PRELIMINARY STUDY UPON THE PAPER GUIDE WEAR IN DESKTOP PRINTERS

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Abstract: *The aim of this paper is to evaluate the contact geometry between pulling rollers and paper sheets used in desktop printers and to determine the primary cause of wear. For the proposed tests, a rubber cylindrical roller was placed in contact with a rigid flat surface. Between the two contacting surfaces, a paper sheet was inserted and the imprinted contact area was recorded. The rubber roller was covered with black ink similar to that used in the printing process. The imprinted contact area was compared to other tests. The results show small deformation of the roller on longitudinal direction and high stress at the end regions. The main cause for this is due to paper roughness.*

Keywords: *wear, desktop printers, rubber rollers, linear contact,*

1. Introduction

For expensive desktop printers it is important to determine device reliability in order to evaluate the correct service time and lifetime. The mechanical structure of desktop printers influences directly the lifetime. The mechanical system of printers consists of motors, transport - guiding rollers and guiding walls, [1].

A classic paper printer structure is presented in Figure 1, [2].

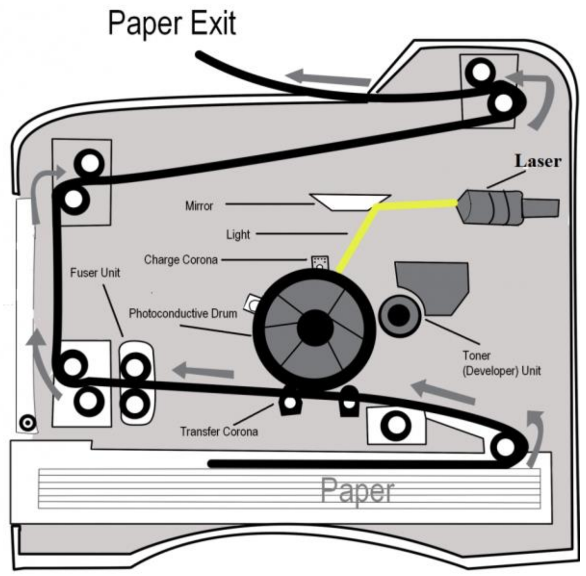

Figure 1: *The internal structure of a laser printer [2].*

Only the moving parts are subjected to high wear, in this case the transport and guiding rollers. The main purpose of this paper is to evaluate the primary cause of the roller's wear and to understand their damaging mechanism.

Some authors made a series of tests in order to investigate the contact between rubber bodies, [2-6]. The rubber is a nonlinear elastic material and the classic equation for the contact geometry doesn't apply. To obtain a theoretic characterization of the contact area and the stress state, FEA have to be conducted.

Some experiments on nonlinear elastic materials were done by Ciutac, [2], Diaconescu [3]. Romanu [4,5,6], and other. Ciutac and Diaconescu study the circular contact area between a rubber sphere and a rigid flat plate. Mineral oil was inserted between the contact bodies and the contact area was evaluated by comparing its dimensions with those of a known body. The results obtained by the abovementioned researchers show a nonlinear correlation between contact radius and load. Also, due to the mineral oil, the roughness of contact surfaces doesn't affect too much the contact dimensions and the stress state.

Românu, [5,6], also presents some tests made on rubber bodies. He investigated the contact between rubber cylinders and rigid flat surfaces. The loaded contact was immersed in a liquid ferric chlorite solution. The liquid attacks the uncovered surface of the flat rigid and an imprint of the contact area is thus achieved. The contact between rough surfaces takes place in high moisture conditions so the roughness doesn't affect substantially the obtained contact local geometry. The contact area was recorded using a laser profilometer.

Other papers propose some experiments made to determine the normal approach between contact bodies. Kosarev, [7] presents an experimental setup design to measure the total deformation between two parallel plates pressing steel cylinders. The approach between plates has two components: deformation of the bodies in contact and cylinder deformation.

Lurie, [8], presents aspects regarding materials elasticity and theoretical models for nonlinear elastic materials.

Suciu, [9], describe another method to measure the contact area between EVA spherical cap and a sapphire flat surface. The contact surface was determined using a laser profilometer.

Considering the aspects presented above, it is of interest to evaluate the contact between rubber rollers and paper and to highlight the contact particularity which conducts to wear.

2. Experimental setup

As was shown in Figure 1, the guiding system of the printers contains a series of rollers in contact. Three types of contacts can be identified in a printer transport system: roller-roller; roller-steel; roller - paper sheet. The present paper aims to investigate the rubber-steel and rubber-paper sheet contacts.

In order to achieve this goal, an experimental setup was conceived and built. Regular 80g/m^2 sheets of paper were used for tests. Also, a smooth steel surface was used. The paper roughness was evaluated using a laser profilometer and the results are presented in Figure 2.

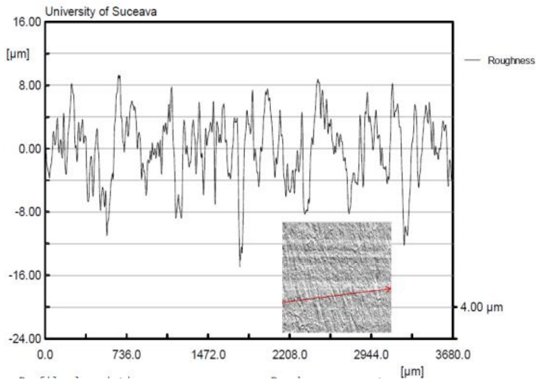

Figure 2: *Paper roughness.*

The rubber roller geometry was recorded using the same profilometer. The roller has sharp edges, 11.4mm length and 10 mm radius. The geometry of the roller is represented in Figure 3.

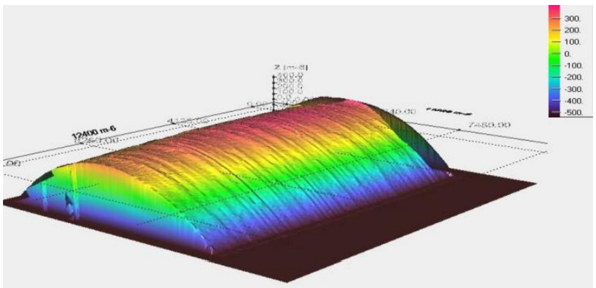

Figure 3: *Roller geometry.*

The roller is pressed against a steel flat surface (a smooth steel plate). The loading system is represented schematically in Figure 4.

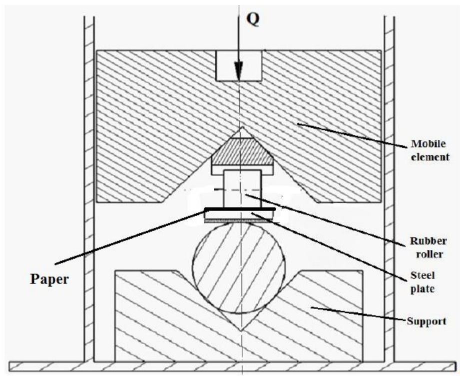

Figure 4: *The contact loading system*

The loading force is generated by an elastic spring. The rubber roller is pressed against a steel plate using a guiding system presented above. First, the roller is covered with black ink similar to that used in printers. The paper sheet is inserted between roller and steel plate, pressed and then the contact area will be imprinted on paper.

3. Results

A typical result obtained using this procedure is presented below, in Figure 5.

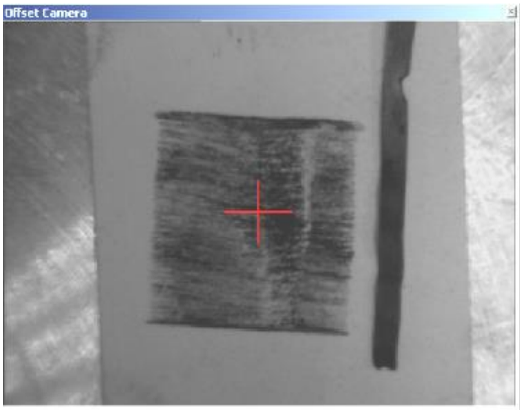

Figure 5. *The contact area imprinted on paper*.

The loading force for this test is approximately 200N. The force was evaluated by measuring the spring compression.

In order to determine the contact area dimensions, the imprinted paper was measured with the laser profilometer. The reflectivity of the contact area footprint was recorded. Two reciprocally perpendicular cross-sections of the obtained contact area reflectivity are represented in Figure 6 and Figure 7.

By studying the imprinted contact area, some conclusions can be highlighted:

-The contact area is a stripe;

- A small extension of the contact area appear in the end regions.

For validation, the experimental result was compared with previously obtained results. For the contact between rubber roller – steel plate, Romanu [6], presents the contact area illustrated by Figure 8.

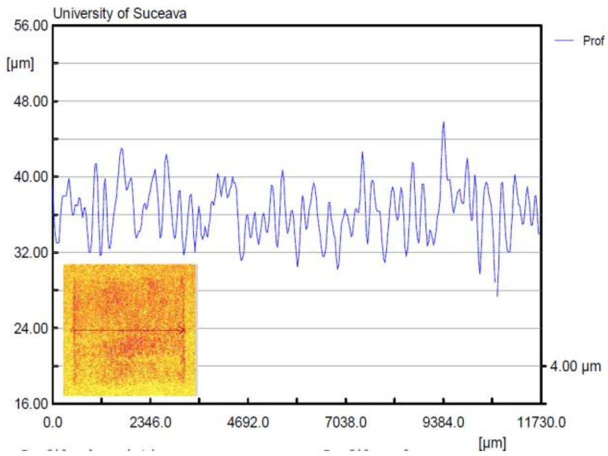

Figure 6. *The contact area length.*

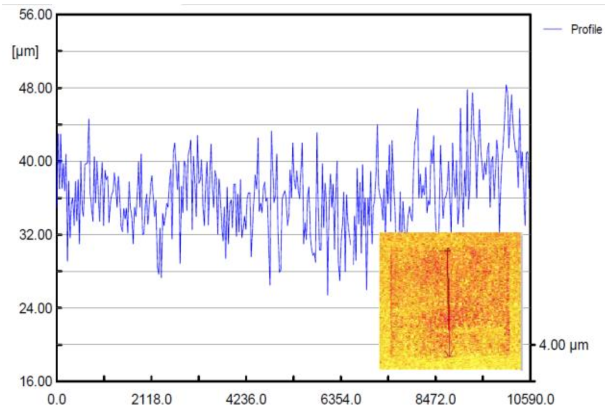

Figure 7. *The contact area width.*

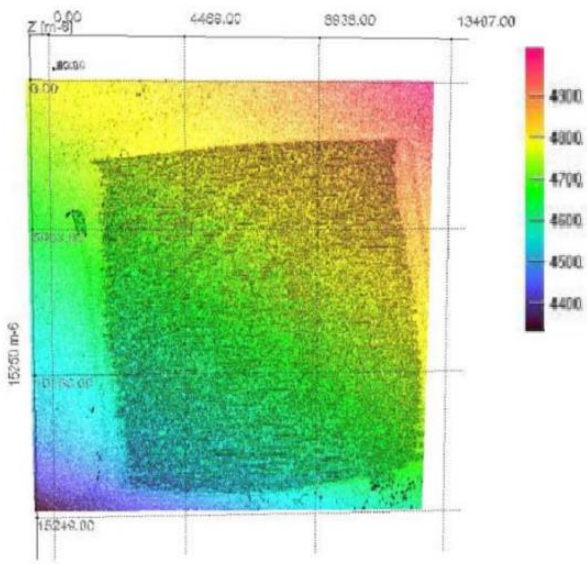

Figure 8. *The contact area rubber roller-steel plate, [6]*

The contact area presented in Figure 8 was obtained for the same contact bodies. The loading force is approximately 200N.

4. Conclusions

Comparing the results presented in Figure 5 and Figure 8, similar aspects can be highlighted:

-The longitudinal extension of the contact area is much bigger in the case of rubber roller-steel surface contact. This fact appears due to low friction between surfaces. The rubber-paper contact is much rougher and because of this, the surfaces don't slide during contact.

-Because of the smaller extension of the contact area, the pressure is higher in rubber-paper contact. This can be seen in Figure 5. The edges of the contact area on longitudinal direction are much more impregnated with ink. The ink transfer is directly influenced by contact pressure. So, if some regions of the contact area are covered with more ink then others, the pressure distribution can be estimated by ink transfer.

The extension of the contact area was measured in both cases. In the case of roller-steel contact, loaded at 200N, the longitudinal extension has 900 microns, [4]. In the second case, the rubber-paper contact using same contact bodies and load, has only 330 microns longitudinal extension. These facts show that the coefficient of friction in the second case is much higher. The contact pressure, especially in the marginal zones, affect the local geometry of the contact and influence the traction and guiding rollers wear. In order to improve the rollers, rounded edges can be used.

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