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 AGREGGATION MODULE

Abstract: The paper presents aggregation module and the author's Interchangeable Refurbishment Method (IRM). The aggregation module is an integral part of expert system that aid the overhaul process preparation. By operation oriented to the abstracts (technical documentation, structure, symptoms and list of damaged or mechanically used elements) reveals possibility of estimation: which elements should be replaced and which should be examined. Next the Interchangeable Refurbishing Method is proposed, in which mechanically used or damaged elements assigned to syndrome are replaced, by what time for further examination and refurbishment is simultaneously gained. Furthermore with provided aggregation, assignment of element a copy is possible and placement of that copy. The Aggregation module by automatically assignment of elements to replacement or further examination, improve stage of initial decision in the author's Technical Mean Recirculation Method (TMRM). The Aggregation is based on data gained form technical documentation, what are: element complexity, mass and joins quantity. Relative cost based on results is determined.

1. Introduction

The Aggregation module is an part of the TMRM. The aggregation helps to take initial decision about sending damaged or mechanically used element to further examination, same as helps select target (in refurbishing point of view) elements in assembly to provide interchangeable refurbishing (Fig. 1.). When aggregation is don for specific technical mean, an group of refurbishing potential elements is gained. It's important to focus on elements which relative cost is high, unlike provide replacement for all elements in technical mean. Interchangeable refurbishing method is proposed especially when element has mechanical usage. Mechanical use unlike damage is predictable according to: placement, range, and time of appearance. According to mechanical use character, once prepared disassembly, examination (but periodically examination repeat is needed), and refurbishing technology; can be used repeatable after each interchange.

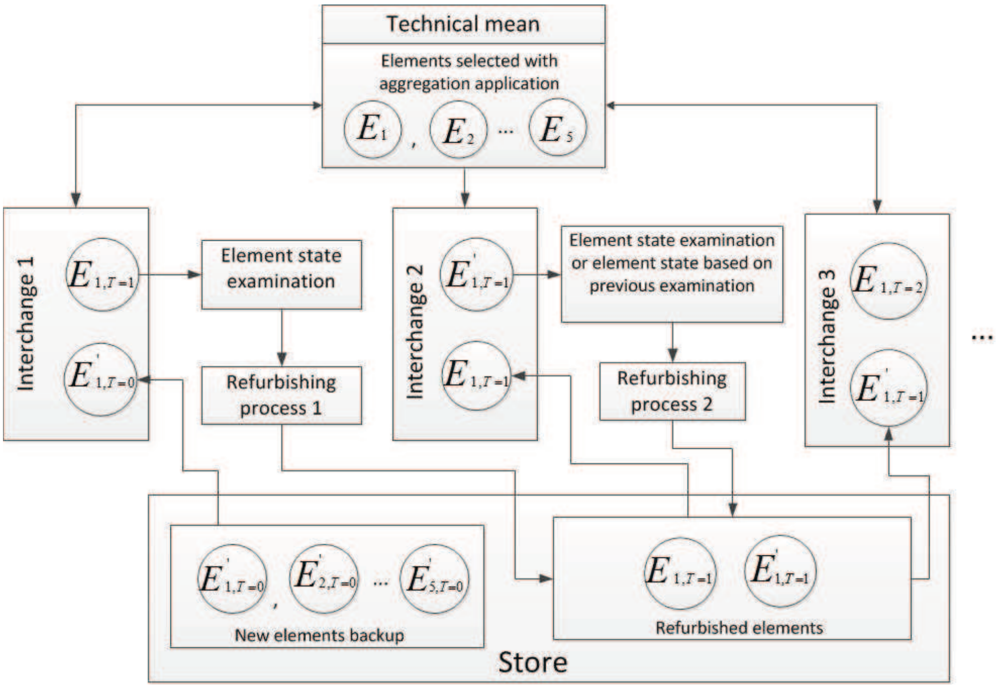

Fig. 1. Interchangeable refurbishing method (IRM)

2. Agreggation module

The aggregation stage is important because in overhaul process preparation, it could be provided in base of abstracts. There is no need to operate on existing technical mean [1], so aggregation can be also provided as prediction stage of overhaul process. Aggregation implementation of TMRM presentation is based on example depicted in Fig. 2. The Aggregation module is a proposition to initial decision approach oriented to elements refurbishing. If damaged or mechanically used elements are disassembled, these elements can be categorized as: normalized or catalogue elements (NCE) and manufactured elements (ME). NCE's should be in most cases directly replaced in technical mean for ex.: screws, gaskets, guidance rings etc. [2]. NCE's are typically mass production elements. Unlike NCE's, ME's are typically more complex, what has an important impact to overall cost of an element [3], (especially machined elements) for ex: piston rods, gears hafts, stabilizer coupler's arm etc.. Aggregation module UI is presented in Fig. 3. In this module user selects technical mean, then syndrome. After syndrome selection is completed automatically the mechanically used and damaged element list is loaded from database. Simultaneously list of elements in reference model features group is updated with same elements. Additionally user has a possibility to add other elements to aggregation from technical mean by selecting proper assembly in elements panel. Next step is to collect data from each element by selecting 3D model of an element in NX graphical display (when element is selected automatically changes colour to red) and then use decoding option. Material assignment is needed to retrieve mass data during aggregation algorithm prosecution. Decode option gets all information about reference model needed in aggregation.

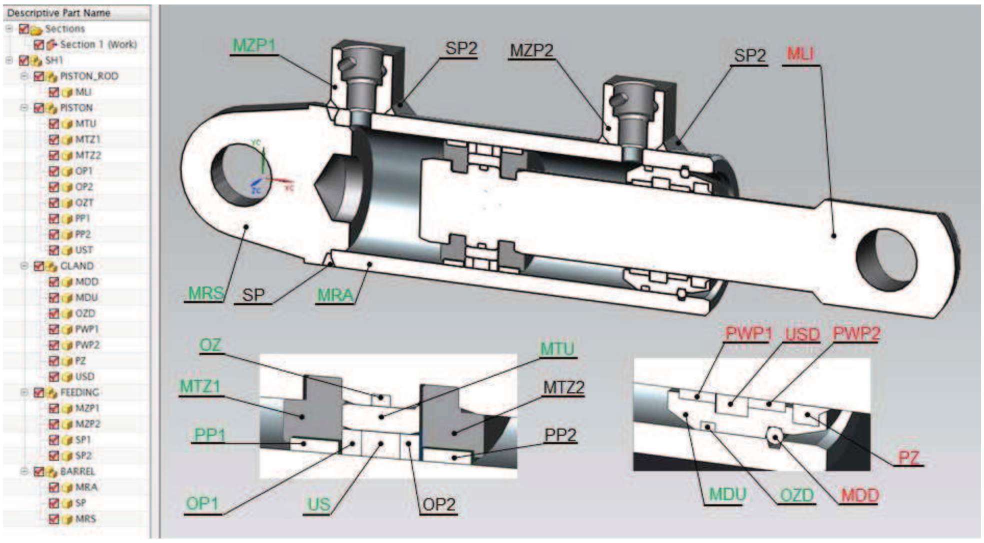

Fig. 2. 3D model of an hydraulic actuator example[4]. Red marked elements are damaged or mechanically used, green marked elements are elements that are used to extend range to improve aggregation results.

When decode is provided all important data is presented in Reference model features panel like: surfaces quantity, total surfaces area, volume, material and mass. Additional information is an element status which can be described as {0,1,2} assignment. Assignment describe kind of status as: 0 – acceptable, 1 – mechanical use, 2 – damage.

Used		Name	Label	Category	Type	Location	Library
		00_15HN	1	Other	Isotropic	MDD.prt	ISO.xml
		00_POLIURETHANE	1	Other	Isotropic	PZ.prt	ISO.xml
		00_32HG2A	1	Other	Isotropic	MRA.prt	ISO.xml
		00_POLIURETHANE	1	Other	Isotropic	USD.prt	ISO.xml
		00_18G2A	1	Other	Isotropic	MZP1.prt	ISO.xml
		00_40H	1	Other	Isotropic	MTU.prt	ISO.xml
		00_18G2A	1	Other	Isotropic	MZP2.prt	ISO.xml
		00_45G2	1	Other	Isotropic	MTZ1.prt	ISO.xml
		00_STAL	1	Other	Isotropic	SP1.prt	ISO.xml
		00_POLIACETAL	1	Other	Isotropic	PP1.prt	ISO.xml
		00_40H	5	Other	Isotropic	MLI.prt	ISO.xml
		00_STAL	1	Other	Isotropic	SP2.prt	ISO.xml
		00_E295	1	Other	Isotropic	MDU.prt	ISO.xml
		00_RUBBER	1	Other	Isotropic	OZD.prt	ISO.xml
		00_45G2	1	Other	Isotropic	MTZ2.prt	ISO.xml
		00_POLIACETAL	1	Other	Isotropic	PWP1.prt	ISO.xml
		00_18G2A	1	Other	Isotropic	MRS.prt	ISO.xml
		00_POLIACETAL	1	Other	Isotropic	PWP2.prt	ISO.xml
		00_POLIURETHANE	1	Other	Isotropic	OP2.prt	ISO.xml
		00_POLIURETHANE	1	Other	Isotropic	UST.prt	ISO.xml
		00_POLIURETHANE	1	Other	Isotropic	OP1.prt	ISO.xml
		00_POLIACETAL	1	Other	Isotropic	PP2.prt	ISO.xml
		00_RUBBER	1	Other	Isotropic	OZT.prt	ISO.xml

Fig. 3. Material UI (NX software) – material assignment

The description is selected by the user in element status list in reference model features panel. This particular data is not considered during aggregation process. User has also possibility to manually input data if there is no possibility to retrieve documentation or 3D model. When all data are decoded or inputted by the user, for particular element (for ex. MDD element – Fig. 4), the data can be recorded in aggregation data collection, what is visualized in “Elements aggregation list panel”. When user decides that list is complete, can execute aggregation procedure. In a result user retrieve information about each element ratios and relative costs according to specified group (author algorithm). Visualization on chart reveals which element can be send to further examination. It the “Initial decision” panel according to Fig. 4, to replace list which is automatically updated with NCE’s elements and user decide which of ME’s elements can be send to examination by elimination of low relative cost ME’s. Aggregation chart reveals that MLI element – piston rod, have significantly greater relative cost then other damaged or mechanically used elements. Beside of MLI element MDD – clamping wire (Fig.2.) is ME. In comparison of these two relative cost is still significant. To improve Aggregation and check relative cost in larger group of elements in example assembly an group extension is provided. Aggregation group is extended by elements marked in green colour – Fig. 2. As result user retrieve from aggregation new extended chart – Fig. 5. In this chart this chart all the hydraulic actuator elements were presented (without doubling in extended group of elements).

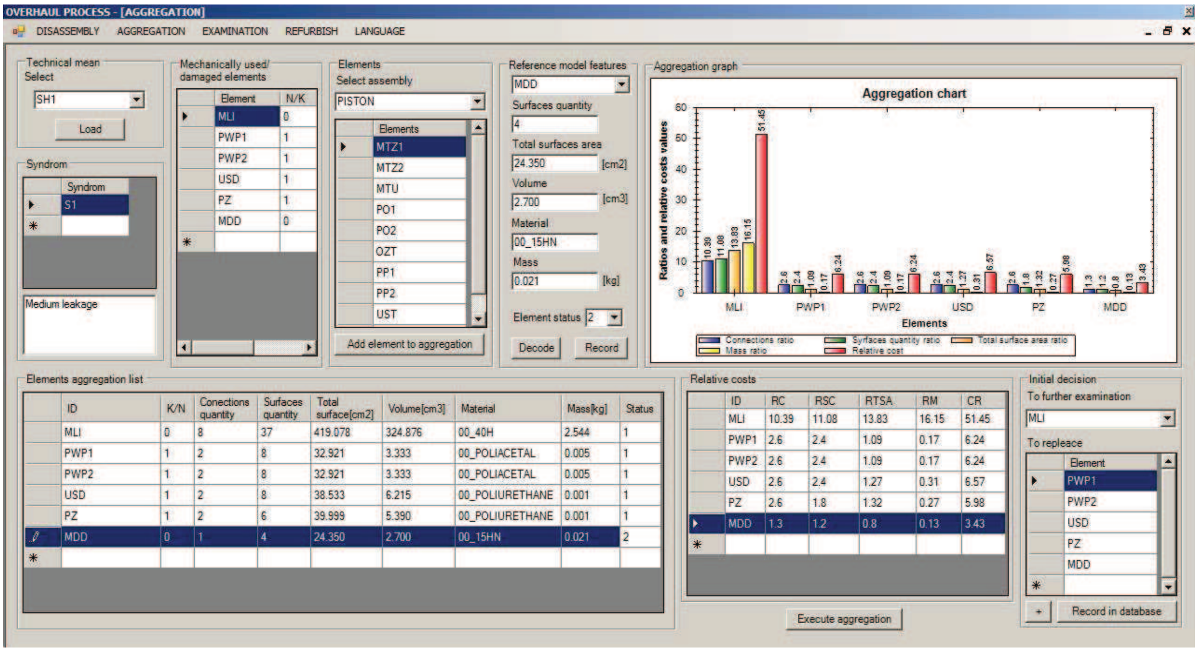

Fig. 4. Aggregation UI Dialog: RC – connections ratio, RSC – Surfaces quantity ratio, RTSA – Total surfaces area ratio, RM – mass ratio, CR – Relative cost

For better case presentation all gathered data from the reference model were set together in the Tab.1. The elements collection set is oriented also to extended group and as result aggregation data is presented in Tab. 2. Results indicate MRA, and MLI as most acceptable elements for further examination. Also results group extension improve aggregation process and still sustain high relative cost value for MLI element. The MRS and MDU elements could be conditionally considered as refurbishment capable elements.

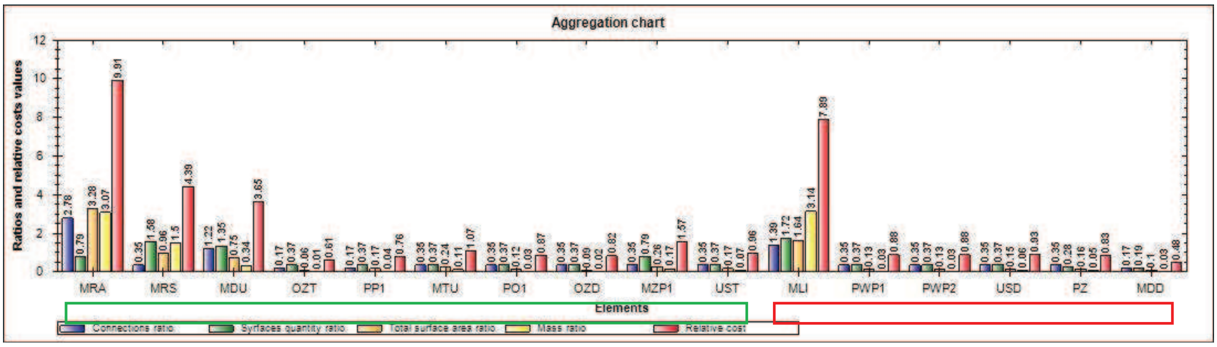

Fig. 5. Aggregation Chart (green boarder extended group of elements, red boarder – mechanically used or damaged elements) – elements marked in Fig. 2.

Result also reveals correct combination of selected parameters like: surface quantity, quantity of connections between elements, total surface area, mass; to obtain relative cost of an element. User should remember that this type of aggregation is oriented specify to machined elements. What reveals disadvantage of TMRM implementation in aggregation matter. Solution proposition to this disadvantage is to assign weights values to each ratio that modify integral value.

Tab. 1. The data gathered during decoding procedure (aggregation list)

No.	ID	K/N	Connections quantity	Surfaces quantity	Total surface [cm^2]	Volume [cm^3]	Material	Mass [kg]	Status
1	MRA	0	16	17	835.002	317.417	00_32HG2A	2.485	0
2	MRS	0	2	34	246.025	155.519	00_18G2A	1.218	0
3	MDU	0	7	29	191.077	35.389	00_E295	0.277	0
4	OZT	1	1	8	14.280	1.058	00_RUBBER	0.002	0
5	PP1	1	1	8	44.540	4.510	00_POLIACETAL	0.006	0
6	MTU	0	2	8	60.751	11.224	00_40H	0.088	0
7	PO1	1	2	8	30.508	3.450	00_POLIURETHANE	0.000	0
8	OZD	1	2	8	21.855	1.620	00_RUBBER	0.003	0
9	MZP1	0	2	17	67.281	17.118	00_18G2A	0.134	0
10	UST	1	2	8	44.331	6.906	00_POLIURETHANE	0.001	0
11	MLI	0	8	37	419.078	324.876	00_40H	2.544	1
12	PWP1	1	2	8	32.921	3.333	00_POLIACETAL	0.005	1
13	PWP2	1	2	8	32.921	3.333	00_POLIACETAL	0.005	1
14	USD	1	2	8	38.533	6.215	00_POLIURETHANE	0.001	1
15	PZ	1	2	6	39.999	5.390	00_POLIURETHANE	0.001	1
16	MDD	0	1	4	24.350	2.700	00_15HN	0.021	2

Unfortunately weights values cannot be obtained other else then trough expert estimation or neural network implementation (neural network teach process should be based on specific cases). For example consideration of two elements comparison. If first one is machined element; the quantity of surfaces have a great matter. If unlike the first then the second element is injected one, quantity of surfaces are not so important.

Tab. 2. The Ratios set according to Fig. 5

No.	ID	R_C	R_{SC}	R_{TSA}	R_M	C_R
1	MRA	2.78	0.79	3.28	3.07	9.91
2	MRS	0.35	1.58	0.96	1.5	4.39
3	MDU	1.22	1.35	0.75	0.34	3.65
4	OZT	0.17	0.37	0.06	0.01	0.61
5	PP1	0.17	0.37	0.17	0.04	0.76
6	MTU	0.35	0.37	0.24	0.11	1.07
7	PO1	0.35	0.37	0.12	0.03	0.87
8	OZD	0.35	0.37	0.09	0.02	0.82
9	MZP1	0.35	0.79	0.26	0.17	1.57
10	UST	0.35	0.37	0.17	0.07	0.96
11	MLI	1.39	1.72	1.64	3.14	7.89
12	PWP1	0.35	0.37	0.13	0.03	0.88
13	PWP2	0.35	0.37	0.13	0.03	0.88
14	USD	0.35	0.37	0.15	0.06	0.93
15	PZ	0.35	0.28	0.16	0.05	0.83
16	MDD	0.17	0.19	0.1	0.03	0.48

3. Summary

The main problem of nowadays estimation according overhaul process is accurateness. Presented solution gives specific values and data that explicitly brings result. User can not only backup taken decision, but also present what is the difference between two elements according to relative cost (for example MRA element has 0.2 higher relative cost then MLI, for selected elements group). Initial decision about which element should be replaced at once and which should be sent to further examination in author's TMRM is supported with aggregation implementation. The aggregation can be provided without influence to technical mean, but all procedures are made on an abstract 3D model. Main disadvantage comes with lack of technical documentation or need to prepared 3D assembly model from 2D technical drawing. For each technical mean aggregation can be prepared once for all elements in technical mean or for separate groups of elements. Provided syndrome assignment gives possibility to prepare aggregation for each syndrome separately according to damaged or mechanically used elements. The presented aggregation implementation of the TMRM proves that in its range the method is correct.

Bibliography

1. Dietrych J.: System i konstrukcja. Warszawa: WNT, 1985.
2. Gendarz P., Janik W.: Refurbishing technologies of hydraulic actuators applied in mining industry. "Journal of Achievements in Materials and Manufacturing Engineering" 2010, No 41, p. 104-111.
3. Steiner M., Ehrlenspiel K., Schnitzlein W.: Experience with the introduction of knowledge-based extensions of a CAD - system for supporting construction cost estimate. VDI Berichte 1993, No. 1079, p. 33-43.
4. Gendarz P.: Elastyczne systemy modułowe konstrukcji maszyn. Gliwice: Wyd. Pol. Śl., 2009.