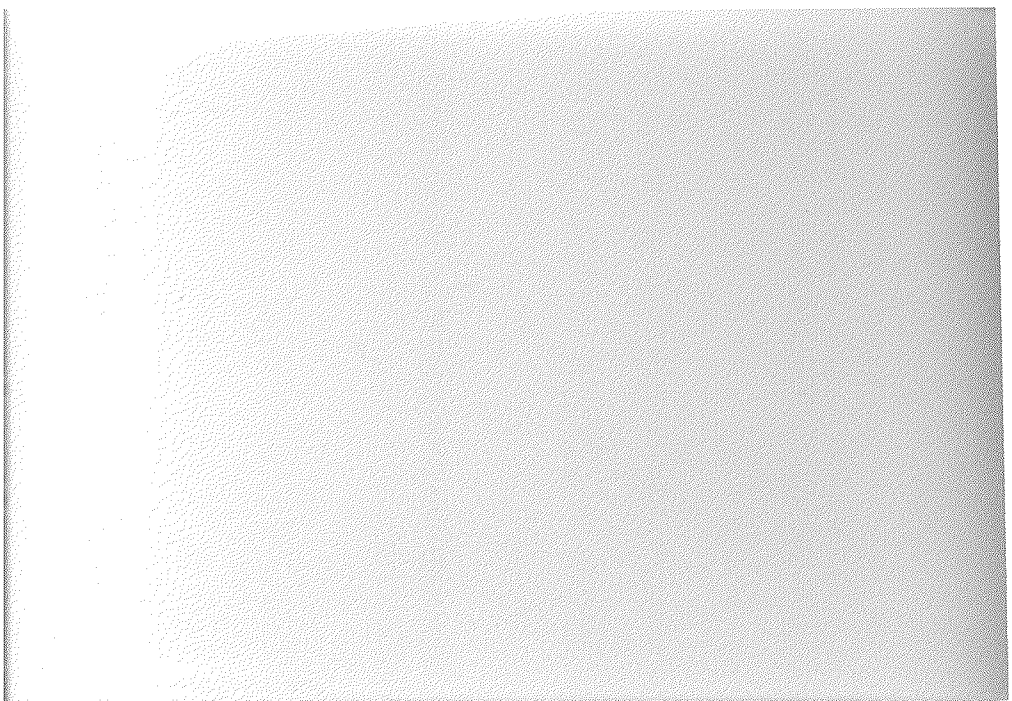
During the process of oil/gas exploitation, well piping and transport pipelines are subjected to varying loads (pressure, temperature) and to the occurrence of corrosion in all the parts of the system, starting from the well until the master pipeline entry and through the pipeline to the consumer. Failures of welded pipes during exploitation or transport of oil/gas, which occur due to damaging during exploitation, influence the operation reliability and safety. Failures generally occur due to corrosion fatigue, Fig. 2. Procedures, which refer to the material degradation of pipes/pipelines during exploitation exist and are presented in Fig. 3, but it is not uncommon that defects are not detected through use of the NDI methods.

3 Database

Reliable evaluation of integrity and suitability for operation regarding the structure elements of welded pipes/pipelines in oil industry can be made exclusively through creation of an adequate database. Additional software packages enable the more efficient use of databases, analysis of certain influential factors, possibilities of failure prevention and creation of alternative solutions in all the phases of design and structure development.

Important information for improvement of the design methods for bearing parts and elements of bearing structures, as well as for improvement of existing materials' properties and technologies for their processing and development of new materials, enable creation of the damage and failure analyses of parts and elements of bearing structures. The damage and failure analyses enable development of new technical solutions and testing methods in the prototype phase. In order to determine and prevent the causes of damage and failure, adequate analyses are being made, and that process requires a systematic approach, Fig. 4.

Databases, which refer to realized inspections and failure analyses, regarding adequate oil and gas well piping, as well as transport pipelines, offer big possibilities when it comes to determining the changes of mechanical properties of materials and welded joints, when a large number of influential factors varies, and some undesirable effects are being reduced to bearable values, or, in other words, in creating the satisfying structural solution.



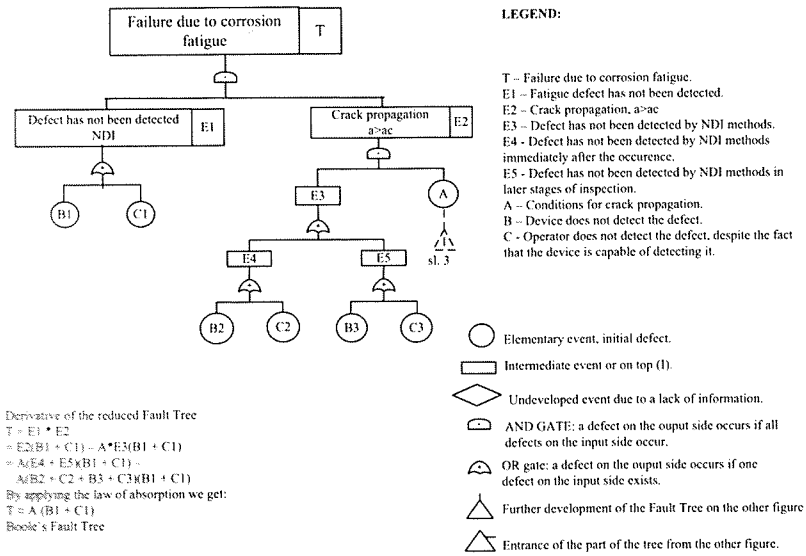


***Fig. 2** Schematic presentation of failure due to corrosion fatigue*

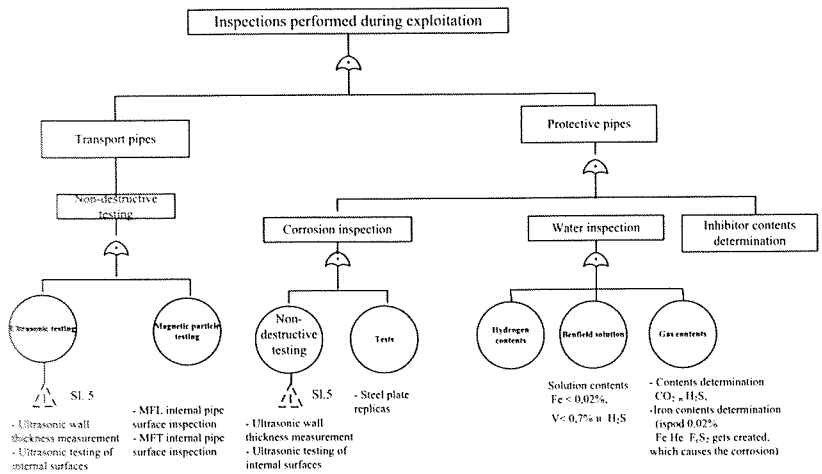


***Fig. 3** Scheme of the pipeline material degradation inspection during exploitation*

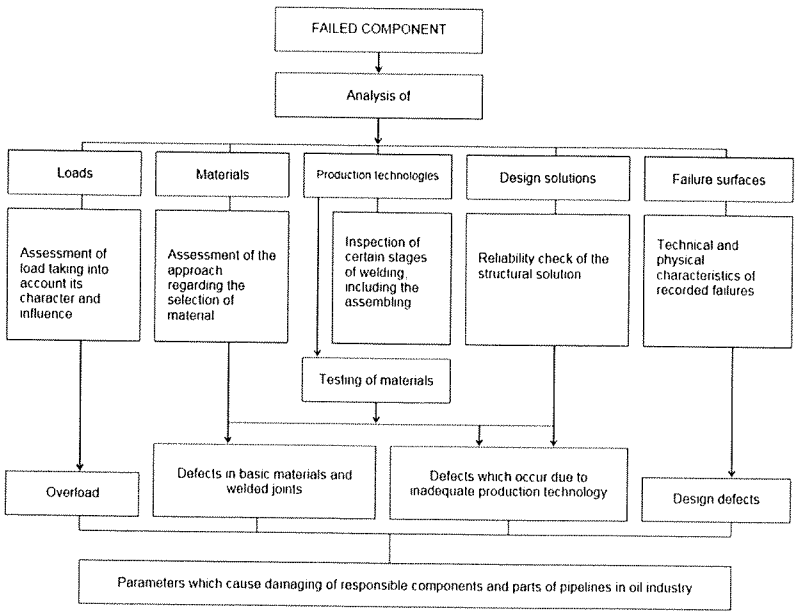


Fig. 4 Process analysis of damage and failure of welded pipes and pipelines in oil industry

4 Measures for damage and failure prevention

Through analysis of damage and failure of responsible parts and pipeline elements in oil industry, the causes, which lead to failure are being determined, enabling the decision making, which refers to rejection of the specific technical solution or preventive measures, Fig. 5. A decision, which refers to rejection of a specific technical solution, initializes making of the new optimal structural solution in varying load conditions, for various operation regimes, dimensions of parts and bearing structure elements, shapes of welded joints, materials, processes and quality of production.

A change of the load type according to the exploitation conditions leads to experimental determination of operation loads when responsible parts and pipeline elements are concerned, as well as to change of the structural solution and determination of operating conditions and load regimes, which secure the reliable operation for the specific technical solution.

Alteration of the production process technology refers to the alteration of shapes and dimensions of parts and elements of bearing structures, welding procedures, basic material and regimes of thermal treatment. Alteration of production quality inspection refers to the more strict inspection and testing before and during production, as well as after assembling.

Taking into account that aforementioned measures of damage and failure prevention represent the group of complex and expensive solutions, supposed to enhance the security of responsible parts and pipeline elements, recently many eminent institutes all over the world undertook comprehensive experimental researches in order to develop techniques for simpler and cheaper improvement of static and fatigue properties of parts and pipeline elements in oil industry. Those improved techniques are not equally successful for various structural solutions, because their effect depends on the load type and regime, material properties and type of structure that consists of welded elements. Therefore, recommendations, which refer to application of certain methods, primarily depend on the possibility of structure building and designer's experience.

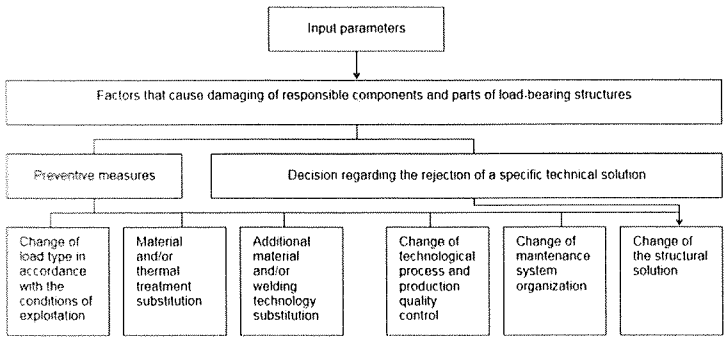


Fig. 5 Preventive measures

5 Organization Scheme of the Pipeline Maintenance System in Oil Industry

The continuing process of building oil and gas wells, their exploitation and transport of oil and gas gets accomplished through the use of piping and transport pipelines. Organization of the maintenance system regarding piping and transport pipelines depends mostly on the shape and structure of tubing, exploitation conditions, number of employees, experience of experts and adequate databases regarding maintenance and inspection of pipelines in oil industry.

Based on realized researches and experience based data regarding the pipeline maintenance system in oil industry, Fig. 6 represents the organizational model of the pipeline maintenance system in oil industry.

Acknowledgement

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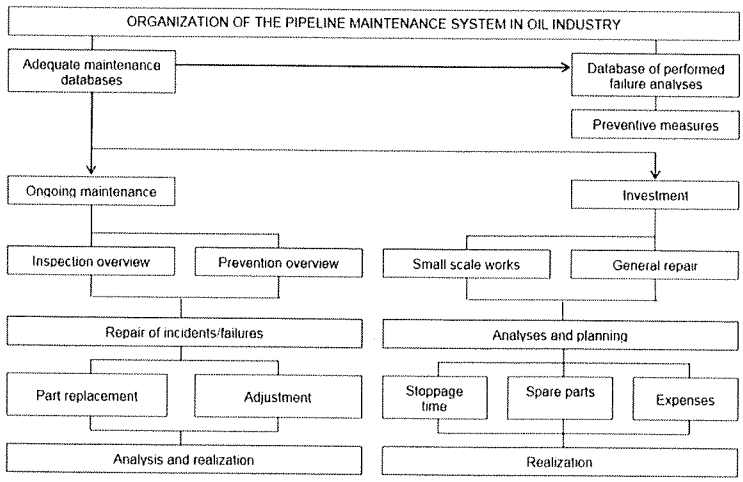

Fig. 6 Organizational Model of the Pipeline Maintenance System in Oil Industry

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