Design and Fabrication of a Pin on disc under standard G99-01 and with diamond indenter

The present poster develops a pin on disc machine that works under standard ASTM G99, which parameters design were established according to the necessities and the characteristics of the design when its compared with the competence, also it was added an implement that allows it to increase the pressure contact of area, resulting in bigger stresses, being the case for the spherical tungsten carbide 85.035 MPa, while, for diamond indenter was 410.29 MPa, hence, changing the wear mechanism, from abrasion to a combined effect of abrasion and micro-ploughing Introduction In the study of the mechanical properties of a material, friction is a common characteristics to be measure, however it is not a simple task, since there are a lot of variables that can affect the final measure, hence, machines that are capable to determine the force friction and the coefficient of friction has been developed, this instruments are called: tribometers [1]. To normalize the process to determine the measure of coefficient of friction and wear rate values, the standard ASTM G99 is used to determine the main characteristics of design [2].

There is another mechanism to characterize materials, a scratch test is useful to determine the resistance to abrasion and wear for a lot of different materials [3], parameters for load, distance, and humidity are mention in ASTM C-1624 [4], however, there is no information that exposes the uses of a scratch test using the configuration of a pin on disc machine, hence, the aim of this work is to develop a machine that can perform an standardized pin on disc test, with the chance to use, in the same configuration, a diamond indenter to increase the contact and wear damage, by changing the wear mechanism from only abrasion present by the spherical tungsten carbide to abrasion and micro-ploughing using a diamond indenter. Methodology For designing it was necessary to consider the characteristics that we have implemented to the design, for this, the Quality Function Deployment (QFD) was developed, considering the necessities that the machines has to cover, how good is doing it, and compare it against the competition, Figure 1, shows the QFD diagram, that validates the viability of the design.

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▲	3
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	What	Who: Option 1	Who: Option 2	1 Weigth (kg)	2 Noice (B)	3 Vibration (Hz)	4 Data acquirment (Bytes)	5 Normal Force (N)	6 Friction Force (N)	7 Operation time (seg)	8 Maintain ($)	9 Critic Parts (pza.)	10 Range of diameters (mm)	Anton Paar	Nanovea-T50
1	Comfortable	4.07	3.69							▲	▲	▲	■	4.00	3.60
2	Easy to use	4.13	3.75				▲			•	■	▲		4.50	4.21
3	Rapidly instalation	3.50	3.56	•						•	•	▲		2.10	3.69
4	Maintenace	3.13	3.19		▲	▲	▲			▲	■	▲		3.12	2.80
5	Intuitive	3.25	3.88				▲			▲				4.56	4.10
6	Heavy	4.19	3.56	■		▲		•				•		3.57	3.20
7	Accurate	3.93	4.06		•	▲	▲		•	•	■	•		5.00	3.70
8	Compact	3.13	3.44	▲				•	•				▲	3.93	4.50
9	Affordable	3.19	3.38				▲				•		■	2.01	3.50
10	Stable	4.50	3.20	▲	•	▲					▲		•	4.78	4.20
		Option 1		12.71%	3.53%	9.37%	10.49%	1.45%	1.40%	8.51%	26.40%	10.43%	15.71%		
		Option 2		11.53%	3.49%	8.84%	11.37%	1.45%	1.56%	9.06%	26.28%	10.42%	16.00%		
		Product 1		11.74%	3.72%	9.61%	11.20%	1.46%	1.74%	9.07%	28.02%	9.68%	13.75%		
		Product 2		11.98%	3.33%	8.53%	11.24%	1.57%	1.68%	8.82%	25.97%	10.19%	16.69%		

Figure 1. QFD for Pin on disc machine.

The purpose to use a diamond indenter is to increase the contact pressure that exists between the pin (or indenter) and the test that is going to be submitted the test, in this, scenario, it was convenient to analyze how the stresses behave according to the contact of area, for this reason, the contact was analyzed using ANSYS Workbench to determine it. The parameters for boundary conditions were fixing the lower part of the disc and applying a force of 10 N, in the elements that apply load. Figure 2 a) shows the boundary condition used for the diamond indenter, while on b) shows the boundary conditions for the ball on the disc.

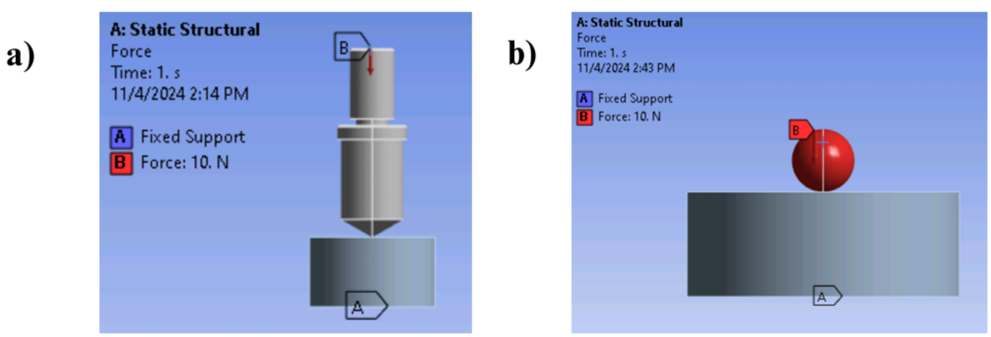

Figure 2. a) Boundaries conditions for diamond indenter, b) Boundaries conditions for ball on disc

The machine that work as a tribometer pin on disc under standard ASTM G99 with a complement that allows the use of a diamond indenter to increase the contact area bewteen surfaces was designed using the software SolidWorks ® , Figure 3 on a) shows the isometrical views of the final assmebly, meanwhile, on b) it is possible to see the transmission, load and acquisition system in a cross sectional view.

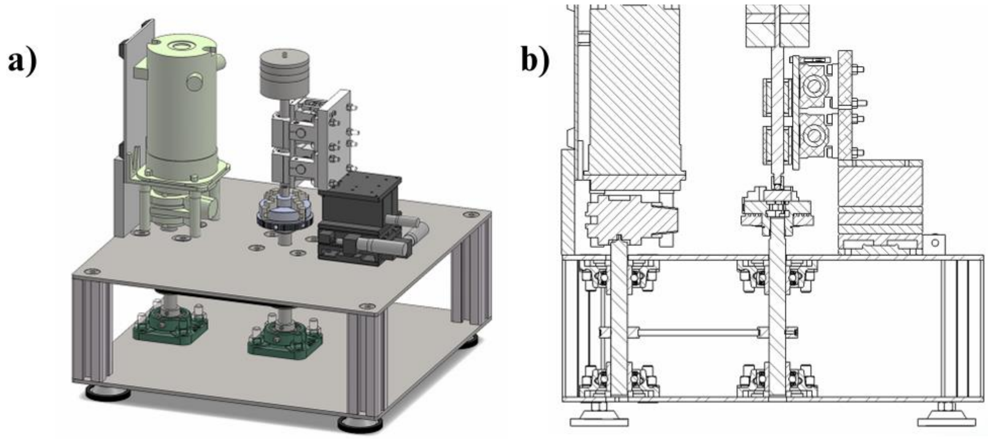

Figure 3. a) Isometric view of the general assembly. b) Cross Sectional View

Figure 4, a) shows the zoomed cross sectional area that is related to the pin on disc condition test, in this case is a ball of 6 mm that is clamped with a holder to the load axis, in this case is following the disposition of the standard that establish that the test must be performed perpendicularly between surfaces. b), is the new implementation, in this case the diamond indenter is inside the axis load and clamped with a screw and a holder.

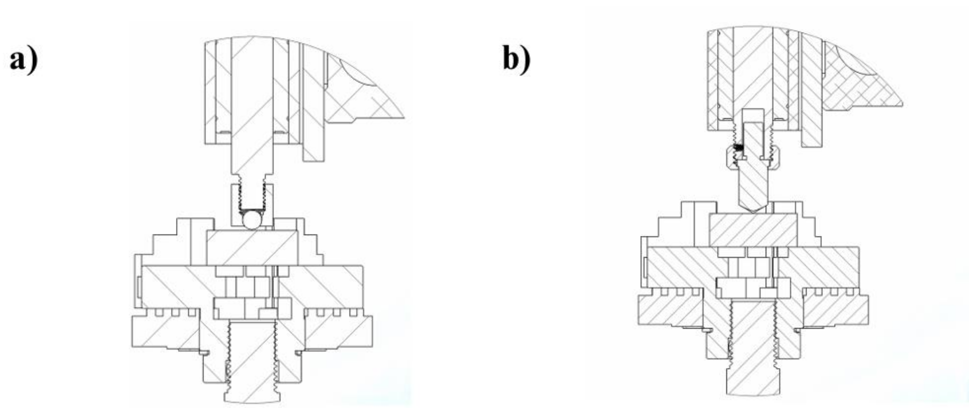

Figure 4. a) Cross Sectional view of pin on disc machine. b) Cross Sectional view using a diamond indenter

Figure 5, a) presents the isometric view of the machine that has been manufactured during the last period, while, in b) shows the left view. in this part it is possible to see the system that transmits motion and how the load is applied to the piece that is hold by the chuck.

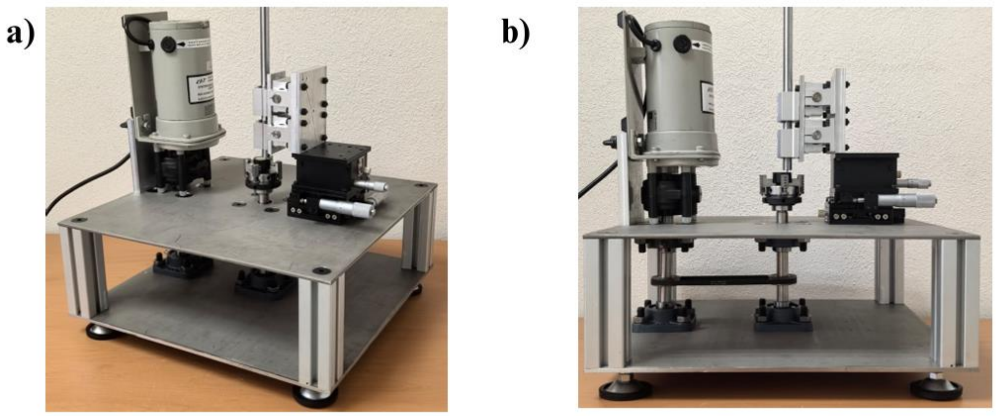

Figure 5. a) Isometric view of the real assembly. b) Cross Sectional View of the real assembly

Figure 6 presents the equivalent von Mises stress and total deformation results. In (a), the diamond indenter reached 410.29 MPa with 0.25 µm deformation, while in (b), the tungsten carbide pin reached 85.04 MPa with 0.08 µm deformation. The simulation confirms that the indenter concentrates and increases stress compared to the spherical pin.

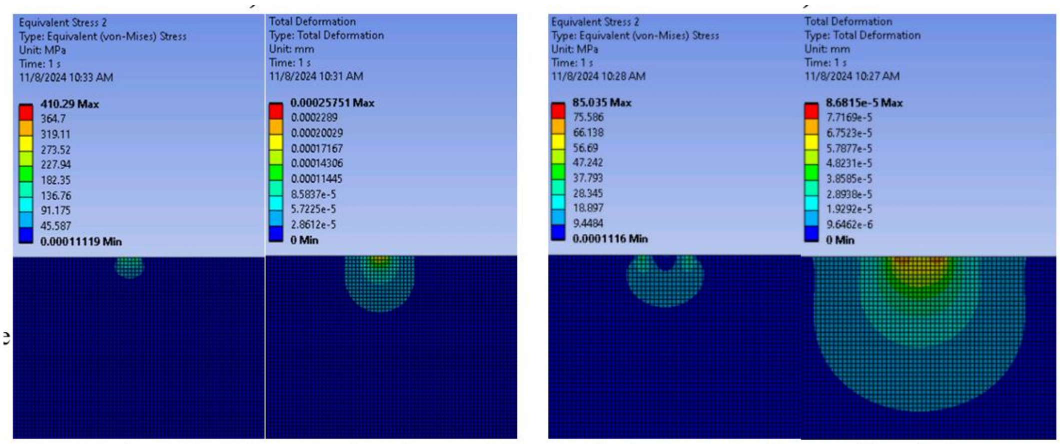

Figure 6. a) Cross Sectional area of diamond indentator on disc machine. b) Cross Sectional Area using a pin tungsten carbide.

Conclusions

The new design increased contact pressure from 85.04 MPa to 410.29 MPa using a diamond indenter. This shift changed the wear mechanism from pure abrasion to a combination of abrasion and micro-ploughing, significantly increasing wear damage. Additionally, the setup allows testing both standard pin-on-disc and diamond indenter configurations under international standards.

References:

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