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ANALYTIC STUDY OF THE EFFORTS FROM THE STRUCTURE OF A INDUSTRIAL SERIAL ROBOT 5R

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Abstract: In this paper is presented the analytic study of the efforts, in static conditions, for the mechanical structure of industrial serial robot FANUC LR Mate 100iB. Had taken into study two positioning of the robot's elements, analyzed under the following aspects: 1) robot under the load of its own weigh; 2) to the first aspect is added the maxim load which the robot can manipulate.
Key words: reactions, efforts, industrial robot, analytic.

1. Introduction

Under the action of external loads, in the volume of solid part are produced efforts which usually have different intensities in different points. Determination of efforts in a section of a part or of a mechanical structure is one of the principal issues of material strength.

The purpose of this paper consist in determining the axial and shear efforts, bending and torsion moments for the mechanical structure of the industrial robot with five degrees of freedom (5R) FANUC LR Mate 100iB.

This robot is designed to execute numerous technological tasks, one of them being to handle different parts with maximum weight of 5 Kg.

To determine the efforts are considered the following aspects:

- The mechanical structure of the robot is rigid (static conditions);
- Are chosen two standby positions (fig.2a,b) which can be disadvantageous from loading point of view;
- For each position, the analytic study is developed for two cases: 1) robot under the load of its own weigh; 2) to the first aspect is added the maxim load which the robot can handle.

In figure 1 is presented the CAD modeling of the articulated serial industrial robot5R, being constituted by following elements: 1- base module; 2- module 2 of rotation of the arm 1; 3- arm 1; 4- arm 2; 5- orientation module of the clamping device.

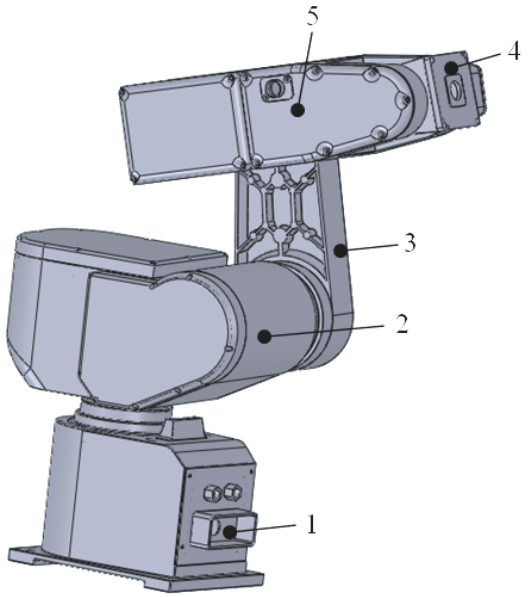
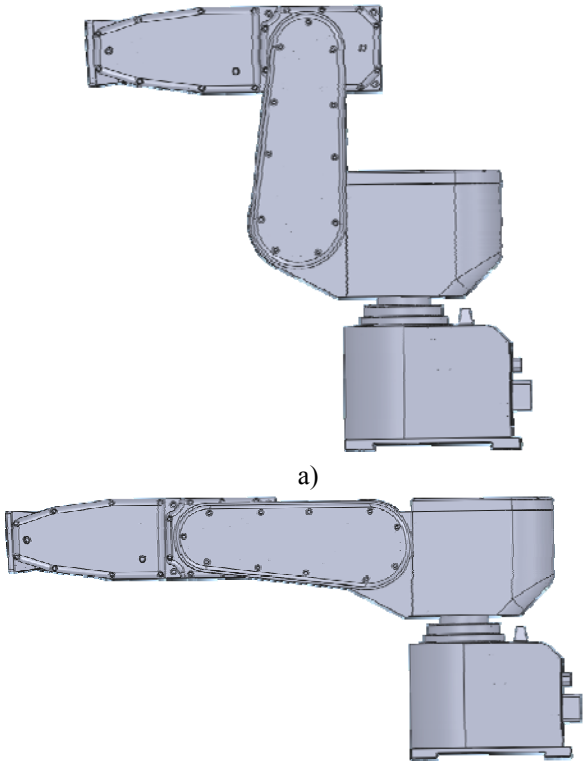


Fig.1. The CAD modeling of the robot FANUC LR Mate 100iB

2. The analytic calculus of the structure

Performing the analytic calculus necessary to determine the efforts is started from hypothesis that the mechanical structure of the

robot is a statically determined framework.



a)

b)

Fig.2. The study positions considered of the robot: a) position 1; b) position 2

In figure 3a and 3b, are given the schematic representations of the frameworks which correspond to the two considered positions.

The frameworks are fixed at one end (in the base modulus), and the own weight (of each structural element of the robot) and the maximum load handling are represented through uniformly distributed load $q_i, i = 1 \div 4$, respectively by concentrated loads $F_i, i = 1 \div 3$, and $l_i, i = 1 \div 5$ represents the distances between centers of gravity of motors drive of the modules by component of the robot.

The analytic calculus has realized using the usual relations from literature, and the values of input dates are:

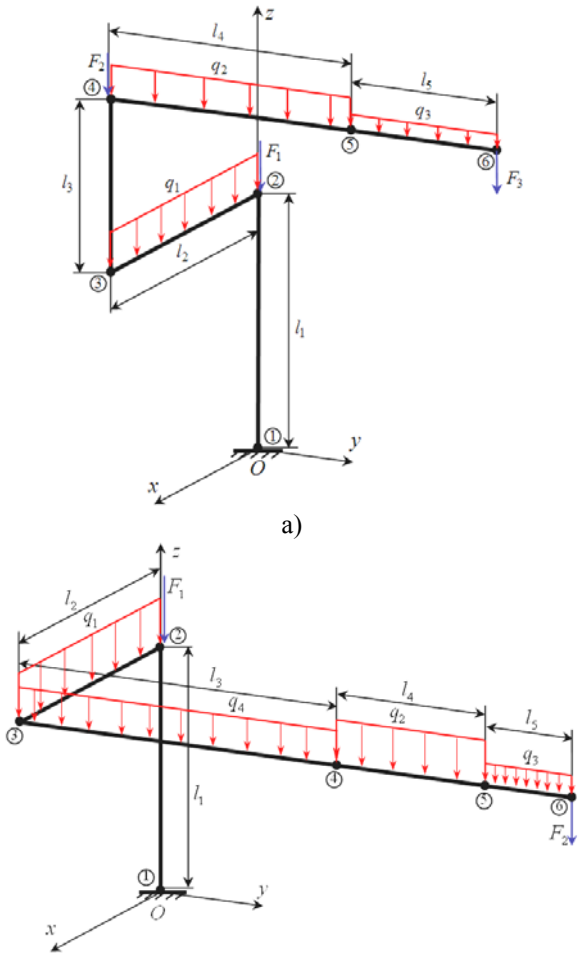
$l_1 = 216\ mm;\ l_2 = 145\ mm;\ l_3 = 250\ mm;$

$l_4 = 175\ mm;\ l_5 = 100\ mm;\ q_1 = 0.68\ Nmm;$

$q_2 = 0.57\ Nmm;\ q_3 = 0.1\ Nmm;$

$q_4 = 0.32\ Nmm;\ F_1 = 90\ N;$

$F_2 = 80\ N;\ F_3 = 50\ N.$



a)

b)

Fig.3 a, b. Representation of the frameworks in both positions; the support and loaded mode – own weight, maxim applied force

3. Results

After analytic calculus, has determined the reactions from the fixed point and the efforts, for each case in part.

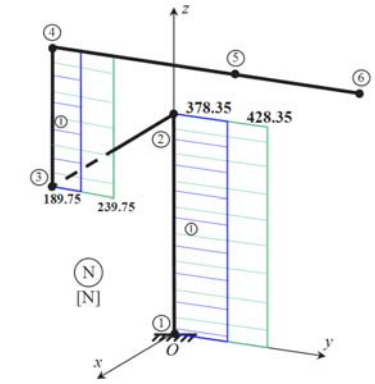
On obtained results were built the diagrams from figures 4 and 5 of axial and shear efforts, of bending and torsion moments.

With blue color had represented, for each type of framework, the first loading case (the own weight), and the green color correspond to case where the framework is loaded by the own weight and so the force F_3 to the free end.

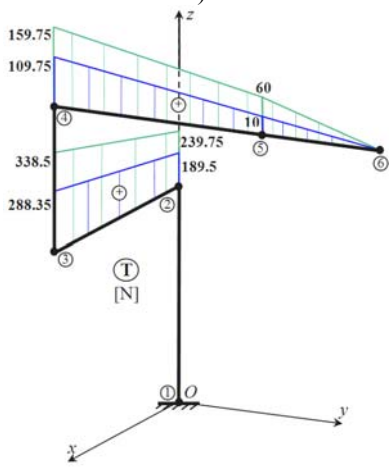
5. Conclusion

Having in view the diagrams exposed the above figures, it can be concluded:

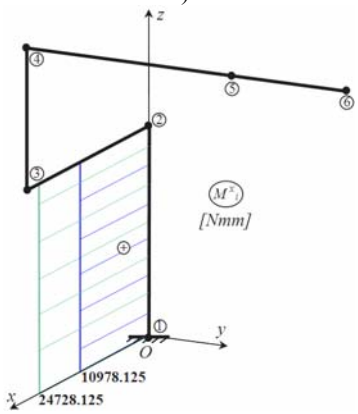
For two particularly positions of the robot it has determined the reactions



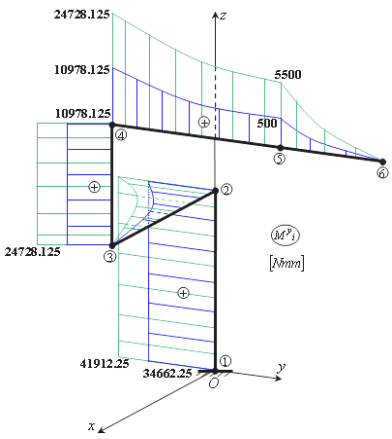
a)



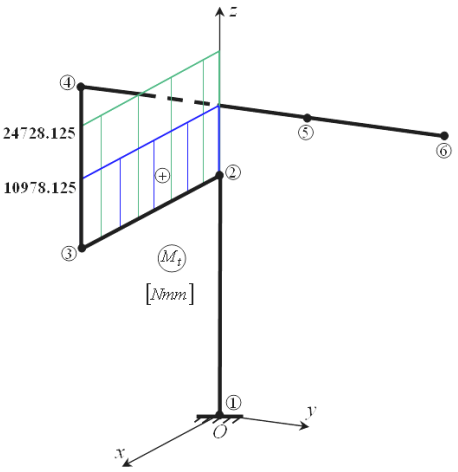
b)



c)

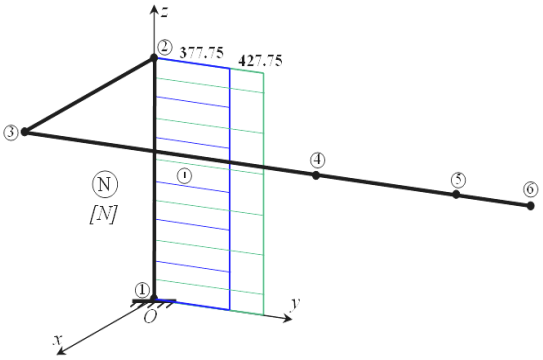


d)

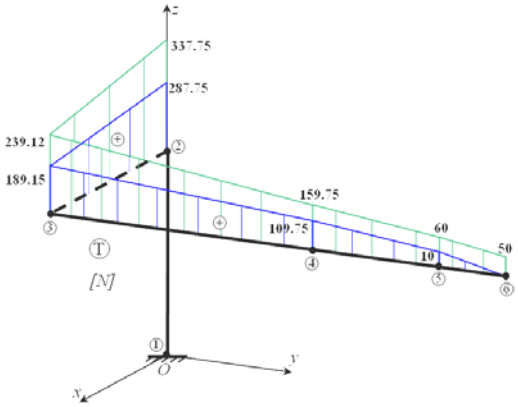


e)

Fig.4. The efforts and moment diagrams for position 1



a)



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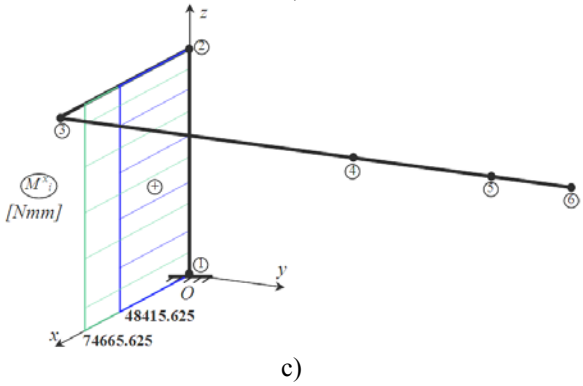

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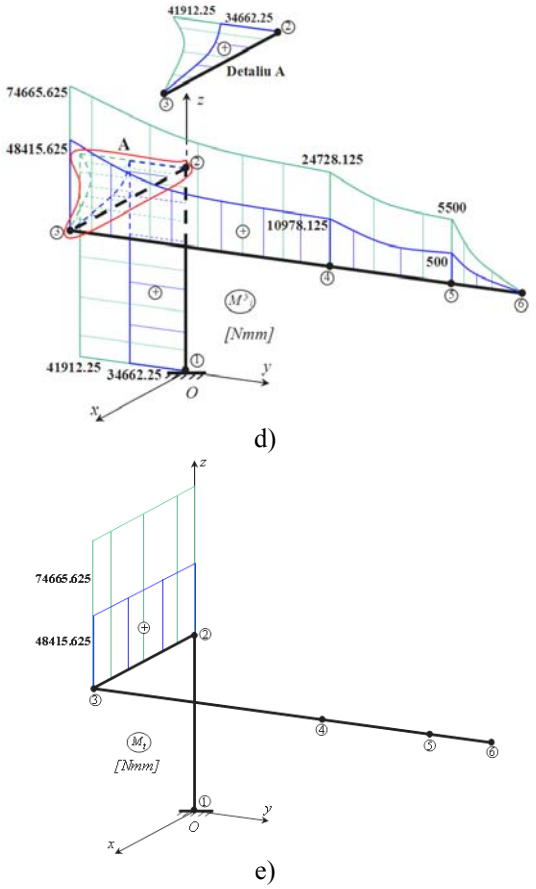

Fig.5. The efforts and moment diagrams for position 2

and the efforts using the usual analytic calculus;

- In both loading situations appear compose solicitations (shear and
- bending), which will generate strains to entire mechanical structure of the robot;
- In position 1, the most solicited element is 1-2, which correspond to base module and rotation module, obtaining high values of bending moment in account with *y* axis; (fig.4.d);
- The highest values of the bending moments had obtained for position 2, to element 3-4 (arm 1) (fig.5e). So, this working position wishes to be avoided because of high loading, and implicit of strains, leading to reduction the positioning accuracy of the handled part.
- Future studies will be realizing on the structure of the robot FANUC regarding the tension and strains state by numerical methods (finite element method) and experimental methods.

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6. References

[1] Bejan, M., *Rezistența materialelor*, Vol. 1 şi 2, Ediția a IV-a, Ed. AGIR, Bucureşti, Ed. MEGA, Cluj-Napoca, 2009.
[2] Crețu, A., *Rezistența materialelor*, vol. 1, Ed. MEDIAMIRA, Cluj-Napoca, 2005.

STUDIU ANALITIC AL EFORTURILOR DIN STRUCTURA 5R UN ROBOT SERIE INDUSTRIALE

Rezumat: În această lucrare este prezentat studiu analitic eforturilor, în condiții statice, pentru structura mecanice de robot industriale de serie FANUC LR Mate 100iB. S-au luat în studiu două poziții ale elementelor unui robot, analizate în conformitate cu următoarele aspecte: 1) robot de încărcătură cu greutatea proprie; 2) la primul aspect se adaugă cu sarcina maximă pe careo poate manipula robotul.

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