TECHNICAL TRANSACTIONS | CZASOPISMO TECHNICZNE
MECHANICS | MECHANIKA
1-M/2013

ŁUKASZ GOLA*

COMPUTER AIDED MODELING ASSEMBLY PROCESS PLAN

KOMPUTEROWO WSPOMAGANE MODELOWANIE PROCESU TECHNOLOGICZNEGO MONTAŻU

Abstract

In the Institute of Production Engineering of Cracow University of Technology carried out research in the field: design manual and robotic manufacturing systems. The paper presents computer aided modeling assembly process plan with using programs: CAD/CAM Catia v5, MS Visio 2010, MS Excel 2010). The assembly process plan is illustrated in the example of dual stage regulator.

Keywords: CAPP, assembly process plan, manufacturing system

Streszczenie

W Instytucie Technologii Maszyn i Automatyzacji Produkcji Politechniki Krakowskiej prowadzone są badania z zakresu projektowania ręcznych i zrobotyzowanych stanowisk i systemów wytwarzania. W artykule przedstawiono proces projektowania procesu technologicznego montażu z zastosowaniem systemów komputerowego wspomagania (system CAD/CAM Catia v5, Visio 2010, Excel 2010).

Słowa kluczowe: CAPP, proces technologiczny montażu, system wytwarzania

* PhD. Eng. Łukasz Gola, Institute of Production Engineering, Mechanical Faculty, Cracow University of Technology.

1. Introduction

Design of complex manufacturing systems (assembly manufacturing systems) is a multi--step process (design anddecision making). During this process, the basic steps are carried out:

- Prepare assumptions
- Preliminarydesign of assembly process plan
- Conceptualdesign of assebly workstations (assembly line)
- Modeling and verification

2. Prepare assumptions

The starting point of any process plan is to define product (Fig. 1) which will be mounted and next specify the production program. Characteristics of the product (the weight and size) affects for selecting appropriate manufacturing instrumentals – for example: equipment of assembly workstations, mode of transport between workstations (conveyor belt, trucks, ...). Whereas the production program determines the production cycle, which limits the duration of individual operations.

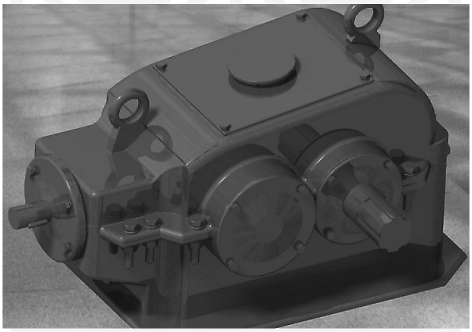


Fig. 1. Dual stage regulator

Rys. 1. Reduktor stożkowo-walcowy

Presented product (Fig 1) was modeled with using CAD/CAM Catia System (Modules: Part Design and Assembly Design).

3. Preliminary design of assembly process plan

The purpose of this step is to analyze the product structure for its possible split (assemblies and subassemblies) which can be mounted independently of each other. This process is also known as aggregation of parts. An example of a product with separate assemblies and subassemblies is shown in (Fig. 2).

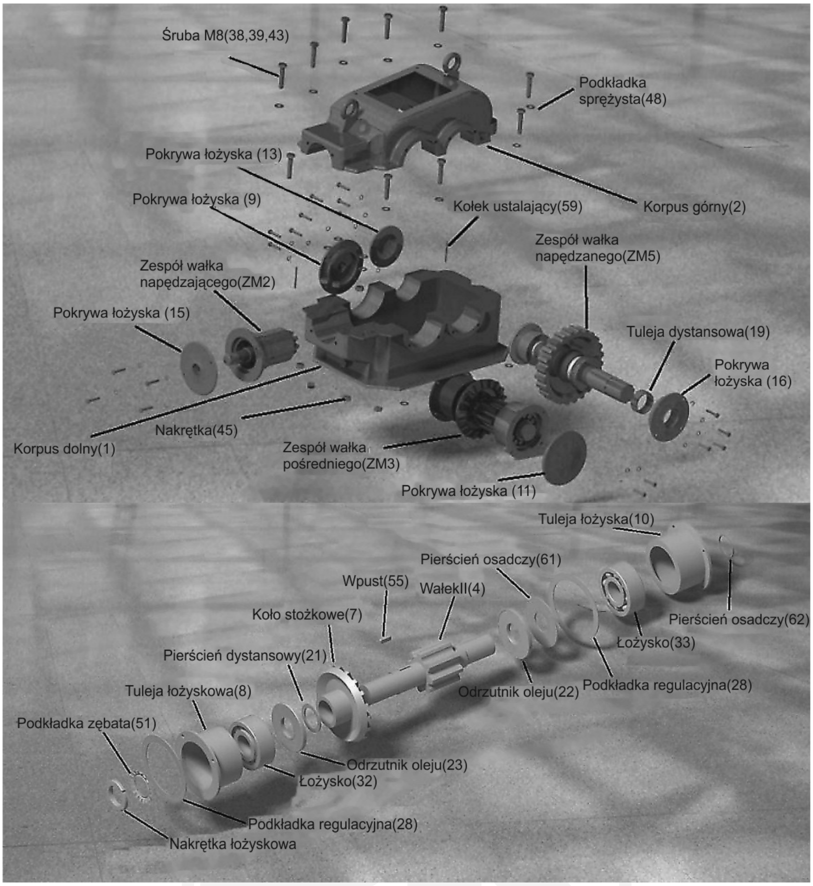


Fig. 2. Assemblies and subassemblies of dual stage regulator

Rys. 2. Zespoły i podzespoły reduktora stożkowo-walcowego

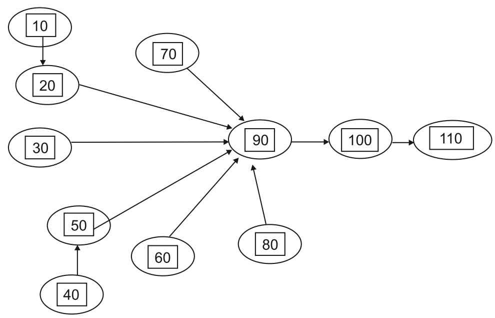


Fig. 3. Follow-graph of assembly operations

Rys. 3. Graf następstw operacji montażowych

Number of operation	Content of operations
10	Mounting subassembly drive shaft (ZM1)
20	Mounting assembly drive shaft (ZM2)
30	Mounting assembly middle shaft (ZM3)
40	Mounting subassembly middle shaft (ZM4)
50	Mounting assembly out shaft (ZM5)
60	Mounting seal of drive shaft (ZM6)
70	Mounting seal of out shaft (ZM7)
80	Mounting subassembly trunk(ZM8)
90	Mounting main assemblies (ZM9)
100	Oil charge and closing regulator (ZM10)
110	Technical control

Fig. 4. The sequence assembly

Rys. 4. Kolejność montażu

Aggregation of parts allow for the identification which assemblies and subassemblies can be mounted independently. On this basis and on the basis of follow-graph (Fig. 3) (showing the correct order of assembly), we can develop the assembly sequence (Fig. 4). The follow--graph can be very helpful in determining the sequence, especially for more complex products.

4. Conceptual design of assembly

The purpose of conceptual design is: determine the duration of the pre-planned operations, division or grouping of operations to finally get the operations of similar duration (balancing). It should also be chosen such time values, that do not exceed the production cycle. To achieve this goal we must first develop preliminary design assembly workstations (flat sketches)

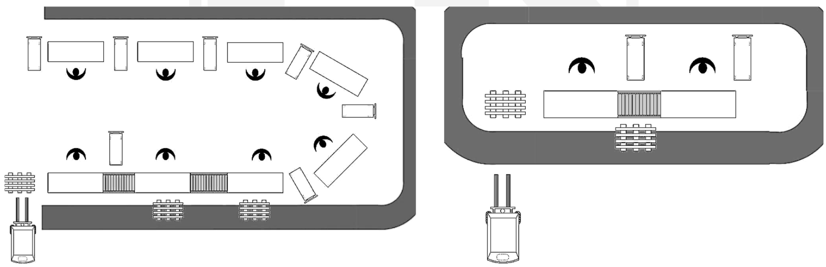
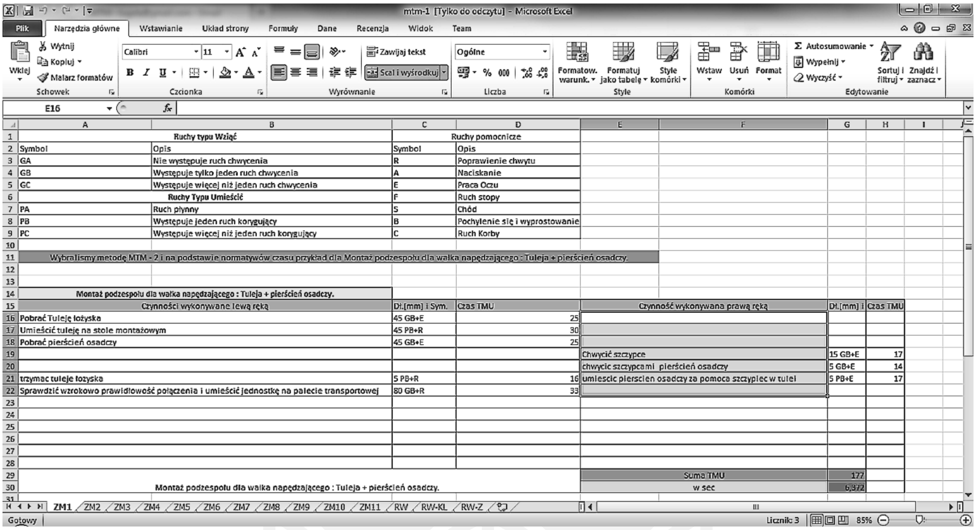


Fig. 5. Sketches of assembly workstations – MS Visio 2010

Rys. 5. Szkice stanowisk montażowych – MS Visio 2010

which include the distribution of equipment and operators (Fig. 5). A convenient computer program for the preparation of such drawings is Microsoft Visio 2010. Next then there is standardization duration of individual operations. In the case of manual work, usually the most useful method of standardization are methods: MTM1 (Fig. 6), MTM2, MOST. The choice of method depends on the expected duration of the operation and its characteristics (standardized operation is divided into individual movements or entire sequences of operations).



	A	B	C	D	E–F	G	H
1	Ruchy typu Wziąć		Ruchy pomocnicze				
2	Symbol	Opis	Symbol	Opis			
3	GA	Nie występuje ruch chwycenia	R	Poprawienie chwytu			
4	GB	Występuje tylko jeden ruch chwycenia	A	Naciskanie			
5	GC	Występuje więcej niż jeden ruch chwycenia	E	Praca Oczu			
6	Ruchy Typu Umieścić		F	Ruch stopy			
7	PA	Ruch płynny	S	Chód			
8	PB	Występuje jeden ruch korygujący	B	Pochylenie się i wyprostowanie			
9	PC	Występuje więcej niż jeden ruch korygujący	C	Ruch Korby			
10							
11	Wybralismy metodę MTM - 2 i na podstawie normatywów czasu przykład dla Montaż podzespołu dla wałka napędzającego : Tuleja + pierścień osadczy.						
12							
13							
14	Montaż podzespołu dla wałka napędzającego : Tuleja + pierścień osadczy.						
15	Czynności wykonywane lewą ręką		Dł.[mm] i Sym.	Czas TMU	Czynność wykonywana prawą ręką	Dł.[mm] i	Czas TMU
16	Pobrać Tuleję łożyska		45 GB+E	25			
17	Umieścić tuleję na stole montażowym		45 PB+R	30			
18	Pobrać pierścień osadczy		45 GB+E	25			
19					Chwycić szczypce	15 GB+E	17
20					chwycic szczypcami pierścień osadczy	5 GB+E	14
21	trzymac tuleje lozyska		5 PB+R	16	umiescic pierscien osadczy za pomoca szczyplec w tulei	5 PB+E	17
22	Sprawdzić wzrokowo prawidłowość połączenia i umieścić jednostkę na palecie transportowej		80 GB+R	33			
29					Suma TMU	177	
30	Montaż podzespołu dla wałka napędzającego : Tuleja + pierścień osadczy.				w sec	6,372	

Fig. 6. Standardization of operation time – MTM-1 (Excel 2010)

Rys. 6. Standardization of operation time – MTM-1 (Excel 2010)

The next step is balancing operations. In practice often used "manual" balancing operations or heuristic methods. The best knownof these isthe methods: RPW method (Ranked Positional Weight), RRPW method (Reversed Ranked Positional Weight), Kilbridge'a and Wester'a method (K&W), matrix method of order Hoffmana, IUFF method (Immediate Update First-Fit).

<table>
<tr><td>Cracow University of Technology Institute of Production Engineering</td><td colspan="2">Operation sheet</td><td>Name of product
Reduktor stożkowo-walcowy</td><td>Symbol
RSW</td><td colspan="3">Name of assembly
ZM1</td><td>Batch</td></tr>
<tr><td>Departament</td><td colspan="3">Name of operation
Mounting subassembly drive shaft</td><td>Number of operation
10</td><td>Work-sation
SM1</td><td>T_{pz} [min] =30</td><td>t_j[min] = 0,63</td><td>Time standardization
T [min] = 30,63</td></tr>
<tr><td>Number</td><td colspan="4">Content</td><td colspan="4">Mounting Devices
Hand press</td></tr>
<tr><td>1</td><td colspan="4">Un - conservation</td><td colspan="4" rowspan="1"></td></tr>
<tr><td>2</td><td colspan="4">Put shaft (5) on the mound, inserted parallel key (56)</td><td colspan="4" rowspan="2">Brackets and mounting devices
Assembly prism</td></tr>
<tr><td>3</td><td colspan="4">Set the shaft (5) in an upright position, slide flinger (26)</td></tr>
<tr><td>4</td><td colspan="4">Set the shaft (5) in an upright position, slide bearing (37) and sleeve.</td><td colspan="4">Tools assembly
Sleeve</td></tr>
<tr><td>5</td><td colspan="4">Visually check that the connections</td><td colspan="4">Tools and measuring instruments:</td></tr>
<tr><td colspan="2">Prepared</td><td colspan="2">Checked</td><td colspan="2">Approved</td><td colspan="3">Comments</td></tr>
</table>

Fig. 7. Sample of operation sheet

Rys. 7. Przykładowa karta instrukcyjna

The final step in this phase is the development of technical documentation (operation sheets (Fig. 7).

5. Modeling and verification of assembly workstations

At this stage of organizational and technological preparation can now proceed to the proper design of assembly workstations. This stage includes:
- designing the structure of distribution workstations with the way transport links,
- design of individual workstations (Fig. 8; Fig. 9), developed based on early sketch of workstations,
- design equipment and transport (Fig. 10),
- assembly simulation (Fig. 11).

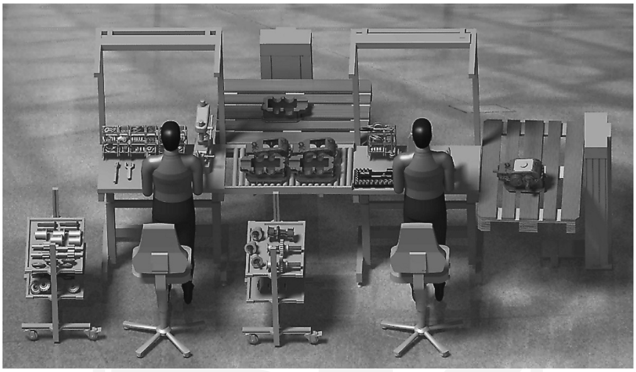


Fig. 8. Assembly workstations – CAD/CAM Catia v5
Rys. 8. Stanowiska montażowe – CAD/CAM Catia v5

Fig. 9. Assembly workstations – CAD/CAM Catia v5
Rys. 9. Stanowiska montażowe – CAD/CAM Catia v5

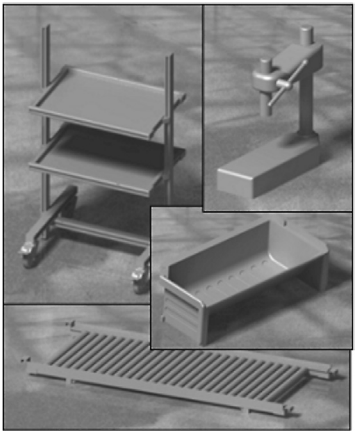


Fig. 10. Equipment of assembly workstations

Rys. 10. Wyposażenie stanowisk montażowych

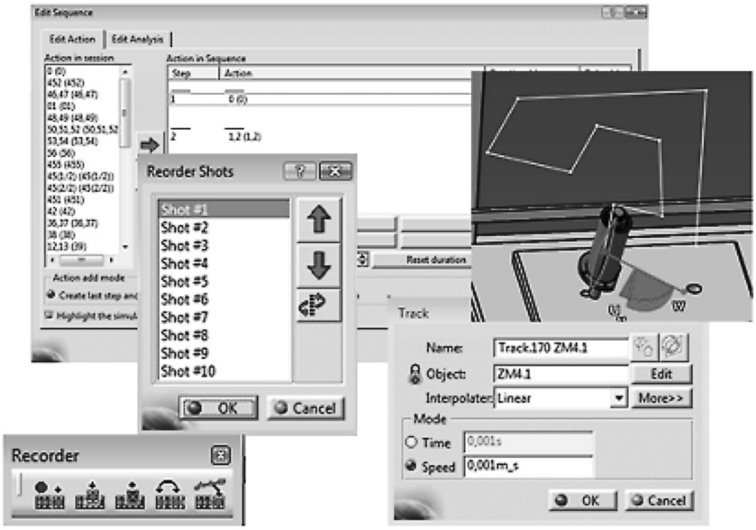


Fig. 11. Assembly simulation – Catia/Module DMU Fitting

Rys. 11. Symulacja montażu – Catia/ Module DMU Fitting

The final step, before the physical implementation of the project, is a simulation particular workstations and their evaluation due to the ergonomic requirements. System CAD/CAM Catia v5 (Fig. 12) is a tool which can be comprehensively applied to the implementation of all project activities including3D modeling of individual parts of the product, modeling workstations, modeling transport, ergonomic simulation.

Fig. 12. Modeling ergonomics assembly workstations – Catia/Module Ergonomics

Rys. 12. Modelowanie ergonomicznych stanowisk montażowych – Catia/ Module Ergonomics

6. Conclusions

Designing of any system (assembly system) is a complex process with used in the field of knowledge: design process plans, standardization of operations, balancing operations performed in the manufacturing system, ergonomic principles. Use the tools to create a virtual 3D model of the system, allows to simulate and verify the operation of the system before it is implemented in practice. This allows to avoid a lot of errors in the construction, much lower costs and shorten the cycle time pre-production (from project to construction).

References

[1] Feld M., *Podstawy projektowania procesów technologicznych typowych części maszyn*, WNT, Warszawa 2003.

[2] Kiliński G., *Modelowanie procesu montażu i stanowiska montażu reduktora z zastosowaniem systemu CAD/CAM Catia*, praca inżynierska, Kraków 2013.

[3] Skarka W., Mazurek A., *CATIA Podstawy modelowania i zapisu konstrukcji*, Wyd. HELION, Gliwice 2005.

[4] Wyleżoł M., *CATIA v5 Modelowanie i analiza układów kinematycznych*, Wyd. HELION, Gliwice 2003.