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Effect of Ni particles on Laser Glass Forming

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Abstract
Laser forming (Bending) process is one of the important forming techniques due to its accurate, noncontact, clean process. During this work the effect of adding Ni particles on the bending of clear glass slides were studied using 150W CW CO2 laser. Three different scanning speeds (20, 30 and 40) mm/s and single or double scans were used as study parameters in addition to as is slides or coated with the Ni particles. The best bending angle was at double scans with 30mm/s scanning speed for as is slides. On other hand adding Ni particles enhance the bending process, by decreasing the internal fractures inside the glass.

Keywords
Laser Forming, Clear Glass, CO_2 Laser, Ni particles

I. Introduction
After laser invention in 1960, new perspectives in materials processing techniques were opened, especially with the laser coherency. Laser forming was one of the scientist interest areas of laser materials processing techniques [1].
During laser forming, the surface of the sheet material is scanned with a defocused laser beam such that laser–material interaction causes localized heating of the surface without melting[2]. The heating of the material causes the expansion of the material in a confined region. Due to continuity of the heated region with the surrounding material, the free expansion of the hot region is resisted, resulting in bending of the part [3]. The overall deformation in the sheet material is determined by the complete thermal cycle (heating and cooling) associated with laser processing. The thermal effects during laser–material interaction are complex and depend on both the laser parameters and the material properties. The shape change during laser forming can be classified into three mechanisms; bending, buckling, and upsetting [4].

II. Experimental Work
Clear Glass microscope slides with polished edges and dimensions of (25.4x76.2 x 1.0) mm samples were used during this experiment.
These samples were treated using CMA1640 CO_2 laser CNC machine (10.6µm, 150W, CW and 0.2mm spot dia.). Then their microstructures were characterised using biological microscope model XSZ-PW207 from Pro-way Co.
Nickel spherical shape powder, purity 99.8%, with particle diameter range of 5µm were used as coating powder. The Ni particles were used due to its high melting temperature (T_m1455°C) as compared with glass (T_m 564°C) and (T_l1000°C) which makes the particles immersing possible.
Before setting the suitable scanning speeds, a range of speeds (13, 16, 18, 20, 30, 40 and 50) mm/s, were examined to select the suitable parameters. From this pilot study, scanning speeds (20, 30 and 40) mm/sec were selected. The slower speeds broke the samples, while 50mm/s gives no effect on the sample. Finally the parameters were single and double scans and as received sample and coated with Ni particles, which gives four different group samples with three scanning speeds each.
The glass slides were placed at the laser system bench then scanned with laser beam. The laser beam travelled in the same path for the double scan samples with 2 seconds delay to ensure normal temperature distribution at the sample surface Fig.1. The microstructure of the scanned glass then examined under the microscope at (100 and 400)X magnification. On other hand the bending angle was calculated using image Gwyddion 2.31 free software.

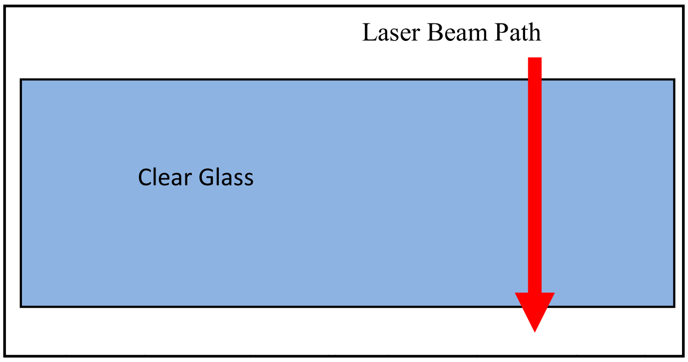

Fig.1: The Laser beam direction on the sample surface.

III. Results

1. The bending angle:
The bending angle was worthy as compared with difficulty of this process, Fig.2 represent a comparison of the results for all the groups. Generally the curves show that the bending angle couldn't exceed 1.2º for the used glass thickness and this expected due to the brittleness and small thermal conductivity coefficient of glass, so the zero values of bending angles in Fig.2 represent the broken samples. On other hand the bending angle increased every more scan but less than the first one and this agreeing with the previous studies [5].

2. The Microstructure Investigations:
The results show that the slower the scanning speed the greater the binding angle, but this provide more fractures inside the sample as the microscopic images show in Fig.3. While the double scans increase the bending angle but less than the first scans angle with more microstructural fractures (as shown in Fig.4) which clearly appeared in the broken of sample that double scanned with 20mm/s scanning speed, and this may be explained due to the brittleness of glass which couldn't suffer higher bending angle.
On other hand the addition of Ni particles increase the bending angle and decrease fractures inside the glass, as shown in Fig.5, this could be described due to penetration of particles inside the glass surface layers. The double scans penetrate more Ni particles inside the materials which gives higher bending angles and that explains the fracture of slides at 20 and 30 mm/s scanning speed Fig.6.

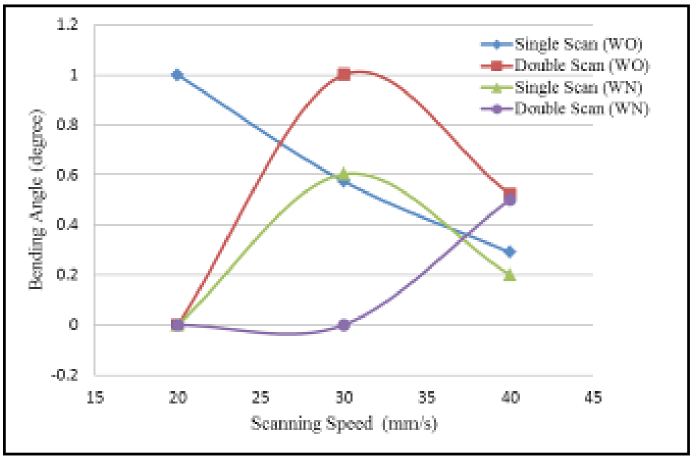

Fig. 2: Represent a comparison of the bending angle results for the four groups

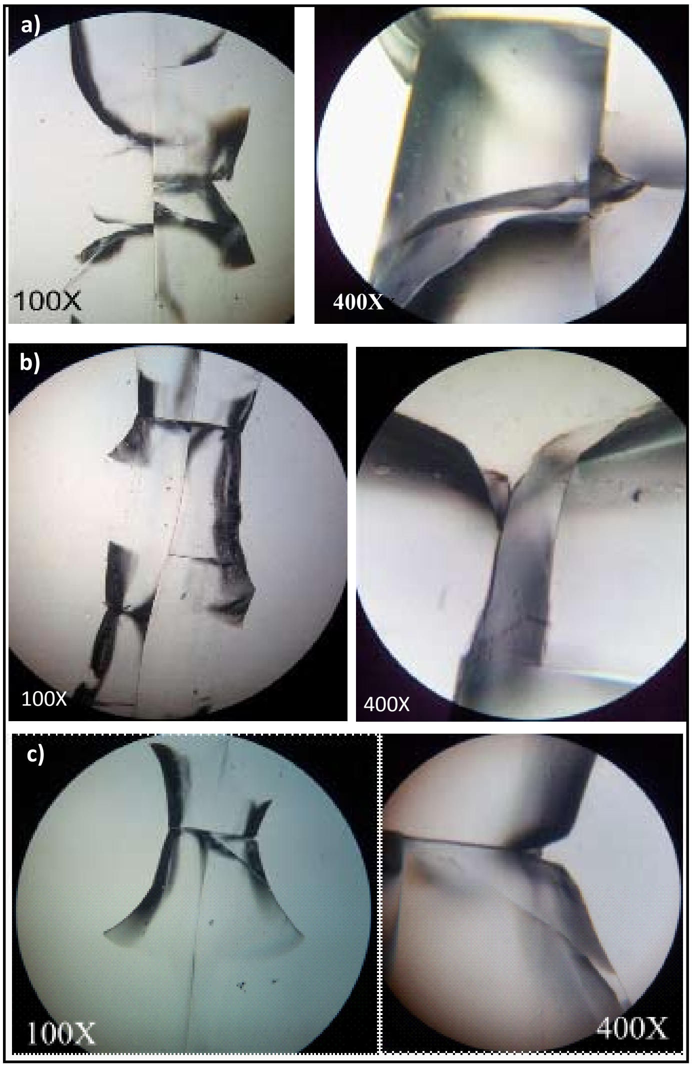

Fig. 3: a)20, b)30 and c)40 mm/s scanning speed, single scan, as is samples

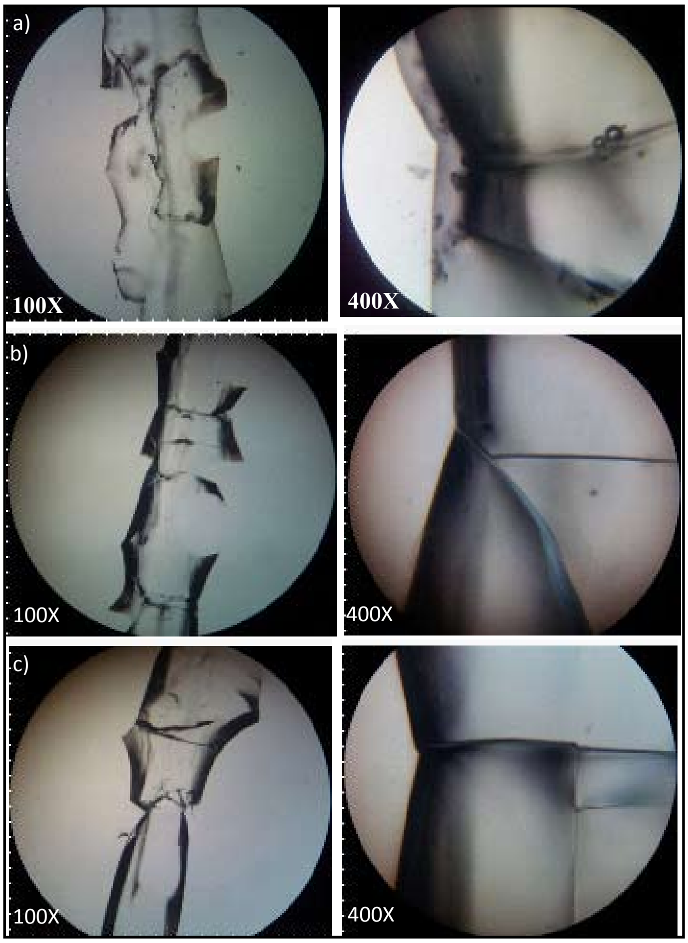

Fig. 4: a)20, b)30 and c)40 mm/s scanning speed, double scan, as is samples

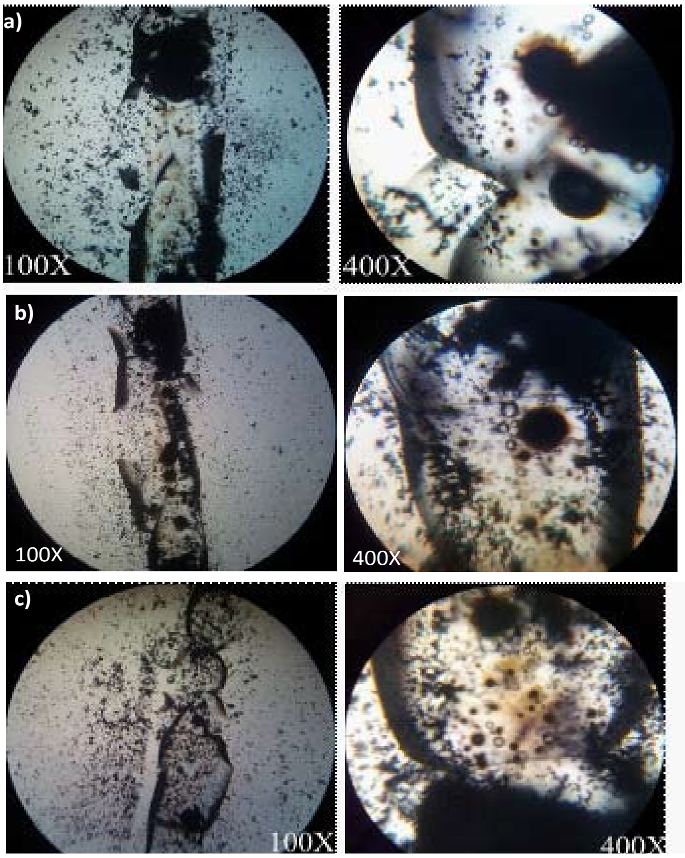

Fig. 5: a)20, b)30 and c)40 mm/s scanning speed, single scan, Ni coated samples

Fig.1: The Laser beam direction on the sample surface.

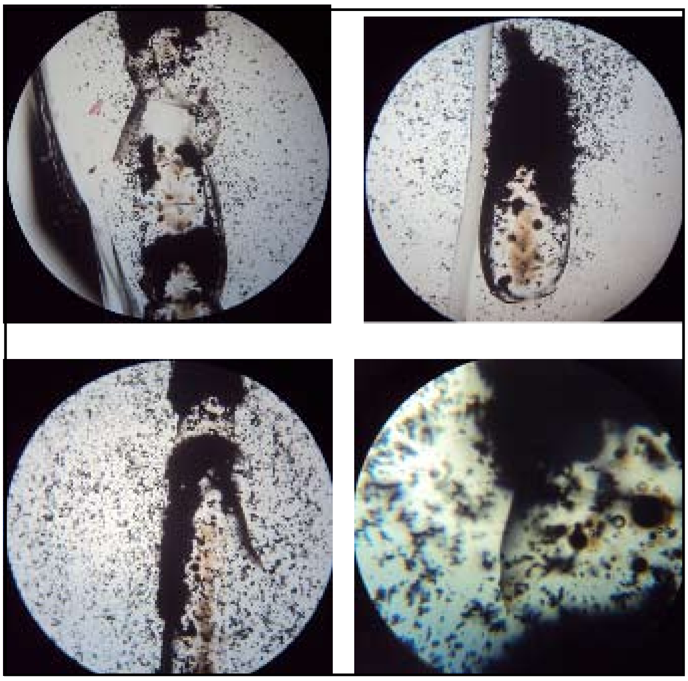

Fig.6: a)20, and b) 40 mm/s scanning speed, double scan, Ni coated samples

IV. Conclusions

1- Brittle materials could be bent using laser forming technique.
2- The first scan gives higher bending angle than the other scans.
3- The Ni particles increase the bending angle and decrease fractures inside the glass, this could be attributes to the penetration of particles inside the glass surface layers, and the high conductivity of Ni, which gives homogeneous thermal distrebution.

Acknowledgment

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References

[1] Jr Elijah Kannatey-Asibu, Principles of Laser Materials Processing., 2009.
[2] N.B. Dahotre and S.P. Harimkar, Laser Fabrication and Machining of Materials.
[3] P. Balling, J. Esberg, K. Kirsebom, D.Q.S. Le, U.I. Uggerhøj, S.H. Connell, J. Härtwig, F. Masiello, A. Rommeveaux, "Bending diamonds by femtosecond laser ablation," Nuclear Instruments and Methods in Physics Research B, vol. 267, pp. 2952–2957, 2009.
[4] J. Sidhu, R.L Cooke J. Magee, "A Prototype laser forming system," Optics and Lasers in Engineering, vol. 34, no. 4-6, pp. 339-353, October 2000.
[5] W. M. Steen and J. Mazumder, Laser Material Processing., 2010