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INDESCA
Development of Rotational Molded Desks COVENIN from 3 through 5.

Progress Report

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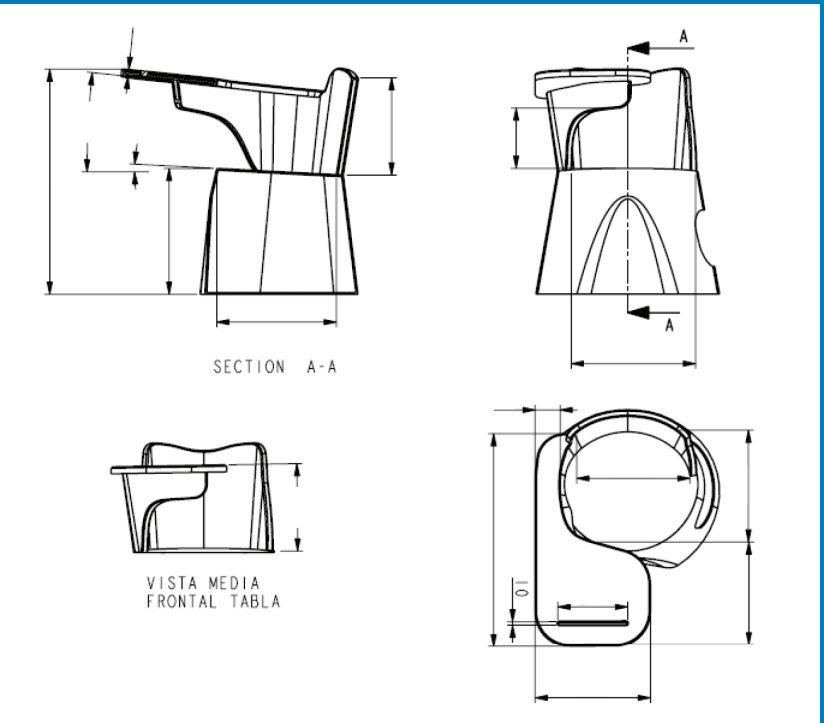

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1. TECHNICAL OBJECTIVE

Executing the modifications to the designs of the desks COVENIN 3, 4 and 5 suggested by the client, based on the revisions made to the design originally presented and on the tests conducted with the final users.

2. BACKGROUND

The design of a desk to be manufactured by rotational molding was started in 2006. Q'Tanque requested the support of Indesca for the design of a desk to be rotational molded.

In 2007, the designs of the desk, versions 3 through 5, were developed for COVENIN, and a first version was manufactured with a test mold. Samples were donated to two education institutions that served as pilot tests, and surveys were conducted that served to make changes to the first version.

This year, an optimization process of the mechanical performance of the desk was conducted, after including the modifications suggested by the students that tried the prototype desk and by the client. This optimization process was necessary because the modifications suggested by the users during the pilot test generated a reduction of the rigidity of the board of the desk, which was also pointed out as a weakness by the students surveyed.

3. RESULTS

The models corresponding to COVENIN versions 3 through 5 were generated. The measurements of the models created comply with COVENIN regulations 1650-89. Iterative computer simulations were conducted in order to verify the mechanical performance of the different versions yielded by the optimization process. This process was made to achieve better ergonomics of the desk and, at the same time, make it sturdier than the versions of the pilot tests (first version).

3.1 Final dimensions and characteristics of the rotational molded desk

Below are the final measurements of each desk model, in accordance with COVENIN regulations 1650-89. The dimensions of the desk regulated by COVENIN's regulation are shown in all cases, as well as some others that are of interest for the ergonomics of the user; for instance, the distance between the seat and the lower part of the board (leg space).

Figure 1 shows the final version of the rotational molded desk.

Figure 1. COVENIN 3 through 5 desk. Final version

3.2 Results of mechanical simulations

The change suggested by the surveys and that caused the biggest problem was the increase in the distance between the support of the board and the seat (space for the user's legs). This measurement was increased, for the case of the COVENIN 5 desk, from 120 mm in the first version to 176 mm in this version, which caused the board to lose rigidity. In the rest of the models the same phenomenon took place. For this reason simulations of static load were conducted to achieve an optimum model.

Also, a simulation of the falling of a concrete plate on the desk was conducted in order to evaluate its rigidity and the degree of deformation generated.

3.2.1 Static mechanical simulations

A series of simulations was conducted modifying the measurements of the desk until getting a set of dimensions that would be in compliance with COVENIN's 1650-89, and that at the same time provided the best mechanical performance possible.

Load conditions used on the simulations, for all models (COVENIN 3 through 5), are shown on Figure 5, where the red arrows indicate loads, and the green, smaller, indicate movement restrictions of the desk, which in this case simulate the support of the floor. The loads applied on each zone depended on the model studied, which values are shown on Table 1. The value of the load on the table is the same for all models (5.5 kg.), which is equal to the weight of four (4) big books.

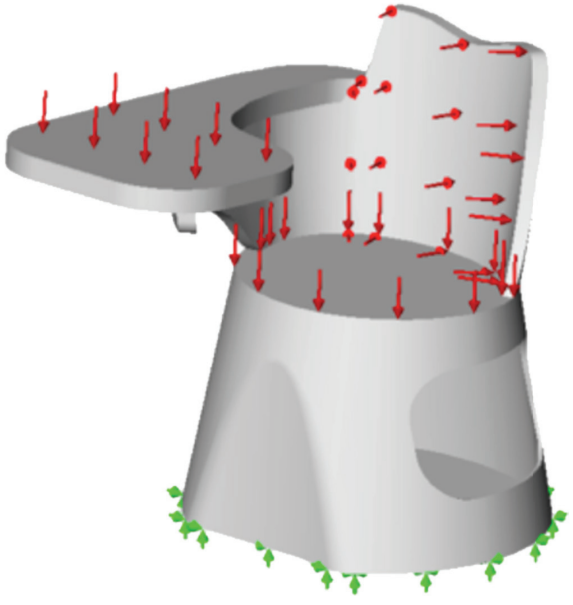


Figure 5. Model used for the simulations under load conditions.

TABLE 1. LOADS APPLIED TO EACH COVENIN MODEL

Model	Seat (Kg)	Back rest	Board (Kg)
COVENIN 3	60	27	5.5
COVENIN 4	80	36	5.5
COVENIN 5	100	45	5.5

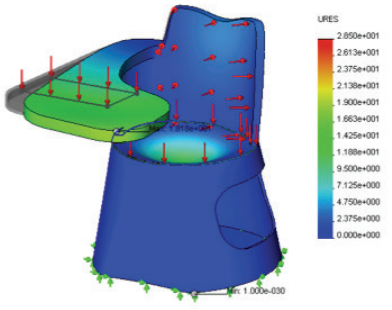
The results of the simulations are shown on Table 2. The material considered was a PEMD grade Venelene® 8405V8D, with a modulus of elasticity of 643 MPa, and 27 MPa of flow stress. The desk models used in the simulations have a uniform thickness of 5 mm. The weight of the piece shown on Table 2 was calculated with this thickness.

TABLE 2. RESULTS OF THE SIMULATIONS FOR COVENIN MODELS 3 THROUGH 5.

Model	Desk weight (Kg)	Maximum displacement (mm)	Maximum stress (MPa)	Safety factor
COVENIN 3	5	18	9	3.1
COVENIN 4	6	16	6	4.5
COVENIN 5	8	28	7	3.9

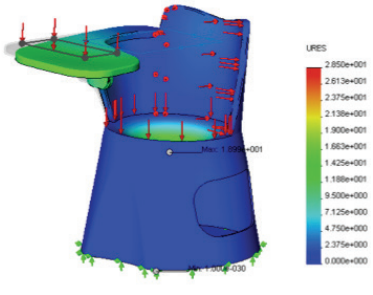
The maximum stress was found on COVENIN 3 with 9 MPa, which results in a safety factor of 3.1 (meaning that it is necessary to apply 3.1 times the load used on the simulation to produce fauilure), while for the rest of the models, the stress level was lower and thus higher safety factors are obtained, which indicates that they will not fail.

Figure 6 shows the displacement maps for the desk models studied. The maximum displacement on the table is found in COVENIN model 5, with 28 mm, due to its larger dimensions.



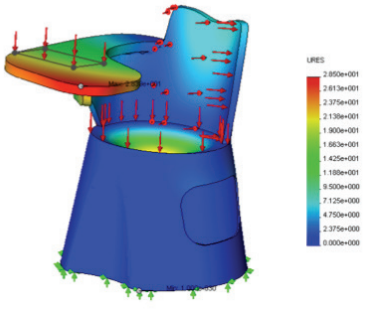
COVENIN model 3

User height: 128 to 140 cms.



COVENIN model 4

User height: 141 to 157 cms.



COVENIN model 5

User height: 158 or more.

Figure 6. Displacement map (in mm.) for COVENIN models 3 through 5.

Figure 6 shows that the larger displacement portion of the table is lateral and not vertical. Table 3 shows the components of the displacements that take place on the board of the desk. It can be seen that on COVENIN models 3 and 4 the larger portion of displacement is lateral, while on COVENIN 5 distribution is more uniform. The result of this is that a higher sense of lateral movement of the board would be felt than its deflection.

TABLE 3. VERTICAL AND LATERAL DISPLACEMENTS OF THE DESK'S BOARD

Model	Lateral displacement (mm)	Vertical displacement (mm)	Total displacement (mm)
COVENIN 3	15	9	18
COVENIN 4	15	7	16
COVENIN 5	25	24	28

3.2.2 Impact simulations. Modelling of the falling of a plate on the desk

The client requested the evaluation of the desk's performance under such load conditions that would be generated when a concrete plate (the roof of a building) falls on the plastic desks.

This analysis was requested because as a consequence of the Cariaco earthquake, in 1997, certain education facilities suffered the collapse of some of its levels, and several children were saved because desks softened the blow of the falling of the collapsing plate, which generated a space in which the children were able to take refuge until they were rescued.

The modelling of the falling of the concrete roof on one of the desks was carried out, and the falling of a block of the roof on a desk was studied. The case studied was that of the desk COVENIN 4. It was assumed that a 0.7 m2 concrete block falls on the desk, with a total weight of 500 kg, from a height of 2.5 m.

Permanent deformations of the desk are taken into consideration in the simulations made. The graphic results, for the three different time moments (11.13, 15.38 and 19.36 milliseconds) are shown on Figure 7.

Up to the moment of simulated time it has been found a desk deformation of 12 cm, which leaves a space between the plate and the floor of 52 cm.

According to the prediction of the simulator, the desk does not suffer excessively significant deformations as to cause the collapse of its structure. This can be observed on Figure 7.

4. CONCLUSIONS.

The new versions of COVENIN models 3 through 5 comply with COVENIN regulations 1650-89, and also have a good mechanical performance because of the optimization process implemented.

The safety factor for each desk predicted by the simulator is high for its application (>3) and, thus, the desk will not present any failure or flow of the material. The desk turned out to be safe even in the case of the falling of a concrete plate from the roof on its structure.

Displacement of the board was reduced to the minimum in every desk model in order to make it as rigid as possible, following the recommendations of the students that tested it and answered the surveys for the first version of the desk.

The desk has a good mechanical performance during the falling of a plate over it. There is no collapse of its structure, neither are there any excessive deformities.

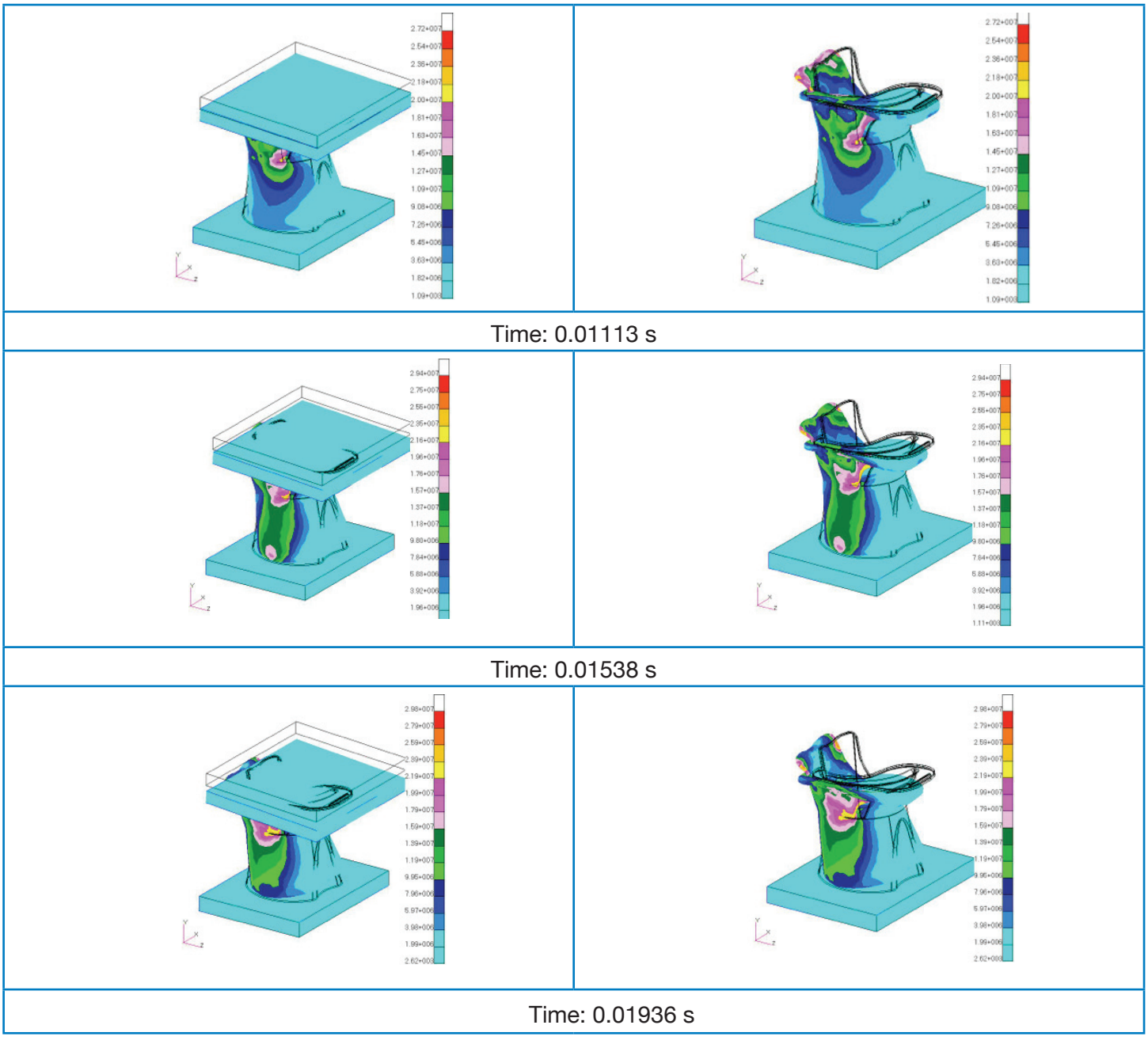


Figure. 7. Fall of concrete block on the desk

5. RECOMMENDATION.

No modifications should be made to the dimensions of the rotational molded desk, since there are critical measurements that determine the good mechanical performance of the desk. Should it be necessary to make modifications to the desk, and especially to the measurements of the board, Indesca personnel shall be consulted on the matter.

Keep the distribution of the thicknesses as uniform as possible with the molding conditions of the product. This would prevent possible failures and would optimize the mechanical performance of the desk.

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