Bulletin of the *Transilvania* University of Brakov ÅVol. 9 (58) No. 2 - Special Issue ï 2016
Series I: Engineering Sciences

MECHANISMS WITH CAM: STRUCTURAL AND CAD MODELS

I. STAREŢU[1]

Abstract: *Gripping systems used in robots are classified according to their complexity in gripping systems with jaws, anthropomorphic gripping systems and tentacle gripping systems. Gripping mechanisms with cam have as main part one or more cams. Depending on the shape of the cam or the cams, the jaw support elements and the object gripping are possible. Structural variants of gripping mechanisms with cam are obtained based on the method of creative synthesis of gripping mechanisms with jaws. The structural schemes so obtained can be diversified by using another solution for closing the cam follower coupling, other than the solution of closure by force, ie closing through shape or using double roller. In the category of derived structural schemes there are as well mechanisms with multiple cam (poly-cam) or with adjustable cam.*

Key words: *gripping mechanisms, structural synthesis, cams, CAD model.*

1. Introduction

Gripping systems used in robots are classified according to their complexity in gripping systems with jaws, anthropomorphic gripping systems and tentacle gripping systems [9, 12, 13, 15]. Gripping systems with jaws have as main module a mechanism that provides jaw support elements movement and therefore jaws movement until contacting the object to grip and reaching the required grip strength. These mechanisms known as gripping mechanisms with jaws, depending on the characteristic elements are: with articulated shafts, with screw, with gears, with cams and rollers and wires [1, 5, 6, 9].

Gripping mechanisms with cam have as main part one or more cams. Depending on the shape of the cam or the cams, the jaw support elements and the object gripping are possible. On the other hand the use of these mechanisms can be restricted if they have, as constructive part a single cam, or extended, if they are composed of a multiple or adjustable cam.

2. Structural variants

Structural variants of gripping mechanisms with cam are obtained based on the method of creative synthesis of gripping mechanisms with jaws [2, 3, 8, 9]. Thus, gripping mechanisms with cam, less complex, can have a single jaw support element, and therefore only one mobile jaw. Its variants are obtained by taking into account the main types of basic mechanisms with cam: plane mechanism plan with rotation cam and translation cam follower with roller, plane mechanism with rotation cam and rotation (swinging) cam

[1] Centre ñAdvanced Research on Mechatronicsò, *Transilvania* University of Brakov.

follower with roller, plane mechanism with translation cam and translation cam follower with roller, plane mechanism with translation cam and swinging cam follower with roller, spatial mechanism with cylindrical rotation cam and translation cam follower with roller, spatial mechanism with cylindrical rotation cam and swinging cam follower with roller, spatial mechanism with translation cam and translation cam follower with roller and spatial mechanism with translation cam and swinging cam follower with roller (see Figure 1)[2, 3, 9].

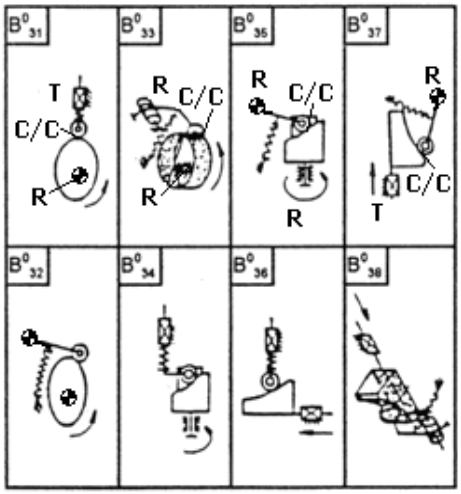


Fig. 1. *Elementary cam mechanisms[9]*

By using two elementary cam mechanisms, identical or different, we obtain the variants of gripping mechanisms with cam with two jaw support elements active from the kinematic point of view (see Table 1), and by using three elementary mechanisms with cam, identical or different, we obtain the variants of gripping mechanisms with cam with three jaw support elements active from the kinematic point of view (see Table 2). In these tables we noted the main modules to decompose the gripping mechanism with jaws [4, 9, 15], as follows: A-engine module, B-module of actuating mechanism for jaw support elements, C-module of jaw support elements, D-jaws module and E-gripped object module. The indices *ij* represent the *j* sub-variant of the *i* variant of that module (A, B, C, D, E).

Table 1 *Gripping mechanisms with cam with two mobile jaw support elements[9]*

$A_1B_{35}B_{35}C_2D^3_4E_5$	$A_2B_{36}B_{36}C_3D^3_2E_5$
$A_1B_{35}B_{35}C_1D^4_4E_5$	$A_2B_{36}B_{36}C_2D^3_4E_5$
$A_1B_{34}B_{35}C_2D^3_4E_5$	$A_2B_{36}B_{36}C_1D^3_4E_5$
$A_1B_{31}B_{31}C_3D^3_2E_5$ $D^3_2=D_2D_2D_2$	$A_1B_{31}B_{33}C_3D^3_2E_5$
$A_1B_{31}B_{31}C_2D^3_4E_5$ $D^3_4=D_4D_4D_4$	$A_1B_{31}B_{32}C_2D^3_4E_5$
$A_1B_{31}B_{31}C_1D^4_4E_5$ $D^4_4=D_4D_4D_4$	$A_1B_{31}B_{32}C_1D^4_4E_5$

In this table there are only two active jaw support elements, active from the kinematic point of view, with the possibility to have a third fixed jaw, so that

the variants of the jaw support elements module are: $C_{1\ ï}$ two jaw support elements, $C_{2\ ï}$ three jaw support elements in plane and C_3[3, 4]

Table 2 *Gripping mechanisms with cam with three mobile jaw support elements[9]*

$A_1B_{31}B_{32}C_2D'_4E_5$	$A_1B_{31}B_{32}B_{32}C_2D'_4E_5$	$A_1B_{31}B_{31}B_{31}C_3D'_2E_5$	$A_1B_{31}B_{31}B_{33}C_3D'_2E_5$	$A_1B_{31}B_{33}B_{33}C_3D'_2E_5$	
$A_1B_{31}B_{34}C_2D'_4E_5$	$A_1B_{31}B_{34}B_{35}C_2D'_4E_5$	$A_1B_{33}B_{33}C_3D'_2E_5$	$A_1B_{33}B_{33}B_{34}C_3D'_2E_5$	$A_1B_{35}B_{33}B_{35}C_3D'_2E_5$	

Table 2 *(continuation)*

$A_1B_{33}B_{33}B_{35}C_2D'_4E_5$	$A_1B_{33}B_{34}B_{34}C_2D'_4E_5$	$A_2B_{38}B_{36}B_{36}C_3D'_2E_6$	$A_1B_{36}B_{36}B_{37}C_3D'_2E_5$	$A_1B_{36}B_{37}B_{37}C_3D'_2E_5$	
$A_2B_{36}B_{36}B_{37}C_2D'_4E_5$	$A_1B_{36}B_{36}B_{38}C_2D'_2E_5$	$A_2B_{38}B_{38}B_{38}C_3D'_2E_5$	$A_2B_{37}B_{37}B_{37}C_3D'_2E_5$	$A_2B_{37}B_{38}B_{38}C_3D'_2E_5$	

The structural schemes so obtained can be diversified by using another solution for closing the cam follower coupling, other than the solution of closure by force, is closing through shape or using double roller. In the category of derived structural schemes there are as well mechanisms with multiple cam (poly-cam) or with adjustable cam.

Two examples of multiple cam are illustrated in Figure 2.

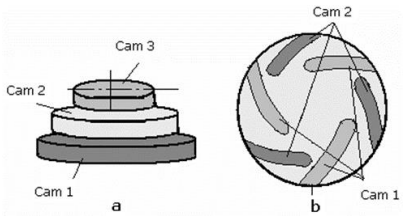


Fig.2. *Multiple cams[15]*

Two examples of structural schemes with multiple cam are illustrated in Figure 3 and two examples of structural schemes with adjustable cam are illustrated in Figure 4.

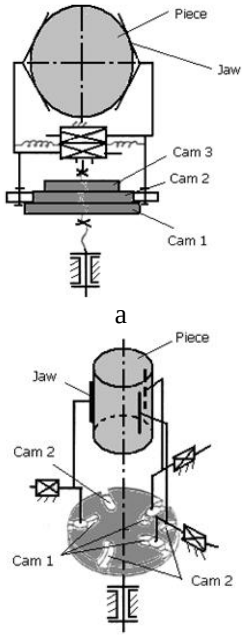
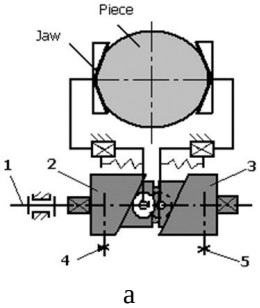


Fig. 3. *Structural schemes with multiple cam[15]*



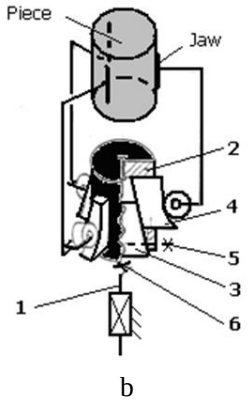
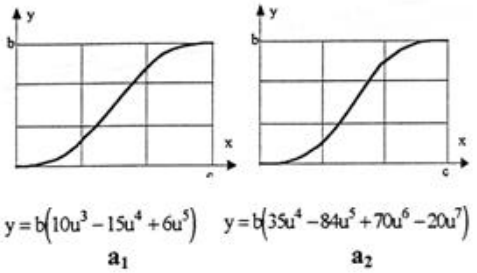


Fig. 4. *Structural schemes with adjustable cam(1-6: constructive elements)[15]*

3. Kinematic conditions

In kinematic terms, gripping mechanisms with cam can solve much better the general problem of gripping mechanisms with jaws, namely completing at optimal speed the two gripping phases: moving jaw support elements, therefore moving jaws too, at increased speed, to close proximity of the object to be gripped and then moving at low speed in the area close to the object to be gripped until reaching the necessary gripping strength [7, 10, 12].

To solve this problem, the cam can be modeled properly using polynomial functions, harmonic and / or plan cycloid functions (see Figure 5) so that the profile may correspond to a coupling between two of these functions (one corresponding to fast movement, and the second corresponding to slow movement).



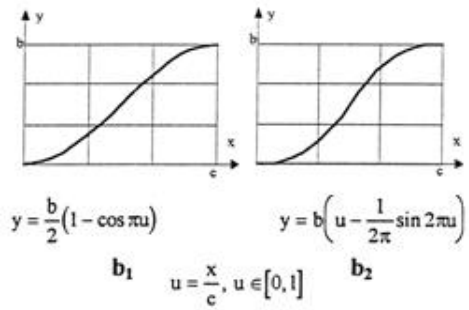


Fig. 5. *Simple kinematical functions [14]*

Compound functions to match the expectance above are shown in Figure 6.

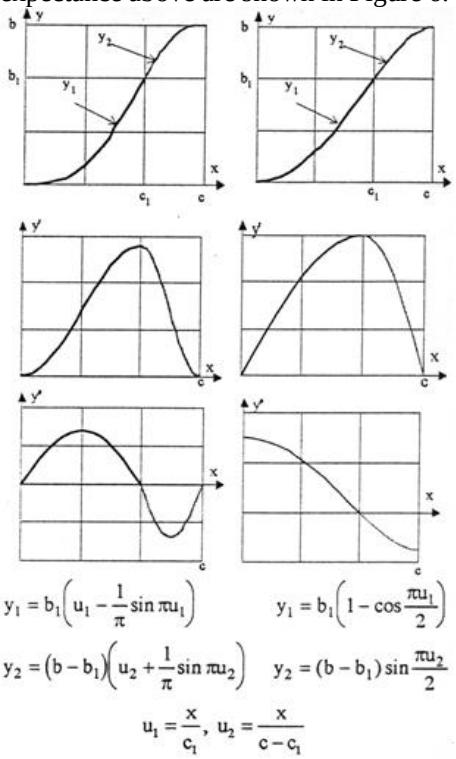
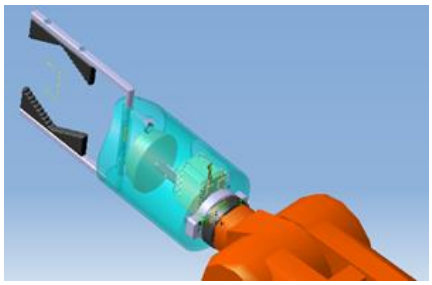


Fig. 6. *Compound kinematical functions [14]*

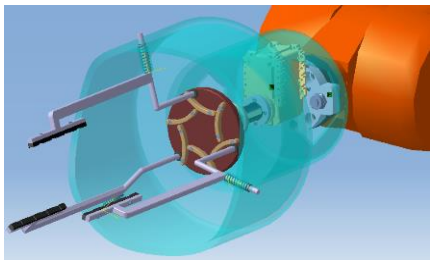
4. CAD models

CAD design of gripping mechanism with jaws is carried out using appropriate software, such as CATIA, from the kinematic scheme where linear and angular dimensions of the elements are specified [11, 9, 15].

In Figure 7 there are two CAD models: for a gripping mechanism with jaws with two jaw support elements and plane multiple cam of rotation, with closure of the cam- cam follower coupling by force (with spring), and for a gripping mechanism with jaws with three jaw support elements and plane multiple cam of rotation with closure of cam-cam follower coupling through shape (with guiding ducts).



a



b

Fig. 7. *Gripping mechanisms with cam: CAD models*

5. Conclusions

Based on the facts presented in this paper the following conclusions can be drawn:

- gripping mechanisms with cam are an important group of gripping mechanisms with jaws;
- gripping mechanisms with jaws and cam, with corresponding shaping of the cam,

can ensure optimal movement of jaw support elements: with increased speed in the area closed to the gripped object and with reduced speed in the vicinity of the gripped object until the right gripping strength is reached;

- gripping mechanisms with cam can be used within limits (there is a unique cam) or their use can be extended when the cam is multiple (poly-cam) or adjustable cam.

Acknowledgements

We express our gratitude to the Company Cloos Germany and its Romanian representative Robcon which partly sustained these works.

References

1. Deliev, S. et al.: *Hvascaci mehanizmî za promîşleni manipulatori i roboti*. Sofia, Ed. TehnicŁ,1982.
2. DudiŞŁ, FL., Diaconescu, D., Gogu, Gr., StareŞu, I.: *Curs de mecanisme. Fasc. 2. Angrenaje. Mecanisme cu camă. Cinematica*. Bra'Hov, Universitatea din Brakov, 1989.
3. DudiŞŁ, Fl., StareŞu, I.: *Sinteza structurală creativă a robotomecanismelor de prehensiune cu camă*. În Buletinul celui de al IX-lea Simpozion NaŞional de RoboŞ Industriali, Baia Mare, 1989.
4. DudiŞŁ, Fl., StareŞu, I.: *Strukturanalyse von greifern mit Kurvengetrieben für Industrieroboter*, Univ. Rostok, N-Reihe 39(1990) 6 S.53-61.
5. Fan Yu Chen: *Gripping mechanisms for industrial robots*. MMT, vo. 17 no. 5, pp. 299-311, 1982.
6. Monkman, G. J. et al.: *Robot Grippers*. Weley ï VCH Verlag GmbH &Co, KGaA, Weinheim, Germany, 2007.
7. Simionescu, I., Ion, I., Ciupitu, L.: *Mecanismele robotilor industriali*, Vol. II. Bucure'Hti, Ed. AGIR, 2010.
8. StareŞu, I.: *Proiectarea creativă în concepţie modulară a mecanismelor de prehensiune cu bacuri pentru roboţi industriali*. TezŁ de doctorat, Universitatea din Brakov, 1995.
9. StareŞu,I.: *Sisteme de prehensiune*. Bra'Hov, Ed. Lux Libris, 1996, 2010.
10. StareŞu,I., Neagoe,M.: *The Optimisation of the Kinematic and Static Design for Some Gripping Mechanisms with Cams*, Proceedings of the 7th . International Workshop on Robotics in Alpe-Adria-Danube Region, Slovacia, 1998.
11. StareŞu,I.: *Optimizarea constructivă a unor mecanisme cu camă folosite la prehensoarele mecanice cu bacuri*, Bul. PRASIC '98 ï cu participare internaŞionalŁ, vol. I, Mecanisme - Tribologie, p.183-186, Brakov, 1998.
12. StareŞu, I., Neagoe, M., Albu, N.: *Mâini mecanice. Mecanisme antropomorfe de prehensiune pentru protezare şi roboţi*. Bra'Hov, Ed. Lux Libris, 2001.
13. StareŞu, I.: *Analiza comparativă a principalelor metode pentru sinteza structurală a prehensoarelor mecanice cu bacuri – prezent şi perspectivă*.În Revista Robotica & Management, vol. 7, nr. 1, pp.53-40, 2002.
14. Staretu, I.: *Creative Synthesis of Gripping Mechanisms with cam with Extended Usage Area*. In Proceedings of the 10-th International Conference MTM 2008, Scientific Bulletin of the POLITEHNICA University of Timisoara, Romania. Transactions on MECHANICS, Tom 53 (67) , Fasc. S1, MTM 2008, pp.201-206.
15. Staretu, I.: *Gripping systems*. Tewksbury, Massachusetts, Derc Publishing House, 2011.