WYBRANE PROBLEMY INŻYNIERSKIE
NUMER 2
INSTYTUT AUTOMATYZACJI PROCESÓW TECHNOLOGICZNYCH
I ZINTEGROWANYCH SYSTEMÓW WYTWARZANIA

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COMPUTER AIDED OVERHAUL WITH THE EXPERT SYSTEM APPLICATION – THE DISASSEMBLY MODULE

Abstract: The Paper presents the disassembly module. The module is an integral part of expert system that is partial implementation of the Technical Mean Recirculation Method (TMRM). The Disassembly module is divided to two separate sub–modules like: Structure and Sequence. The Structure sub–module is used to input technical mean structure and joins (connection character joins), between elements. In the Sequence sub–module the syndrome identify tag is created to which mechanically used and damaged elements are assigned. As result of gained data algorithm analysis, automatically the disassembly documentation is generated with rule of minimal disassembly range taken in consideration. User have also possibility to modify the operation contents or prepare a sequence manually.

1. Introduction

The disassembly module is an part of the TMRM. Technical mean should be treated as target assembly in specific machine or machine itself [1]. Method presented in Fig. 1. As technical mean is in the state that further exploit could be crucial in case of damage or mechanical use that can bring destruction, disassembly process is needed [2]. Disassembly process is based on data that characterize technical mean structure and resultant range of mechanically used or damaged elements. The third most important input is the technical documentation. Greatly useful form of the documentation could be: the 3D model of technical mean with the complete technical drawings, an assembly sequence, the technology of manufactured elements, operation and maintenance manual. As information about the structure, the damaged and mechanically used elements list and the technical documentation is inputted; the correct sequence with reduction to necessary range is prepared with application of disassembly module (DM). The DM is divided to two sub-modules: Structure and Sequence modules. Structure module helps user to input information about: the technical mean structure, joins between elements with specific assembly order. Sequence module helps user to prepare disassembly documentation (the disassembly sheet).

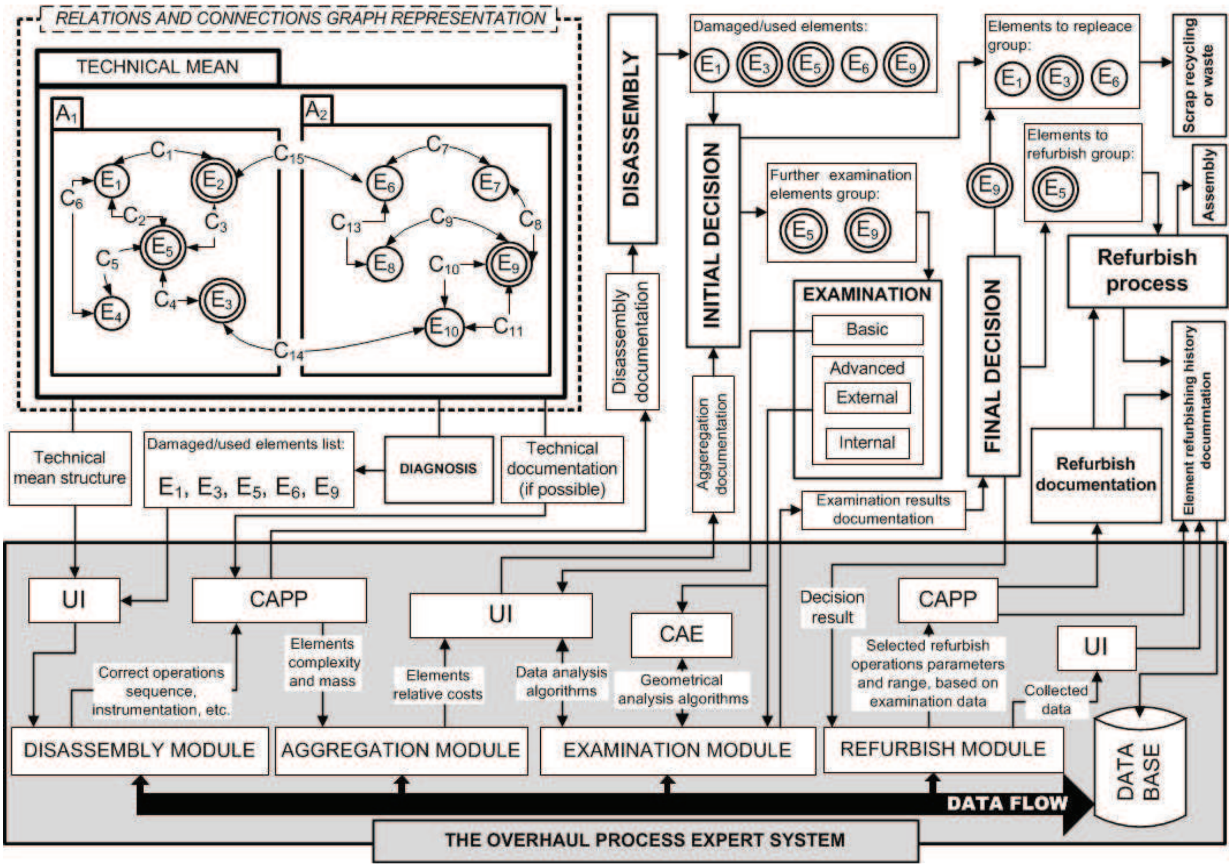

Fig. 1. Technical mean recirculation method (TMRM): A_n – assembly, E_n – element, C_n – join connection between elements for ex.: joint, weld etc., UI – user interface, CAPP – Computer Aided production planning (CAD and CAM), CAE – computer aided engineering, circled elements – catalogue/normalized, double circled elements – manufactured, CAPP and UI blocks should be treated as one.

Method is partially implemented in the Overhaul Process Expert System (OPES) that is software prepared in development environment combined with separate environments. In Fig. 2 advanced development environment is presented with division of task assignment. Provided solution is used to implement TMRM. Overhaul expert system works in multithread ways: provide algorithms prosecution, conclusion data influence stored in algorithms, geometrical operations prosecution (CAPP and CAE range), data storage and management, user interactive interface tasks prosecution. Software development is realized through object-oriented programing language C#.

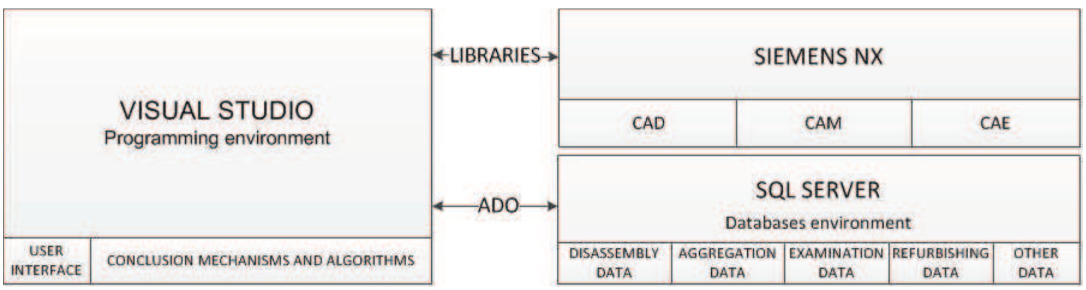

Fig. 2. The TMRM oriented software development environment

2. The disassembly module

The disassembly process have to be provided in minimal range according to damaged or mechanically used elements. To provide that an proper algorithm is needed. Example for disassembly module presentation is the hydraulic actuator assembly presented in Fig. 3.

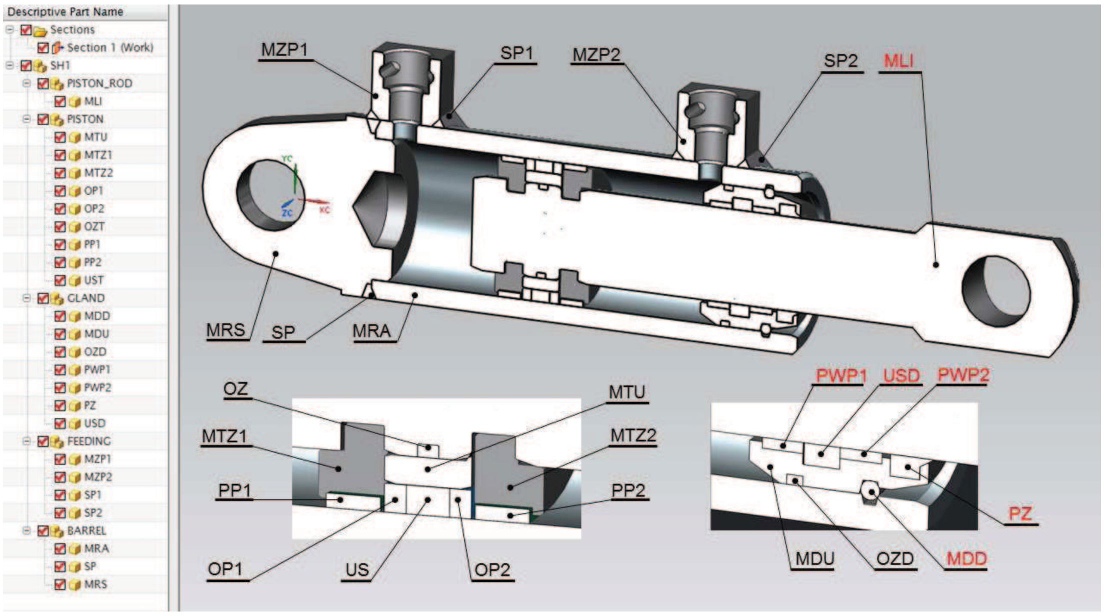

Fig. 3. 3D model of an hydraulic actuator example[4]. Red marked elements are damaged or mechanically used.

Disassembly module contains two separate sub–modules: the Structure and the Sequence. The Structure (Fig. 4.) sub–module helps input technical mean structure with additional information about joins connections between elements. At first user have to input the structure according to existing state or structure inputted earlier in CAD software. In the "Create structure" panel user should input technical mean name and create technical mean top node representation in tree-view panel. Then user can input the subassemblies in considered level. At the end assign specific elements to subassemblies. During input process the structure is simultaneously recorded in the database. "Create joins" panel helps user to input connections between elements. Joins are unlike CAD software constrains oriented to character of the connections. In overhaul processes more important than constrains are information about how two elements are combined together. To input join, user have to select from Assemblies combo boxes specific assemblies. According to which list of elements is displayed instantly; then select two elements in itch list. The last step is to select one of joins representation in icon bar. All joins have to be inputted according to assembly order. As result of inputted data user can generate the graph that represents the technical mean structure (Fig. 6, without colour marks of disassembly range). Graph is undirected and its representation for the example according to equation (1) with 24 vertices and 39 edges. Vertices in previous graphs versions has an random distribution (in automatically generated graphical representation) for each generated distribution of specific auto-isomorphic graph. What gives random quantity of edges intersections in most cases for this particular example from range 89 to 178.

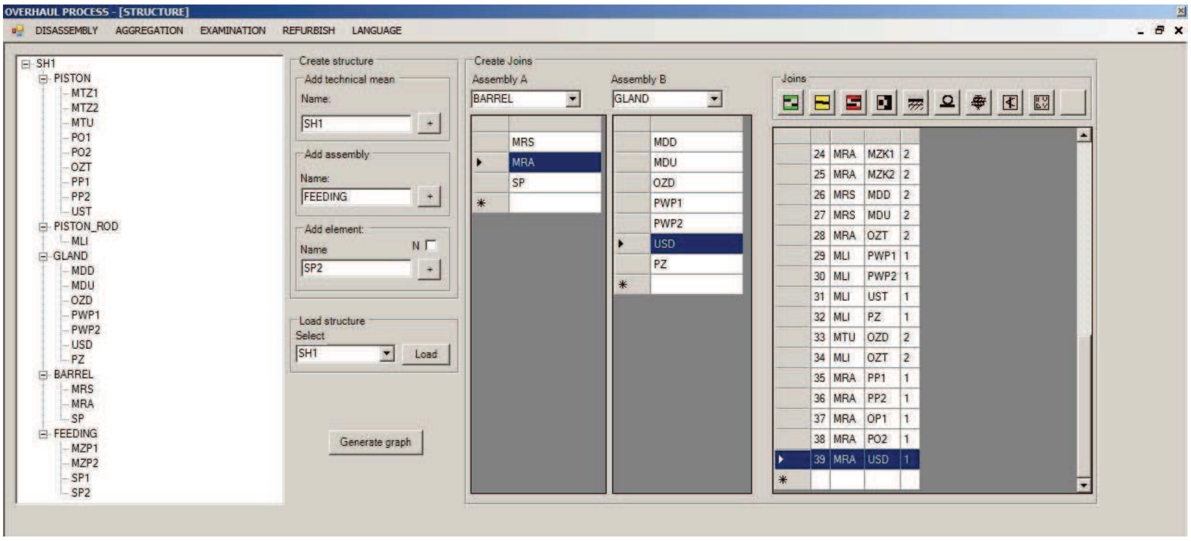

Fig. 4. Structure UI dialog

Circular distribution that groups elements in sub-assemblies gives 65 intersections. Solution for vertices distribution with simultaneously edges intersections reduction is an application of the Simulated Annealing Algorithm [3]. Beside of basic data graph also contains data about joins types. Structures of technical means can be loaded from database through the technical mean ID selection, as well as joins inputted during structure preparation.

$$G = (V, E)\,, \tag{1}$$

where:

$$V=\{MTZ1,MTZ2,MTU,PO1,PO2,OZT,PP1,PP2,UST,MLI,MDD,MDU,\\ OZD,PWP1,PWP2,USD,PZ,MRS,MRA,SP,MZP1,MZP2,SP1,SP2\} \tag{2}$$

$$E=\{\{MRA,MRS\},\{MRA,SP\},\{MRS,SP\},\{MZP1,SP1\},\{MZP2,SP2\},\{MDU,OZD\},\{MDU,PWP1\},\\ \{MLI,PWP1\},\{MLI,USD\},\{MLI,PWP2\},\{MLI,PZ\},\{MLI,OZT\},\{MLI,MTU\},\{MLI,MTZ1\},\\ \{MLI,MTZ2\},\{MTZ1,PP1\},\{MTZ1,PO1\},\{MTZ2,PP2\},\{MTZ2,PO2\},\{MTU,UST\},\{MRA,PO2\},\\ \{MRA,PP2\},\{MRA,MTZ2\},\{MRA,OZD\},\{MRA,MDD\},\{MRA,MZP1\},\{MRA,SP1\},\{MRA,MZP2\},\\ \{MRA,SP2\},\{MDU,PWP2\},\{MDU,PZ\},\{MRA,MTZ1\},\{MRA,PO1\},\{MRA,UST\},\{MRA,MDU\},\\ \{MDU,USD\},\{MRA,MDU\}\} \tag{3}$$

The Sequence sub–module is used for disassembly documentation formalism preparation, especially: correct order of disassembly operations, timings, instrumentation description and personal data. Provided solutions is based on algorithms that analyse technical mean structure and connections between elements in assembly order. In Fig. 5 Module user interface is presented with group of panels that are used to specific tasks. The first step is technical mean ID selection from the list, then syndrome can be assigned with ID and simple main appearance symptom description.

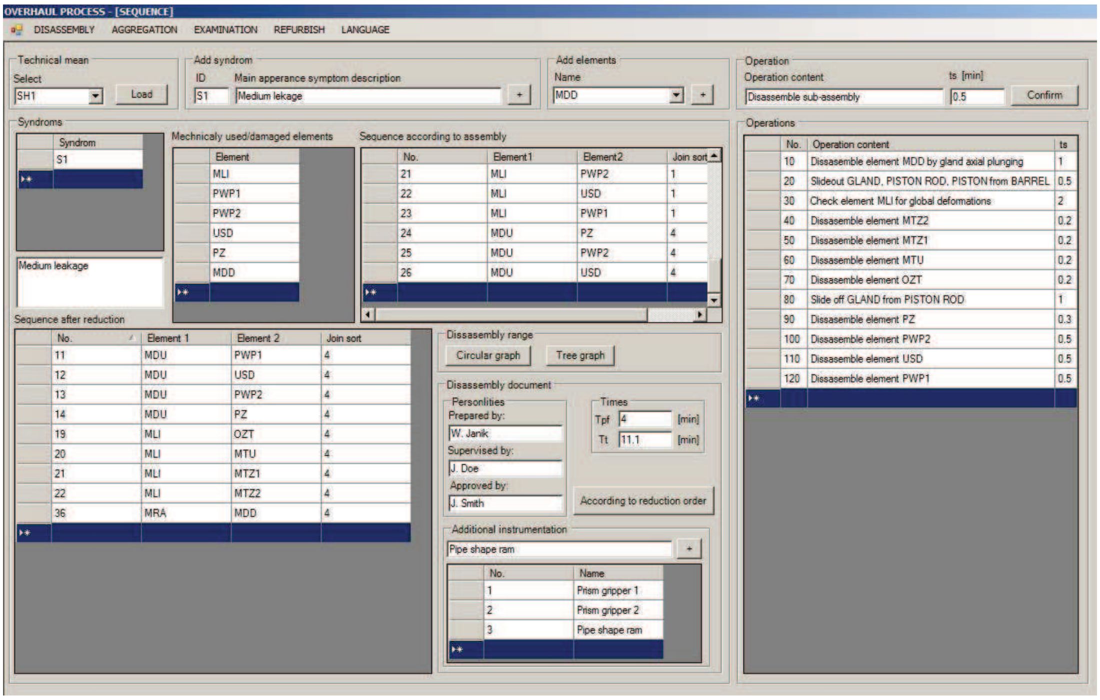

Fig. 5. Sequence UI dialog: T_{pf} – preparation-finish Time, T_t – total time, t_s – singular time

The next step is to provide group of mechanically used or damaged elements assignment to specific syndrome. Instantly data is presented in panels: "Sequence according to assembly" and "Sequence after reduction". Next user have to input data in "Disassembly document" panel: personalities, preparation time (T_{pf}), additional instrumentation. When all data is inputted user can provide "According to reduction order" option to prepare sequence semi–automatically in "Operations" panel. Automatically generated operations contents can be modified by user as well as the singular operations timings (t_s).The prepared algorithm automatically identifies operations like: disassemble operations (with specific type of connections recognition; for ex. welding join – cut element, shape join – disassemble element, screw join – unscrew element etc.), check element operations (if few elements are assembled on specific element, this element have to be checked; for ex. for global deformations), subassembly disassemble operations.

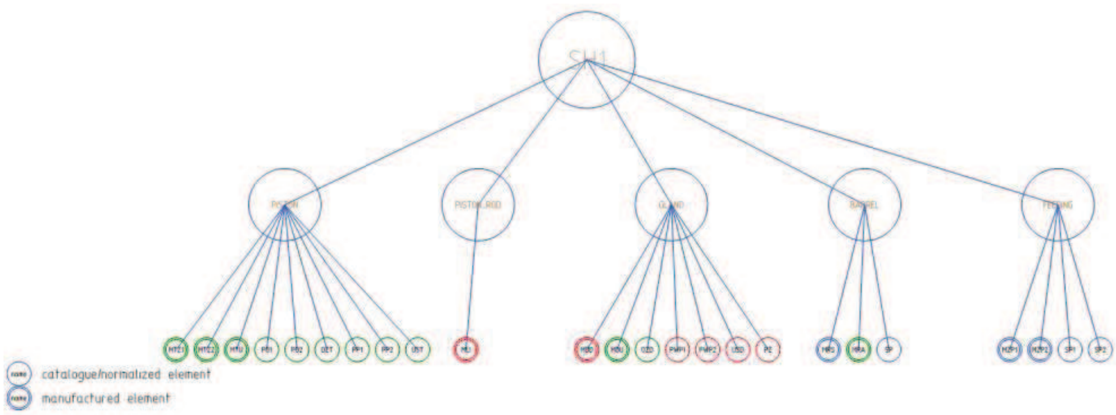

Fig. 6. Tree graph that represents disassembly range with elements colour marks.

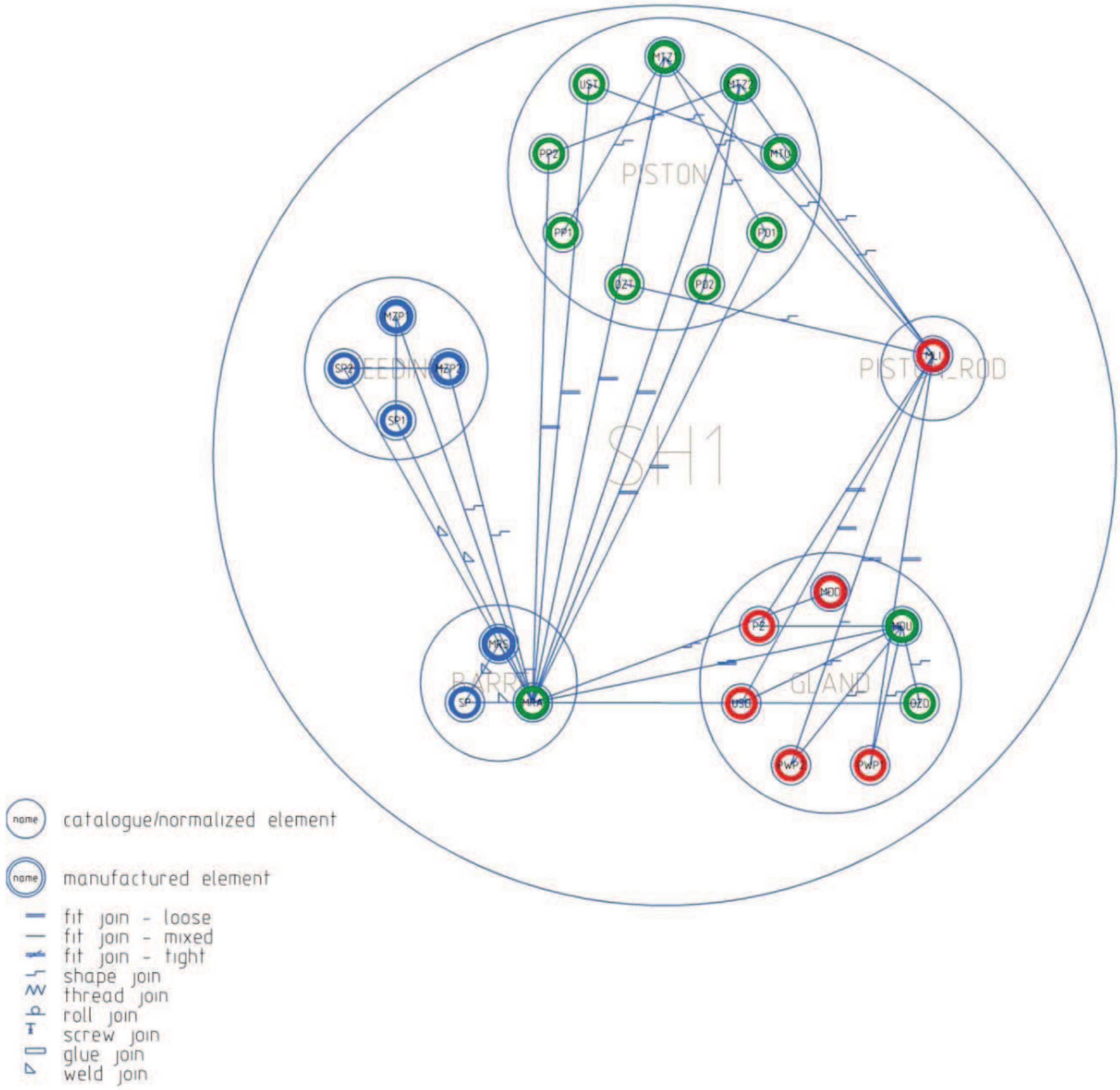

Fig. 7. Technical mean relational connections structure graph with disassembly range marks.

The result of Sequence sub–module operation is tree graph (Fig. 6.), circular graph (Fig.7) and disassembly sheet formalism (Fig. 8). Circular graph generated in the Sequence sub–module contains data about disassembly range. Red circled marked vertices are mechanically used or damaged elements, green circled marked vertices are elements that are a part of disassembly process, blue marked circled vertices are elements that are not a apart of disassembly process. Graph is printed out in *.xps document file, for better graphical representation (high DPI export possibility). TMRM implementation result as graphs provide disadvantage as only 2 level structures presentation. As solution user should prepare separate graphs for each specific target assembly in two level presentation and then combine them together. All documentation is generated automatically in base of inputted data. Presented documentation at the further procedures should be send to disassembly station (according TMRM – Fig. 1) Worker should use disassembly sheet document as primary guidance, and be equipped with technical drawing assembly sheet.

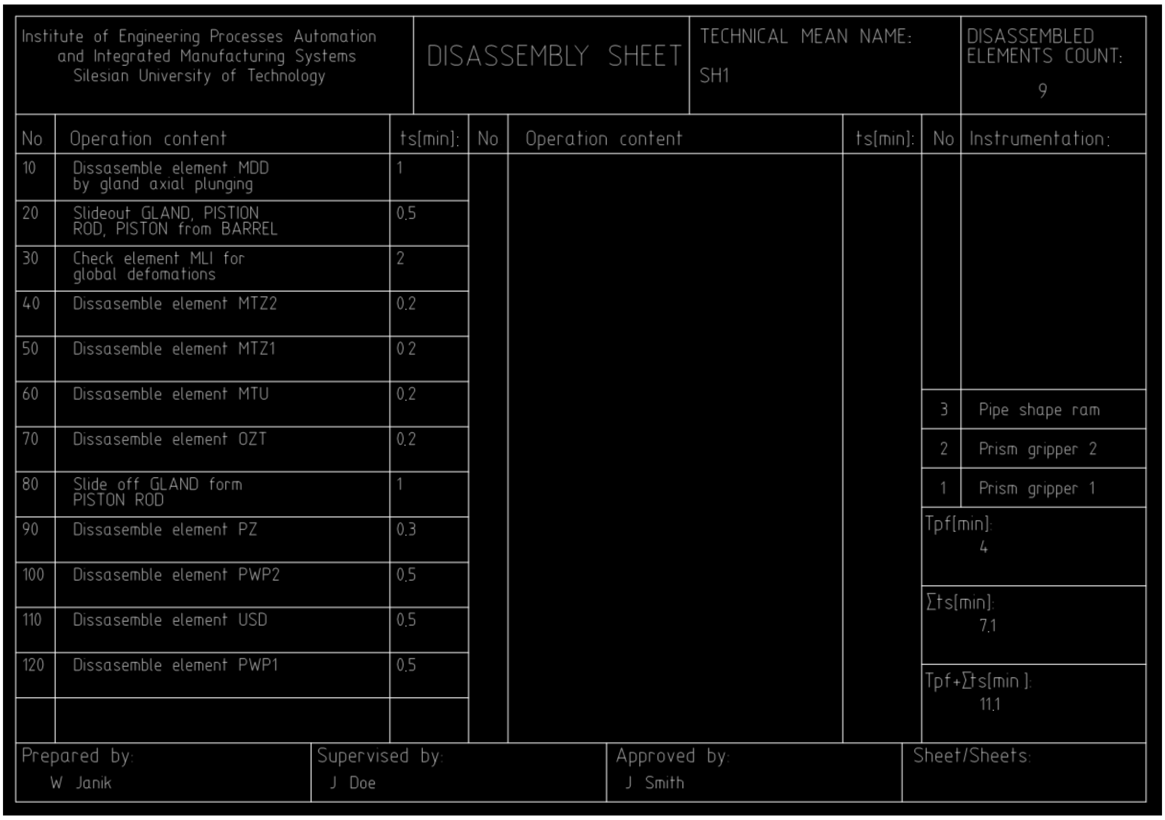

Fig. 8. Disassembly sheet

All sheets can be easily managed as it is shown in the Fig. 9. As it is presented in source box user can select one of sheets and then send to local, remote printer or save on disk as an *.xps file. According to presented print dialog, each document has preserved its specific name like:

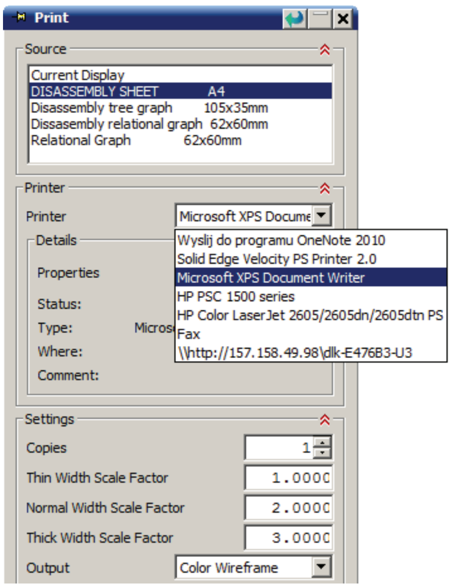

Fig. 9. Print dialog (NX software)

3. Summary

The Technical Mean Recirculation Method is universal, but disadvantages appears with implementation, for ex.: maximum two level structure presentation in graphs. User also should be aware how a technical mean is built (use technical drawing of technical mean assembly) to provide disassembly process. Lack of technical documentation is one of the most critical barrier in the TMRM. This disadvantage have to be minimized by among others reverse engineering techniques. Fortunately possibility of automation and computer aid, can effectively support overhaul processes. Presented disassembly module target is to prepare documentation that can be directly applied at disassembly station. Main document which is the disassembly sheet, completes that target. Additional support of graphs can improve disassembly process. The STRUCTURE sub–module gives possibility to input structure of technical mean only manually, further software development should bring possibility to copy structure straight from CAD program. The Computer Aided Overhaul can be supported with expert system based on the TMRM in the disassembly stage. The proposed solution as the disassembly module provide possibility to short time needed to prepare the disassembly documentation. The automation in the aspect of overhaul process preparation should be obtained through new tools, oriented to minimize subjective decisions during disassembly process preparation. The Further implementation development will be oriented to add new methods operation order generation and implementation of technical mean history knowledge based algorithms. Syndrome assignment gives possibility to prepare alternate solution for each case. At this stage when disassembly is provided, the syndrome can be only described with the ID and the main appearance symptom description. The described symptom in this stage is only appearance coarse attempt to present what is happening with technical mean during failure. Finally syndrome should be described property with group of symptoms that characterize precisely specific case. More extended description should be provided after the disassembly and the examination procedures and integrated with the refurbishment data to describe provided refurbishment and replacement treatment for each element. Estimated time of 11.1 minutes should be corrected during first disassembly attempt. The presented partial implementation of TMRM proves that in its range the method is correct. Presented solutions should be considerate especially in heavy industry.

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