

# THE ACTUATION MECHANISM CONCEPT USED AT THE MODULAR FIXTURE SYSTEM FOR TMA-AL 550 HORIZONTAL MILLING CENTRE

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**ABSTRACT:** The paperwork presents theoretical and practical research for the actuation mechanism concept used at the modular fixture system for TMA-AL 550 horizontal milling centre, used for the prismatic, build and realized by the author into the flexible manufacturing laboratory at the University of Oradea. The constructive solution for actuation mechanism concept used at the modular fixture is new and it was designed and produced in the Faculty of Engineering Management and Technology Laboratory, in order to be used for the loading and unloading of the working parts and tools at the flexible manufacturing cell by means of ABB IRB 1600 robot.

**KEY WORDS:** pneumatic actuation mechanism, modular fixture device, workpiece, cam clamps, horizontal milling centre

## 1. INTRODUCTION

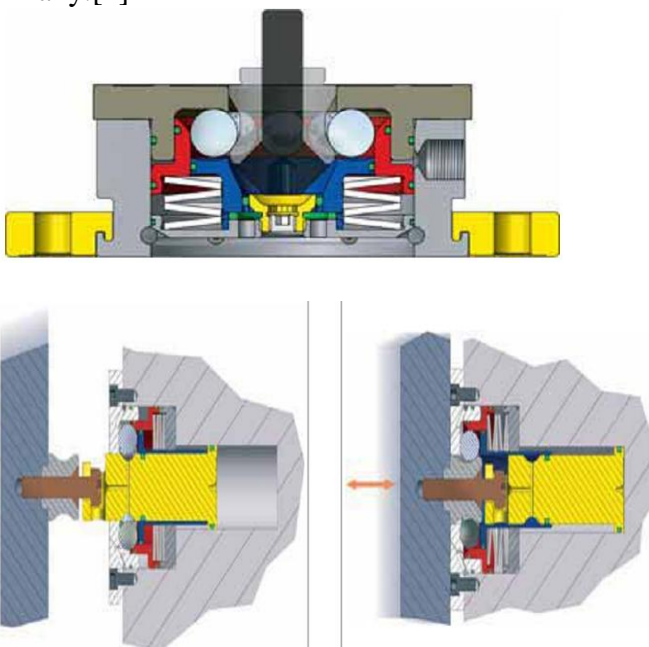
The actuation mechanism assembly has the role to facilitate the loading - unloading and to assure the necessary force for clamping and unclamping the detachable pallets with the workpiece.

In figure 1 is represented a pneumatic actuation mechanism assembly which has the role to assure clamp - unclamp for the removable pallet on the fixed plate, realized by the company AMF from Germany. [1]

by means of the conical pins for positioning which are fixed by means of balls. [2]

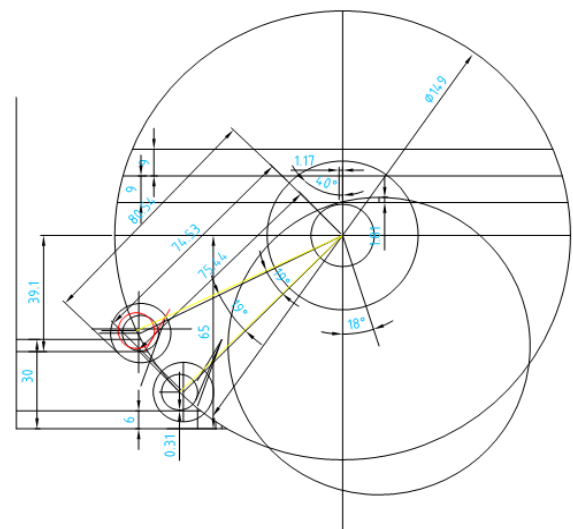
Within the actuator mechanism for modular fixture device were made tests to determine the functioning distance for the pneumatic piston and a rotary cam to ensure auto block in the case of cutting forces. [3]

In order to fix the detachable plate is sufficient the spring force acting on the pneumatic cylinder piston or actuation of the rotary cam clamp and the force given by the auto block of the fixture device, as a result of the placement of the point of contact of the cam clamp and the tie rod so as to achieve the auto blocking.



**Figure 1.** The actuation mechanism assembly realized by AMF company

The clamping - unclamping system for the detachable pallet is composed of a pneumatic piston, which is actuated by means of disc springs, the clamping - unclamping for the pallet is realized



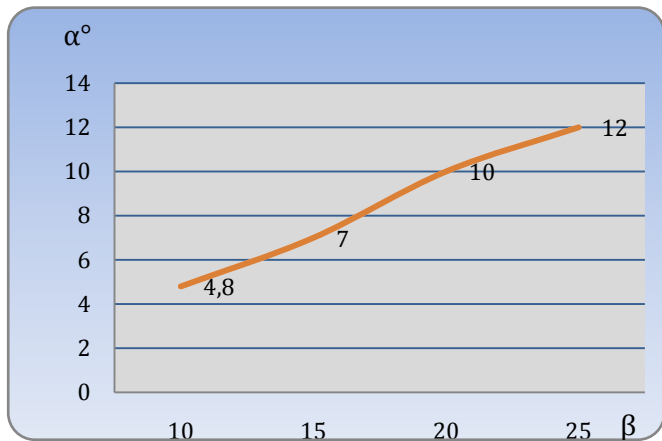
**Figure 2.** Tests to determine the pneumatic piston distance and the profile for the rotary cam

Reference elements that are involved in carrying out the tests are:

d - distance between the perpendicular holes for the rotary cam and the tie rod;

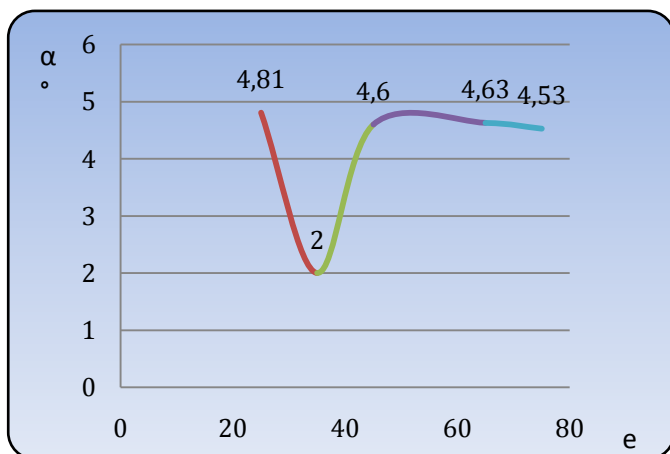
- e- the eccentricity for the rotary cam clamp
- $\Phi_b$  - tie rod diameter;
- $\alpha$  - The vertical tangent angle in the contact point of tie rod with cam clamp which is rotated at  $\beta$  angle
- $\beta$  - the rotation angle of the cam clamp;
- $\Phi_r$ - the shaft cam clamp diameter
- $\beta^\circ = 10^\circ-15^\circ-20^\circ-25^\circ$ ;
- $\alpha = 4,8^\circ-7^\circ-10^\circ-12^\circ$ .

The contact diagram for  $\alpha$  angle which ensures autoblock according to the  $\beta$  rotation angle of the cam for eccentricity  $e = 65\text{mm}$  for  $\Phi_{ax} = 16\text{mm}$ ,  $\Phi_{ext\ cam} = 30\text{ mm}$  is represented in figure 3.



**Figure 3.**The contact diagram for  $\alpha$  angle which ensures autoblock according to the  $\beta$  rotation angle

The contact diagram for  $\alpha$  angle which ensures autoblock according to eccentricity  $e$ , to rotate with  $10^\circ$  for  $\Phi_{ax} = 16\text{mm}$ ,  $\Phi_{ext\ cam} = 30\text{ mm}$  is represented in figure 4.



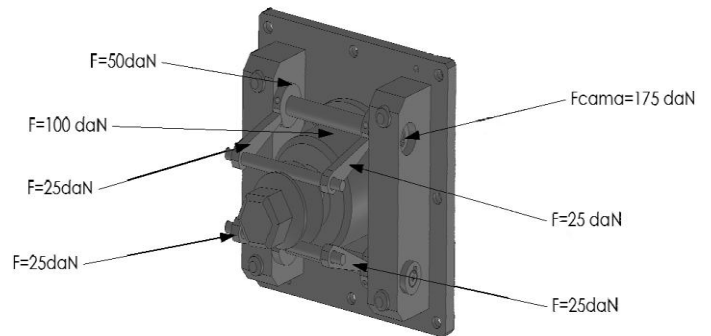
**Figure 4.**The contact diagram for  $\alpha$  angle which ensures autoblock according to the eccentricity  $e$

By doing the simulation of the autoblock with rotary cam clamp, it was concluded that these blocking systems can be used by replacing the classic locking solutions existing in the field: conical pins - elastic bushing - balls. Also, by different computer simulations using rotary cam clamping

profiles, it was concluded that for certain profiles and rotation angles thereof, the autoblock of the tie rod it is realized.

Based on these virtual simulations analyzed it was designed and realized a modular fixture device by own conception.

In figure 5 are represents the actuation mechanism forces which actioned to the modular fixture device.

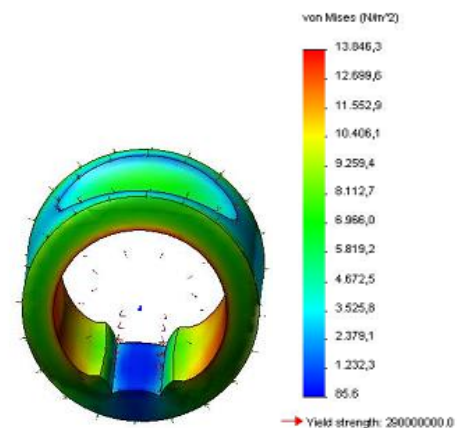


**Figure 5.**The actuation mechanism forces representations which are actioned to the modular fixture device

## 2. FINITE ELEMENT ANALYSIS FOR THE ROTARY CAM CLAMPING FROM ACTUATION MECHANISM CONCEPT

Within the actuation mechanism of the modular fixture device, we performed a finite element analysis to parts which are charge with loading force.[4],[5].

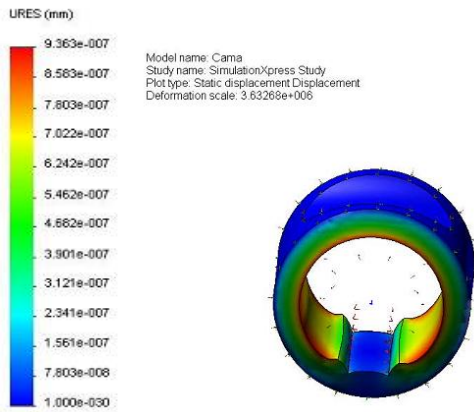
In order to achieve we checked the loading force of the rotary cam clamping when is actioned by a force  $F=175\text{ daN}$  by finite element analysis.



**Figure 6.**Finite element analysis for rotary cam clamping in deformation

The results of the finite element analysis for rotary cam clamping when checked the loading force confirm that occurred deformation represented in figure 6 is not over the limit, the maximum deflection is  $9.363 \times 10^{-2}\text{ mm}$  and stress

tensions represented in figure 7 have a maximal value of  $13.846 \times 10^6$  N/m<sup>2</sup>, the construction rotary cam clamping and the entire project designed and practical performed is correct.[4],[5].



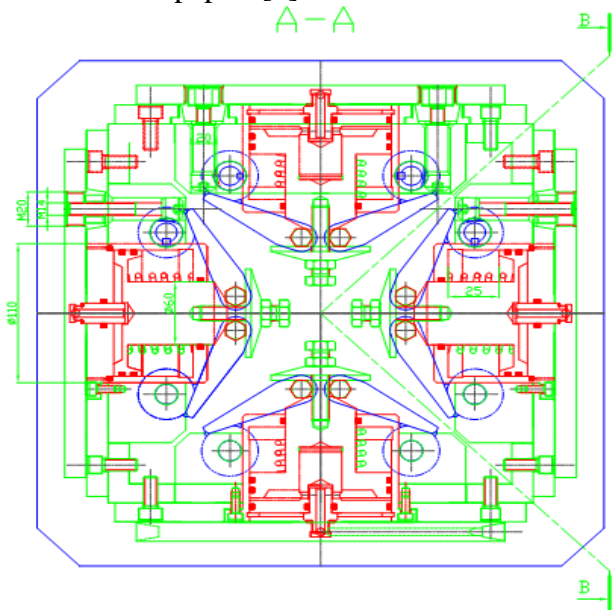
**Figure 7.**Finite element analysis for rotary cam clamping in tensions stress case

### 3. DESCRIPTION OF THE PROJECT AND THE EFFECTIVE FOR ACTUATION MECHANISM CONCEPT REALIZED AT UNIVERSITY OF ORADEA

The main components of the clamping device integrated in the nest are shown as follows in figure 8. [6], [7]

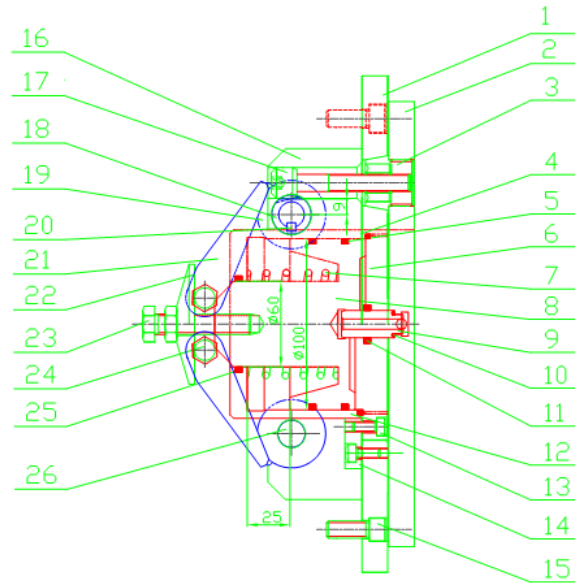
Is represented assembly mode of the modular operating mechanism of the device so that be able to mounted four nests disposed in the same plane.[8]

The figure 8 presents the actuation mechanism concept for modular fixture device realized by the author of the paper. [8]



**Figure 8.**Assembly drawing for the actuation mechanism concept

In figure 9 is represented actuation mechanism structure for the modular fixture device.



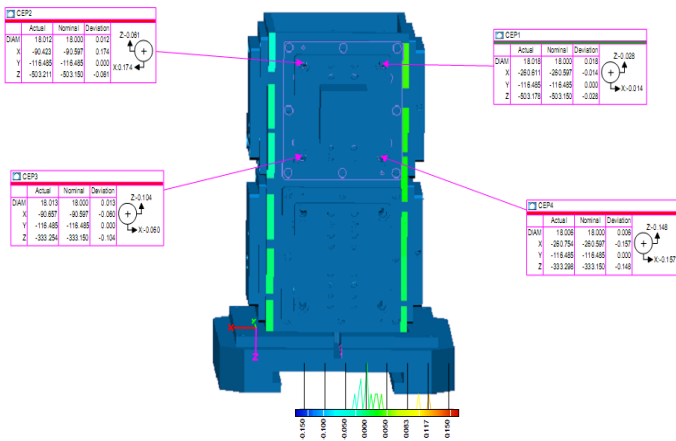
**Figure 9.**Actuation mechanism structure represented in 2D

The actuation mechanism of modular fixture device shown in **Figure 9** is composed by:

1. Fixed support pallet;
2. Detachable pallet;
3. conical pins for positioning the detachable pallet;
4. pneumatic cylinder;
5. the sealing ring for piston
6. pneumatic cylinder cap;
7. coil spring for mounting the detachable plate in the modular device;
8. pneumatic piston;
9. pin for the piston that is actioned with compressed air;
10. sealing ring on detachable pallet
11. sealing ring fixed on the support pallet;
12. pneumatic cylinder cap seal ring;
13. screw for pneumatic cylinder to fixed on flange
14. fixed flange for pneumatic cylinder;
15. fixed screw for fixed pallet on "Tombstone"
16. support
17. lateral pallet for fixed the rotating cam clamp;
18. tie rod for fixed and block the detachable pallet
19. rotary cam clamp;
20. fixed wedge for fixed the rotary cam clamp on the shaft;
21. lever for actioning the piece who is actioned the shaft of cam clamp
22. flange for actioning the lever
23. screw for fixed the flange;

24. tie rod for transformation of the rectilinear motion of the piston into rotational movement of the lever;
25. ring seal for rod piston;
26. shaft for fixed the rotary cam clamp

To determine the precision of the conical pins positioning were performed in the initial phase measurements with Tracker Ion Laser model 2010 from Faro Company with Metrologic Group XG 13.01 version within which was introduced 3D model for the fixed pallet which is fixed on Tombstone in the initial phase of processing. [9]



**Figure 10.** Measurements of precision for the conical pins positioning [9]

In figure 10 were determined precisions for four conical pins of positioning in order to establish the orientation and positioning for the detachable pallet. The value of the measurements realized for establish the orientation and positioning for the detachable pallet are presented in table 1. [9]

**Table 1.** Measurements value realized for the conical pins [9]

REFER.	NOMINAL	ACTUAL	TOL-	TOL+	DEV.	OUT OF TOL.
CEP1 Circle Criterion : Least Square (From 6 Pts On PLAN_CEP)						
DIAM	18.000	18.018	-0.000	0.050	0.018	
RAD	9.000	9.009	-0.000	0.025	0.009	
X	-260.597	-260.611	-0.100	0.100	-0.014	
Y	-116.485	-116.485	-0.100	0.100	0.000	
Z	-503.150	-503.178	-0.100	0.100	-0.028	
F.F.		0.000			0.000	
CEP2 Circle Criterion : Least Square (From 6 Pts On PLAN_CEP)						
DIAM	18.000	18.012	-0.000	0.050	0.012	
RAD	9.000	9.006	-0.000	0.025	0.006	
X	-90.597	-90.423	-0.100	0.100	0.174	0.074
Y	-116.485	-116.485	-0.100	0.100	0.000	
Z	-503.150	-503.211	-0.100	0.100	-0.061	
F.F.		0.000			0.000	
CEP3 Circle Criterion : Least Square (From 6 Pts On PLAN_CEP)						
DIAM	18.000	18.013	-0.000	0.050	0.013	
RAD	9.000	9.007	-0.000	0.025	0.007	
X	-90.597	-90.657	-0.100	0.100	-0.060	
Y	-116.485	-116.485	-0.100	0.100	0.000	
Z	-333.150	-333.254	-0.100	0.100	-0.104	-0.004
F.F.		0.000			0.000	
CEP4 Circle Criterion : Least Square (From 6 Pts On PLAN_CEP)						
DIAM	18.000	18.006	-0.000	0.050	0.006	
RAD	9.000	9.003	-0.000	0.025	0.003	
X	-260.597	-260.754	-0.100	0.100	-0.157	-0.057
Y	-116.485	-116.485	-0.100	0.100	0.000	
Z	-333.150	-333.298	-0.100	0.100	-0.148	-0.048
F.F.		0.000			0.000	

The detachable pallet is provided with four equidistant threaded holes positioned which are mounted on the conical pins so as to enable their

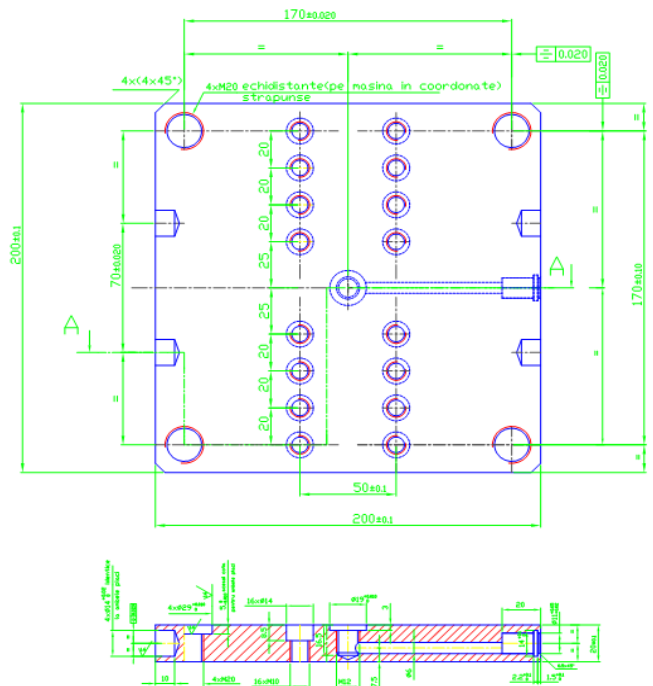
fixing and indexing to 4x90° on the fixed plate support.

On detachable pallet, the conical pins it snaps for centering and positioning, the tie rods for fixed and a central pin for air feed.

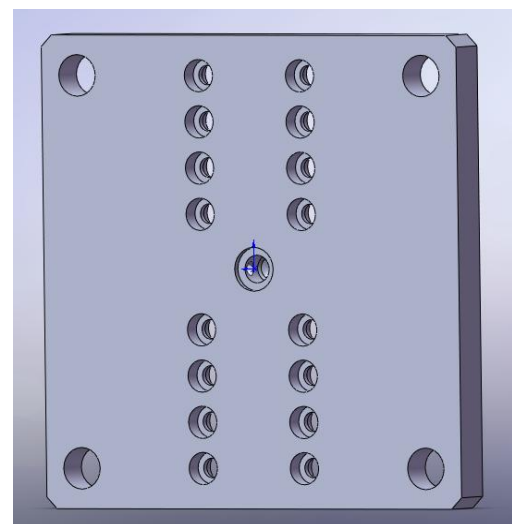
On a side surface there is a central hole that communicates with the hole M12 in which the pin for air supply is fixed.

On the detachable pallet through four holes the four tie rods it snaps for pull and fixing having conical pins for centering into the corresponding holes in the fixed pallet which will ensure repeatability precision for detachable pallet on any fixed plate.

In the figure 11 is represented the 2 D drawing and in figure 12 the 3 D drawing for detachable pallet with the hole M12 in which the pin for air supply is fixed.



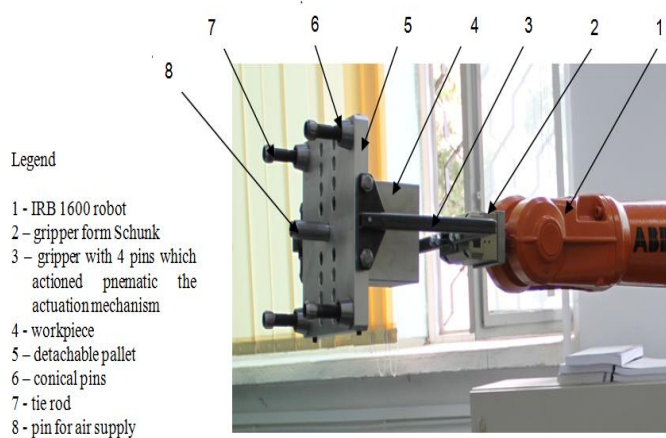
**Figure 11.** Detachable pallet 2 D drawing



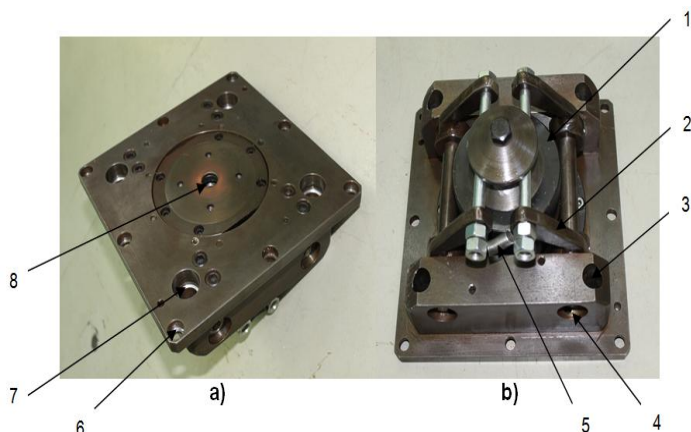
**Figure 12.** Detachable pallet 3 D drawing

The actuation mechanism is actuated pneumatically by the gripper who fixed at ABB IRB 1600 robot through the detachable pallet.[10]

In figure 13 is presented the practical realization for the gripper with 4 pins and central pin for air supply which actuated pneumatic the actuation mechanism, practical realization represented in figure 14. [11]



**Figure 13.** Practical realization for gripper with 4 pins which actuated pneumatic through detachable pallet the actuation mechanism



**Legend**

- 1 - central pneumatic piston
- 2 - lever actuating for blocking
- 3 - access holes for tie rod
- 4 - axis for cam clamp locking
- 5 - return spring
- 6 - mounting holes for fixed pallet
- 7 - hole for centering and fixing the detachable pallet
- 8 - hole for air access

**Figure 14.** The practical realization for actuation mechanism used at the modular fixture system

**4. CONCLUSIONS**

The experimental research was realized into the flexible manufacturing laboratory, at the University of Oradea, using unconventional method with laser Traker Ion to confirm the

improved quality of the actuation mechanism used for actioning the modular fixture device.

**5. ACKNOWLEDGMENTS**

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