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COMPARISON OF FIRST LEVEL MOTION TRANSFORMATION MATRIX AND OPERATIONAL CONSTRAINT VECTOR WITH MOTION CHARACTERISTIC CODE AT THE MECHANISMS DESIGN

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ABSTRACT
In this paper a comparison of two methodologies of mechanisms design has been analysed. The first methodology uses the Motion Transformation Matrix (MTM) of 1^{st} level and the Operational Constraint Vector (OCV).
The Motion Transformation Matrix of 1^{st} level presents the type of motion and space orientation of basic kinematics blocks. The Operational Constraint Vector presents continuity, linearity, reversibility and direction of basic kinematics blocks.
The second methodology uses the Motion Characteristic Code (MCC) for the design of mechanisms with helical motion using dual-vector algebra. The Motion Characteristic Code determines the motion type, continuity, linearity and direction of basic kinematics blocks.
Keywords: Motion Transformation Matrices, Operational Constraint Vector, Basic Kinematics Blocks, Motion Characteristic Code.

1. INTRODUCTION
Mechanism design can be realised using several methodologies [1,2,6,7,8].
The first methodology includes the algorithm for identification of many possible solutions concerning of mechanisms synthesis using the Basic Kinematics Blocks: (a) Motion Transformation Matrix of first level, (b) Decomposition Procedure, (c) Motion Transformation Matrix of Second Level and (d) Operational Constraint Vector [2].
At second methodology the algorithm that presents the mechanisms design using Basic Kinematics Blocks goes through four basic phases: (a) Motion Specifics, (b) Functional Synthesis, (c) Topological Synthesis and (d) Dimensional Synthesis [2]. In the motion specifics and functional synthesis the Motion Characteristic Code is taken into consideration, while at topological synthesis the methodology of dual-vector algebra is used [1].

2. METHODOLOGY OF THE MOTION TRANSFORMATION MATRIX OF FIRST LEVEL AND OPERATIONAL CONSTRAINT VECTOR
The Motion Transformation Matrix of 1^{st} level present the type of motion and space orientation of basic kinematics blocks. First the desired motion transform matrices MTM^1 are built knowing that the axis of input is perpendicular to the axis of the output, where the input is rotational motion (copier) and output is translation motion (blade) [2]. General form of the matrix at first level is given by

$$\underset{Output}{\begin{bmatrix} R \\ T \end{bmatrix}} \cdot \underset{Input^T}{\begin{bmatrix} R & T \end{bmatrix}^T} = \underset{MTM^1_{desired}}{\begin{bmatrix} R \cdot R & R \cdot T \\ T \cdot R & T \cdot T \end{bmatrix}}, \quad \underset{Output}{\begin{bmatrix} 0 \\ 1 \end{bmatrix}} \cdot \underset{Input^T}{\begin{bmatrix} 1 & 0 \end{bmatrix}^T} = \underset{MTM^1_{desired}}{\begin{bmatrix} 0 & 0 \\ 1 & 0 \end{bmatrix}} \tag{1}$$

If item '1' in equation (1) is replaced with '3' for perpendicularity, matrix for model has form as

$$MTM_{desired}{}^{1} = \begin{bmatrix} 0 & 0 \\ 3 & 0 \end{bmatrix} \tag{2}$$

The Operational Constraint Vector presents continuity, linearity, reversibility and direction of basic kinematics blocks. The operational constraints are given in a vector form:

$$\mathbf{OCV_{desired} = (Continuity, Linearity, Reversibility, Direction)} \tag{3}$$

$$OCV_{desired} = \left(1, \quad 0, \quad 0, \quad \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 0 \end{bmatrix} \right) \tag{4}$$

$$\underset{Output}{\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}} \cdot \underset{Input^T}{\begin{bmatrix} 1 & 0 & 0 \end{bmatrix}^T} = \underset{Direction}{\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 0 & 0 \end{bmatrix}} \wedge \underset{Output}{\begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}} \cdot \underset{Input^T}{\begin{bmatrix} 0 & 1 & 0 \end{bmatrix}^T} = \underset{Direction}{\begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 1 & 0 \end{bmatrix}} \tag{5}$$

Following steps match desired MTM^1 with MTM^1 of the building blocks, finding five building blocks that match with desired and one of them satisfies operational constraints at the mechanism copier-blade [2].

3. METHODOLOGY OF MOTION CHARACTERISTIC CODE (MCC)

Motion Characteristic Code (MCC) including data is used to determine the type of motion, continuity, linearity and direction of building blocks [1,5,6,8].

Table1. Motion Characteristic Code (MCC)

MOTION CHARACTERISTIC CODE (MCC)			
Motion type	Continuity	Linearity	Direction
Rotation (Value: 0)	Continuous (Value: 0)	Linear (Value: 0)	Unidirectional (Value:0)
Translation (Value: 1)	Intermittent (Value: 1)	Non-Linear (Value: 1)	Bidirectional (Value:1)
Screw (Value: 2)			

Motion Characteristic Code from the *Table 1* can be described by:

$$MCC = (MotionType, Continuity, Linearity, Direction) \tag{6}$$

Therefore, it is notable that Motion Characteristic Code contains four elements (e.g., a simple rotational motion of an electric motor is coded as MCC=MCC(0000) meaning rotation, continuity, linearity and unidirectional motion).

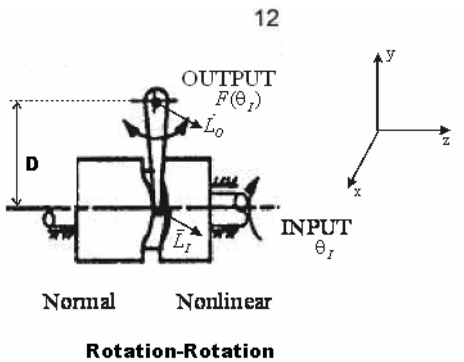
4. OPERATIONAL CONSTRAINT VECTOR (OCV) AND MOTION CHARACTERISTIC CODE (MCC) FOR SOME BASIC KINEMATICS BLOCKS

Therefore, for two basic kinematics blocks Cylindrical Cam-Follower and Slider-Crank are given: Operational Constraint Vector (OCV), Motion Characteristic Code (MCC) and spatial orientation [1,2].

$$OCV = \left(1, \quad 0, \quad 0, \quad \begin{bmatrix} 0 & 1 & 0 \\ 1 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix}\right) \qquad OCV = \left(1, \quad 0, \quad 1, \quad \begin{bmatrix} 0 & 0 & 0 \\ 0 & 0 & 0 \\ 1 & 1 & 1 \end{bmatrix}\right) \tag{7}$$

MOTION CHARACTERISTIC CODE (MCC)	
INPUT	**OUTPUT**
0-Rotation 0-Continuous 0-Linear 0-Unidirectional	0-Rotation 0-Continuous 1-Nonlinear 0-Unidirectional

MOTION CHARACTERISTIC CODE (MCC)	
INPUT	**OUTPUT**
0-Rotation 0-Continuous 0-Linear 0-Unidirectional	1-Translation 0-Continuous 1-Nonlinear 1-Bidirectional



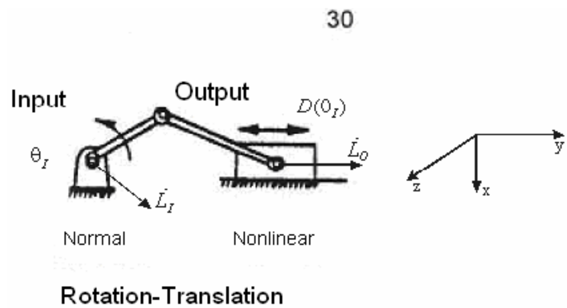


Figure 1 Cylindrical Cam-Follower
Figure 2 Slider-Crank

5. CONCLUSIONS

Comparing the two elaborated methodologies, the methodology that uses the Motion Transformation Matrix (MTM) of 1st level and the Operational Constraint Vector (OCV) with the synthesis methodology of the mechanisms using dual-vector algebra, representation of input-output of the screw motion and Motion Characteristic Code (MCC) for basic kinematics blocks, can be concluded as follows:

- The fist methodology during mechanisms design the type of motion, space orientation, continuity, linearity, reversibility and direction are presented by the Transformation Matrix (MTM) of 1st level and the Operational Constraint Vector (OCV);
- At the second methodology of mechanisms design is used the Motion Characteristic Code (MCC) with screw motion using dual-vector algebra;
- Operational Constraint Vector (OCV) is four-element vector, where the fourth element represents direction of the (3x3) matrix;

- Motion Characteristic Code (MCC) is also four-element vector;
- The second methodology for mechanisms design using the Motion Characteristic Code (MCC) is more simple comparing with first one, bringing easier to the desired design solutions;
- Both methods basis is determination of many alternate mechanisms design solutions using the basic kinematics blocks.

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