DYNAMIC ANALYSIS OF A CRIMPING DEVICE WITH MULTIPLE CAMS USING MSC ADAMS

Part II.Shaping of the tightening forces from a crimping device with multiple cams, using MSC ADAMS

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Abstract:*Through the present paper, the author presents the results of the dynamic analysis with MSC ADAMS of the mechanism with a crimping device with 12 tightening cams, designed and used in the technological process of assembly of the indigenous electrical detonators. In this sense, the mechanism with multiple cams is considered a mechanical system and is treated as an assembly of rigid bodies connected by mechanical connections and elastic elements.*
For shaping and simulation of the mechanism with multiple cams using ADAMS program, the author got through the following stages: construction of the pattern, its testing and simulation, validation, finishing, parametrization, optimization of the pattern.

Key words: Shaping, simulation, parts, connection, spring, operation engine, parameterization, optimization.

1. Introduction

For shaping the tightening forces, we have started from the hypothesis that in the process of design and use of the crimping device with multiple cams, the greatest part of the energy receives has been used to realize the crimping operation [1].

It is obvious that the mechanical efficiency of this device depends on the type of the resistances appearing during its functioning, on the working conditions, on the construction of the elements and the cinematic couples of the component mechanism, on the lubrication and maintenance modality of the mechanism, etc. That is why, for the mechanism of the crimping device it is not possible the specific determination of the values for the mechanical efficiency[2]. To realize an energetic study and calculation of the mechanical efficiency it is necessary a theoretical and experimental analyze.

In the stage of theoretical analysis, our study consisted in realizing a dynamic analyze based on which has been established the mathematical pattern and the auctioning force on each crimping tank.

Alongside experimental stage, the study has been focused on the determination of some dynamic parameters in mechanism, using the package of programs MSC ADAMS.

2. Structural shaping of the multiple cams crimping mechanism through the soft ADAMS

The crimping mechanism with multiple cams is considered a mechanical system and is treated in ADAMS as an ensemble of rigid bodies (named parts), connected through mechanical connections (named couples) and elastic elements [3].

The stages for shaping and simulation of the multiple cams crimping mechanism with program ADAMS are presented in scheme in the figure 1.

The types of pasts included in ADAMS are: rigid bodies, elastic bodies and bodies without mass. Rigid bodies are defined by mass and inertial properties.

ADAMS contains a library of elementary solids (sphere, cylinder, torus and so on), from which can be created complex bodies (solid composites) by the application of Boolean operation (reunion, extraction, intersection). Rigid bodies can be created also starting from closed plan surfaces by adding the thickness (extrusion), namely by rotation around a central axis (rotation surface).

On the bodies from the mechanical system of the mechanism with multiple cans can be imposed the initial conditions of positioning – orientation, that are taken into consideration in its assembly process [5,6].

This process, named also the analysis of the initial conditions, is very useful in case it is not recognized completely the shaping functional configuration (in the initial position) of the mechanism.

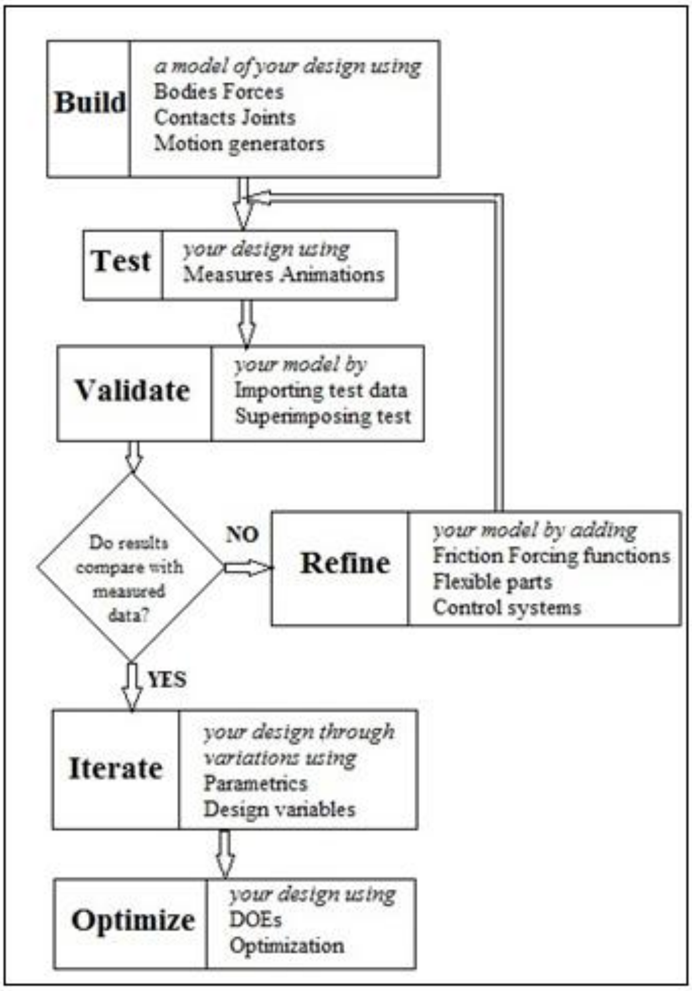

Figure 1. *Stages for shaping and simulation of the crimping mechanism with multiple cams, with the program ADAMS.*

The mechanism with multiple cams in figure 3 consists of 12 identical mechanisms. For shaping and simulation of the crimping mechanism with multiple cams, with the ADAMS program it is sufficient to study on mechanism presented in figure 2.

For this, are known the geometrical dimensions of the crimping tank (PART_8), configuration of the cam (PART_7), location of the spring for maintaining the contact cam – tank (SPRING_1.sforce), locations of the couples on the elements of the mechanism (JOINT_1, JOINT_2, JOINT_3), as well as the ensemble configuration of the mechanism (model_1), in other words the global coordinates of the point where positioned the couple of the cam rotation.

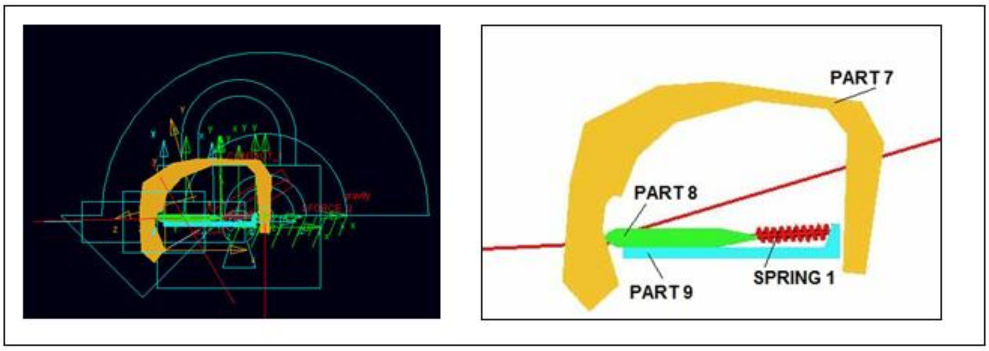

Figure 2. *The pattern executed in ADAMS.*

Shaping based on MSC ADAMS soft has as basis the principles of solid shaping [7]; in this sense, are determined automatically the mass, the inertial tightener and the position of the mass centre of the shaped elements. The couples of the mechanism have been implemented, using the library of couples of the soft, by indicating the connection between different component elements of the pattern realized or from the elements and the fix part on base type (PART_9).

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Topology of model: model_1

  Ground Part: ground

  JOINT_1          connects  ground  with  PART_7 (Revolute Joint)
  SPRING_1.sforce  connects  PART_8  with  ground (Single_Component_Force)
  CONTACT_1        connects  PART_8  with  PART_7 (Contact)
  JOINT_2          connects  PART_9  with  PART_8 (Translational Joint)
  JOINT_3          connects  ground  with  PART_9 (Fixed Joint)
  SFORCE_2         connects  PART_8  with  ground (Single_Component_Force)

  MOTION_1         constrains  JOINT_1          (Rotational Motion)
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Figure 3. *Connexions between different elements of the pattern, external attempts and the engine.*

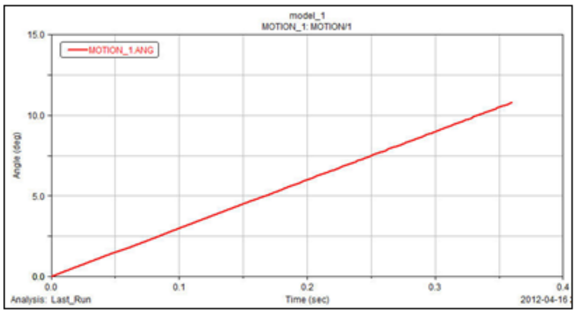


Figure 4. *Graphic of the rotation angle of the cam.*

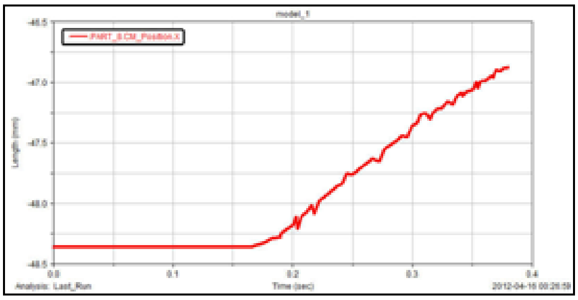


Figure 5. *Graphic of tank's displacement.*

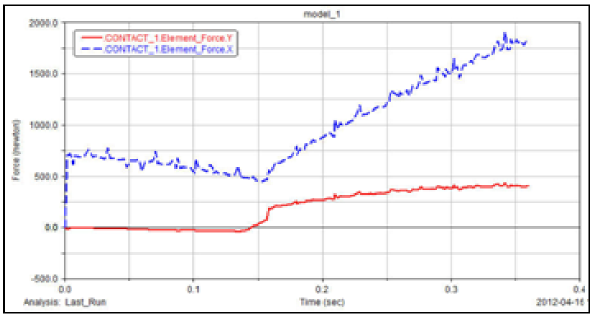


Figure 6. *Graphic of the contact forces on axles x and y.*

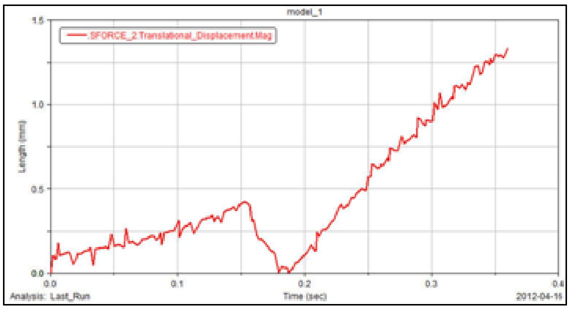


Figure 7. *Graphic of displacement of the radial force for the deformation of the tube.*

In the following stage, has been shaped the engine (MOTION_1) and has been applied the external resistant technological force, auctioning on the mechanism with cams (in the present case, the radial force of tube's deformation - SFORCE_2, applied on the tightening tank). The connections between different elements of the pattern, external tests and the engine are presented succinct in figure 3.

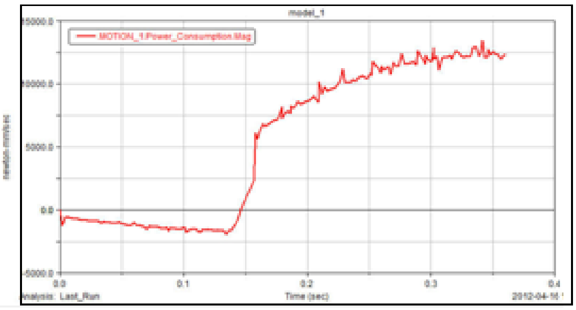


Figure 8. *Graphic of energy consumption.*

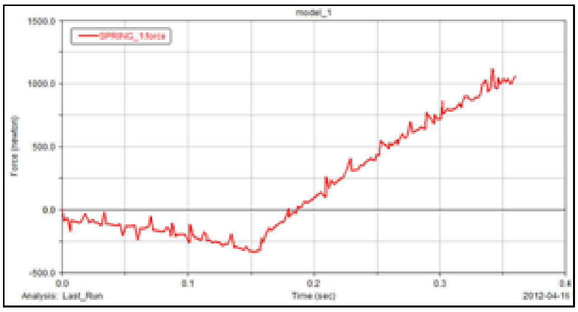


Figure 9. *Graphic of engine torsion moment, applied to the shaft of the cam.*

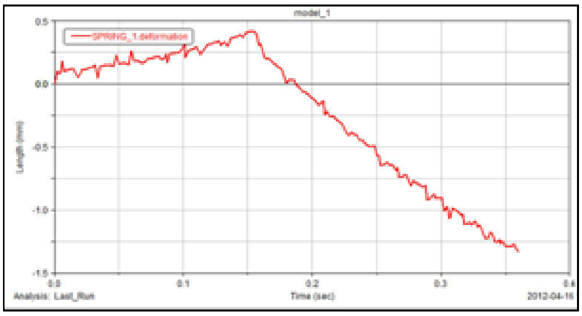


Figure 10. *Graphic of deformation of the spring.*

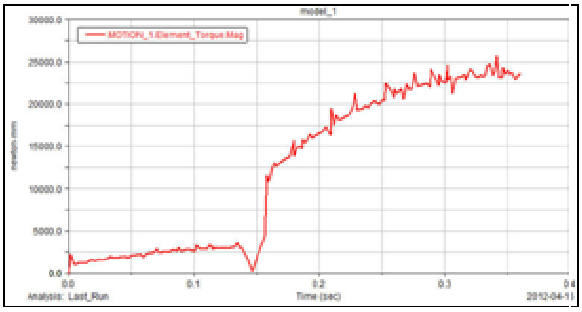


Figure 11. *Graphic of the resort force.*

The signification of the elements from figure 3 is presented as follows: Ground represents the fix element (basis); PART_A - element A; Revoulte Joint - rotation couple; Single_Component_Force - unique component of the force; Contact - contact; Translational Joint - translation couple; Fixed Joint - fix couple; Rotational Motion - rotation engine.

The entrance parameters used for the realization of the simulation are: rotation angle of the cam - seen graphically in figure 4; displacement of the tank - seen graphically in figure 5; contact forces on axes x and y - seen graphically in figure 6; displacement of the radial force for the deformation of the tube - seen graphically in figure 7; consumption of energy - seen graphically in figure 8; moment of engine torsion, applied to the shaft of the cam - seen graphically in figure 9; deformation of the spring - seen graphically in figure 10; force of the spring - seen graphically in figure 11;

Taking into account the character of the variation for entrance parameters (presented in upper figures) are imposed the following observations:

- angle speed of the entrance shaft is constant;

-has been considered a linear variation, in time, of the rotation angle, so that this has the value of 0^o at the end of the simulation and the maximum values of 11^o at the end of the time interval that is necessary for simulation;

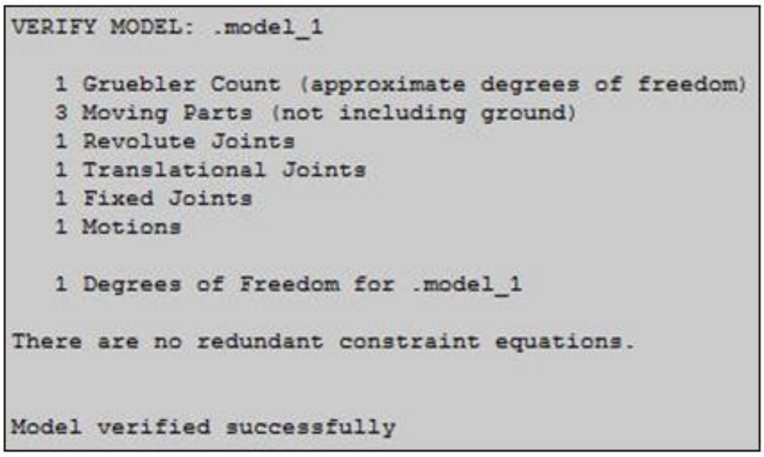
- the value of the displacement speed of the peg has been elected depending on the shape of the cam, to illustrate more convenient the character of the forces on contact1;

- the movement law of the profile of the cam has been realized with 2 bearing: easily increasing, and increasing, depending on time.

Before beginning the simulation, has been realized the verification of the created pattern. By verification, the soft presented automatically the results presented in figure 12.
From the ones presented above, can be considered the following:
- the pattern contains 2 elements in movement;
- there are 2 couples of class V, one of rotation and one of translation (namely 2x5 constraints);
- there is 1superior couple of class IV (1x4 constraints);
- the pattern has one independent movement (rotation realized by the entrance shaft);
- the pattern has one degree of mobility;
- there are no redundant constraints, the pattern being verified successfully.

Taking into account the results of the pattern verification stage (results certifying the fact that the pattern has been correctly realized) as follows will be realised the simulation of the dynamic behavior of the realized pattern.

For simulation has been considered a time interval of 0.36 seconds.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VERIFY MODEL: .model_1

   1 Gruebler Count (approximate degrees of freedom)
   3 Moving Parts (not including ground)
   1 Revolute Joints
   1 Translational Joints
   1 Fixed Joints
   1 Motions

   1 Degrees of Freedom for .model_1

There are no redundant constraint equations.


Model verified successfully
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Figure 12. *Verification of the created pattern*.

3. Simulation results

By simulation of the realized pattern, have been observed: the determination of the displacement distances of the tightening tank; observing the displacement law of the tank; determination of the variation of the forces on contact 1; determination of the variation of the energy consumption at the displacement of the tank.

As results from figure 8, the displacement of the tank n a rotation cycle of the cam (11^o) is of 1,35 mm; even if the displacement speed of the tank is uniform, when the cam rotated with 4,5 ^{o}, for a duration of 0.02 s, the displacement of the peg stops returning to position of 0 mm, after that the displacement is uniform until the end of the cycle. The explanation is given by the beam of connection between the profiles of the cam, not correlated with the contact area of the tank. It has been observed that the contact forces in that area, as well as the moment of torsion of the cam's axle are minimal.

The figure 9 shows that there is an active component of the contact force on the direction of the Ox axis and an inactive component with very small values on the Oy axis.
The active contact force has a linear variation and is maximum at the end of the work cycle.

4. Conclusions

As a result of interpretation the result of the simulation, can be formulated the following conclusions:

1. The displacement of the tightening tank in a cinematic cycle is of 1.35 mm, sufficient to realize a quality peg;
2. 80% from the value of the contact force is transmitted on the direction of the Ox axis and 20% on the direction of the Oy axis;
3. The mechanical efficiency of the crimping mechanism with multiple cams depends to the greatest extent on the active component of the contact force;
4. Advanced usage of the peg on the action direction of the active force or the apparition of the usage points to the area of end of the cycle for the profile of the cam, determines insufficient displacement of the peg as well as internal contact forces for the deformation of the tube, submitted to the crimping operation.

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