

## **Design and fabrication of high energy miller used to synthesis of materials**

Pedro Vera & Homer Lara

P. Vera. & H. Lara.

Universidad Politécnica de Tecámac, División de Ingenierías, Prolongación 5 de Mayo No. 10, Tecamac de Felipe Villanueva, Estado de México, Mexico, ZIP CODE: 55740, email: pedrovera.upt@gmail.com

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## Abstract

This work shows the design of miller machinery to advanced material, the mixer was developed with students based in the process of mechanosynthesis, the design had a price 40% less than commercial miller-mixer in Mexico market, the design was oriented to have better control on program of work, try to reduce the cost, and add capacity. So the mixer was designed using the Software Inventor 2010, materials as aluminum, stainless steel and electric motor 127 V, the angular velocity to work was reduced with flexible system, the results shows a adequate work velocity, continuous operation with the double of capacity and more time to be programed in comparative with commercial miller.

## 8 Introduction

Historically, the growth of technology in many cases increased the use of new materials, the materials have a high resistance to temperature, wear, rigidity and less weight as polymers, ceramics, composites or metals, in the science and technology the traditional methods has been substituted by new process, it get change the phases, size particle, different elements compositions, isotropic or anisotropic properties, so there are methods like mechanosynthesis, sol-gel, polyol, chemical vapor deposition between others that are novel process,<sup>1</sup> in the case of mechanosynthesis the high-energy mills use the mechanical energy to the synthesis of materials directly, while the precipitation method has residues that contaminate in some cases, other advantages of mechanosynthesis are the synthesis in room temperature, is possible has nanometers size particle, different magnetic properties and few space in laboratory to the synthesis.<sup>2</sup>

Mechanosynthesis process can generate the chemical reaction in some hours using a high-energy miller, in the standard process the powders were deposited inside of vials with balls, the balls shake inside of vial and the shaking generate mechanical energy when the balls impact on powders and the inside surface of vial, appear deformation in the particles, generate new chemical active surfaces, the particle show deformation and breaking, to finally weld using diffusion mechanism in some cases. With the aim of reducing the size of the particle, it changes its shape or develops mixing processes, or welding getting a fine and controlled microstructure of advanced metallic, composite and ceramic powders.<sup>2,3</sup> Mechanical mills are used with great success in virtually all areas of research and industrial, especially in those where purity, speed, finesse and reproducibility requirements are high.<sup>4</sup>

The applications of milling and mixer are in the synthesis of nanomaterials; reduce size of particle materials.<sup>5</sup>

In Mexico there are different mixer and miller products, the Spex Mixer-Miller 8000D has been showed the synthesis of materials and mechanical alloy,<sup>6</sup> but the cost of miller is high for some universities, institutions, and small industries with interest in a mixer-miller, so was developed a miller with a cheaper cost on a 40 percent of the price, so could be possible the acquisition easier, double of capacity, and better control time to work.

**Figure 8** Spex Miller-Mixer 8000D with capacity to two vials



### 8.1 Process and methods

In the develop of design of miller first was consider the cost cheaper than the Spex 8000D, were analyzed the possibilities of fabrication, test, the cost of parts, the time of project, get economical support with programs of government, the characteristics of work group, the software used. So the selection of materials were aluminum, stainless steel, alloy steel, acrylic, the light weight was important, the new miller has been designed with a light weight, its facility the displacement and colocation with the participation only with two persons, the list of materials was approximate a fifth part of the price Spex 8000D, the software of design was Inventor 2010 (Autodesk), the parts of miller were modeled, assemblies, dynamics simulations, the electrical motor was chose with the minor revolution per minute, so the final velocity on shaking was lower than 200 m/s, the vial was on 60 cm<sup>3</sup>.

Electrical motor characteristics:

- Siemens
- Phases: 1
- Alternate Current
- Voltage: 127 Volts
- Velocity: 1745 RPM
- Efficiency: 57.5%
- Power: 0.50 HP

Mechanical transmission was with gates, using two reductions and bar mechanism.

The aluminum and stainless steel parts were welded and machining with traditional turn, drill,

Respect to Display and controller was used principally:

- LCD model TOPWAY LMB202D
- Language C
- Thermofit
- Software PCB wizard

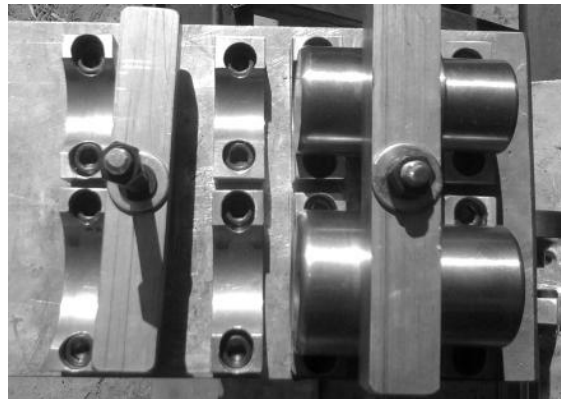
- Current converter 12 v 1A

## 8.2 Experimental

The angular velocity was reduced using a ratio 7:1, using gates type A and V, the axis of transmission were designed with stainless steel, the first one axis was proposed with alloy steel, it showed deflection and was substituted by stainless steel, the result was well and disappear the deflection.

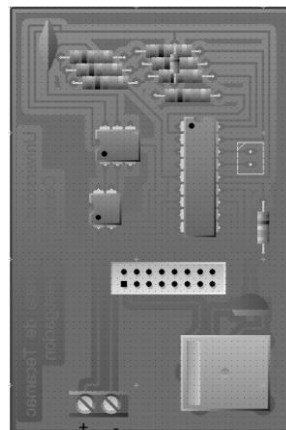
The bars and elements of mechanism were designed with aluminum, were put bearings as support of axis. The mounting part of vials initially was proposed in stainless steel material to avoid the corrosion, due to weight was necessary the material change and the material was aluminum, the vials used were of stainless steel, the capacity of vials was duplicated and was possible watch the good fix of vials, because never was separate the vial of support, while the vials of Spex 8000D due to system of fix, with the shaking the vials were expulsed.

**Figure 8.2** Mechanism with capacity for 4 vials



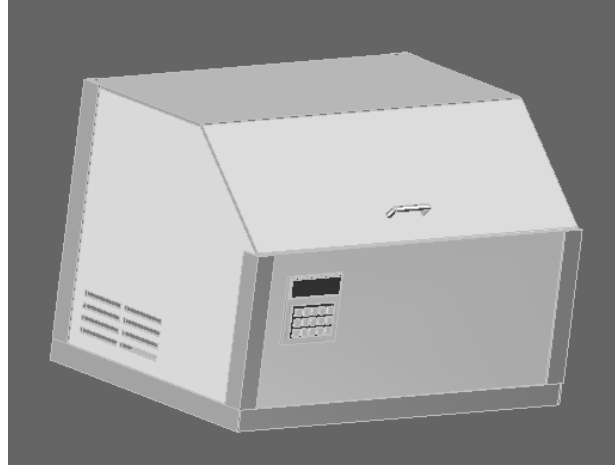
Respect to the programing to operate, the Spex 8000D when start the project of design of mixer, Spex only was possible program the controller until 99 minutes, and every 90 minutes was necessary program the mixer, in the new mixer developed the time of programing until 30 hours, include work and delay times, it was possible with processor directives and precompile functions.

**Figure 8.3** Print circuits with microprocessor

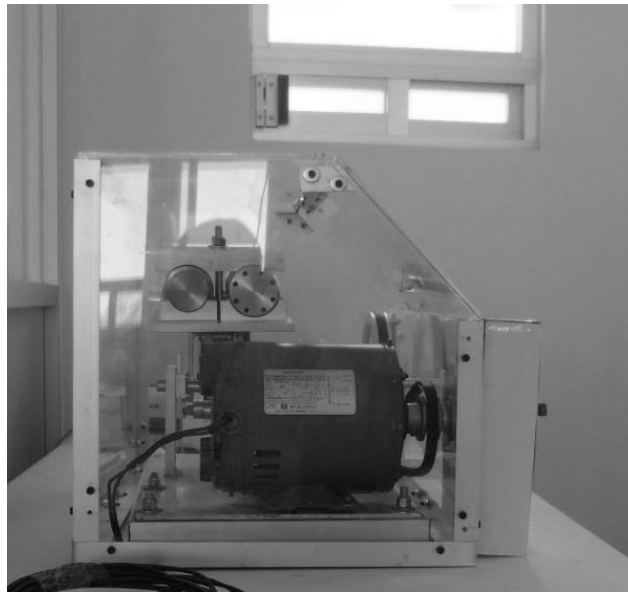


The dynamics simulation was developed with Inventor software, it permit watch the reduction velocity; avoid interference parts, and improvement of parts on shapes and positions, proportional dimensions and the space necessary.

**Figure 8.4** Initial design of mixer using Inventor 2010



**Figure 5** Mixer developed with cover of acrylic



The control was tested during a one week before to work the mixer, after was tested the mixer with the composition  $\text{Fe}_2\text{O}_3\text{-MnO}_2$ , the results were watched after 2 hours of milling; the results were positives without problems, the design and fabrication was possible after 3 years.

### 8.3 Conclusions

The miller was developed with opportunity to sell on 40 percent cheaper than Spex Mixer-Mill 8000D, the synthesis was possible in repetitive millings, the miller works in the research laboratory.

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## 8.5 References

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