Magnetically Improved Color Alignment of CRT's

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Abstract

A 50% reduction of convergence errors of CRT's is achieved by a technique referred to as 'Magnetically Improved Color Alignment' or MICA for short. The MICA technology comprises a ring of synthetic material (polymer) filled with ferrite particles. MICA is meant for repairing CRT's, which are out of convergence specification. The repairing occurs by writing a magnetic correction profile in the ring.

1. Introduction

CRT's having out-of-spec convergence errors are nowadays repaired by either 'spoilering' or by 'coil exchange'.

During 'spoilering', plastic sticks containing plasto-ferrite material ('spoilers') are inserted into the space between deflection unit and tube thereby locally weakening the electromagnetic field generated by the deflection unit. The time and amount of spoilers needed to repair the CRT is determined completely by the experience and skill of the operator.

Coil exchange is the replacement of the deflection unit by another one in case of a convergence reject. The yield of the coil exchange process is usually (much) lower than the normal yield of the matching process because of poor convergence quality of either the tube or of the deflection unit.

2. MICA

2.1 Objective

The objective of the 'Magnetically Improved Color Alignment' (MICA) project was to develop a robust, i.e. an operator independent, technology that is able to reduce convergence errors of CRT's by at least 30% at a competitive price level and at predictable process times.

2.1 Principle

The principle of MICA is to apply a magnetic correction profile into a ring of synthetic material filled with ferrite particles [1]. This ring is then located halfway inside the deflection unit (see Figure 1).

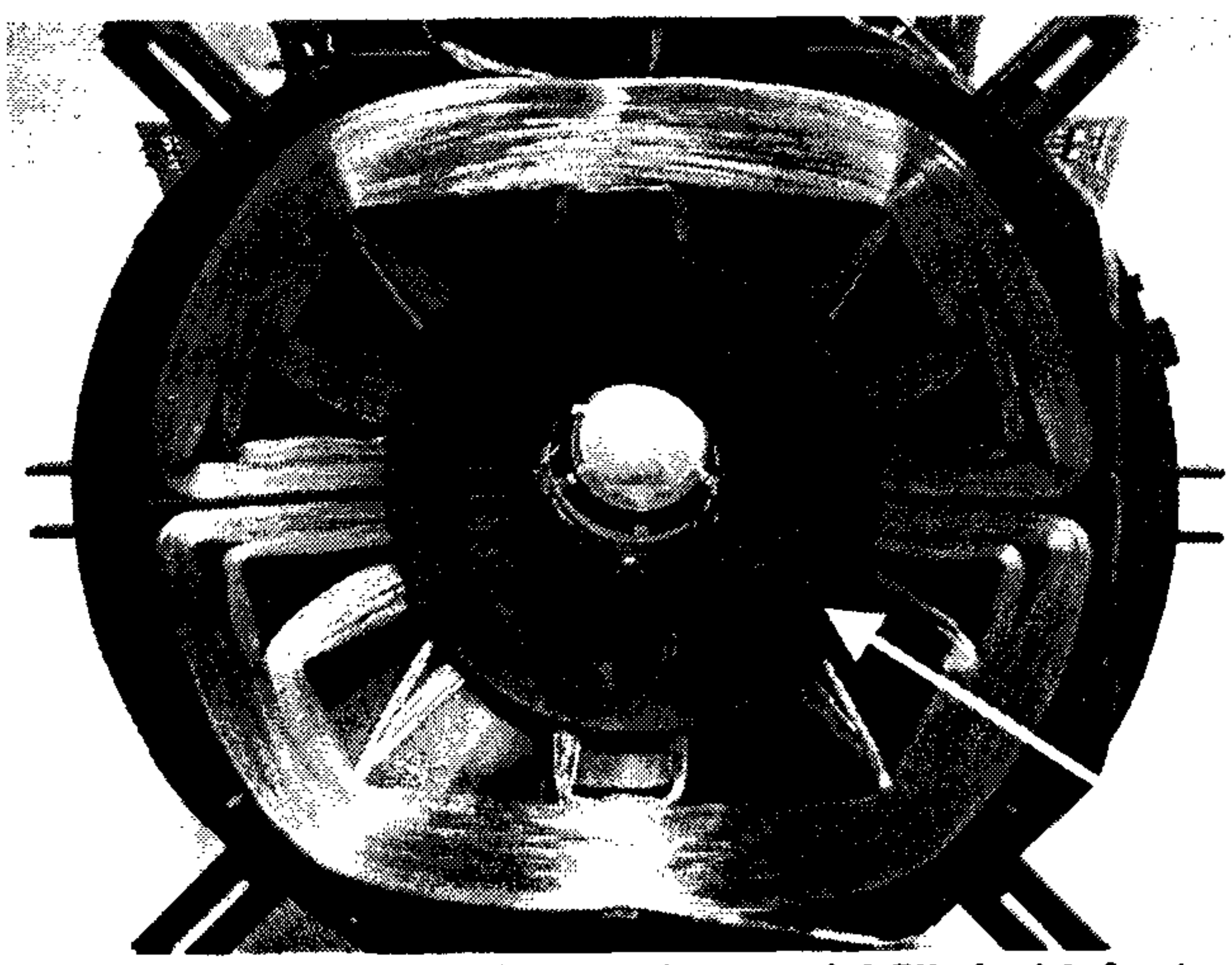

Figure 1. Ring made of synthetic material filled with ferrite particles in which a magnetic correction profile is written.

The writing of the magnetic correction profile occurs in a similar way as for normal magnetic recording. A read-write head writes the magnetic correction profile in the ring (see Figure 2).

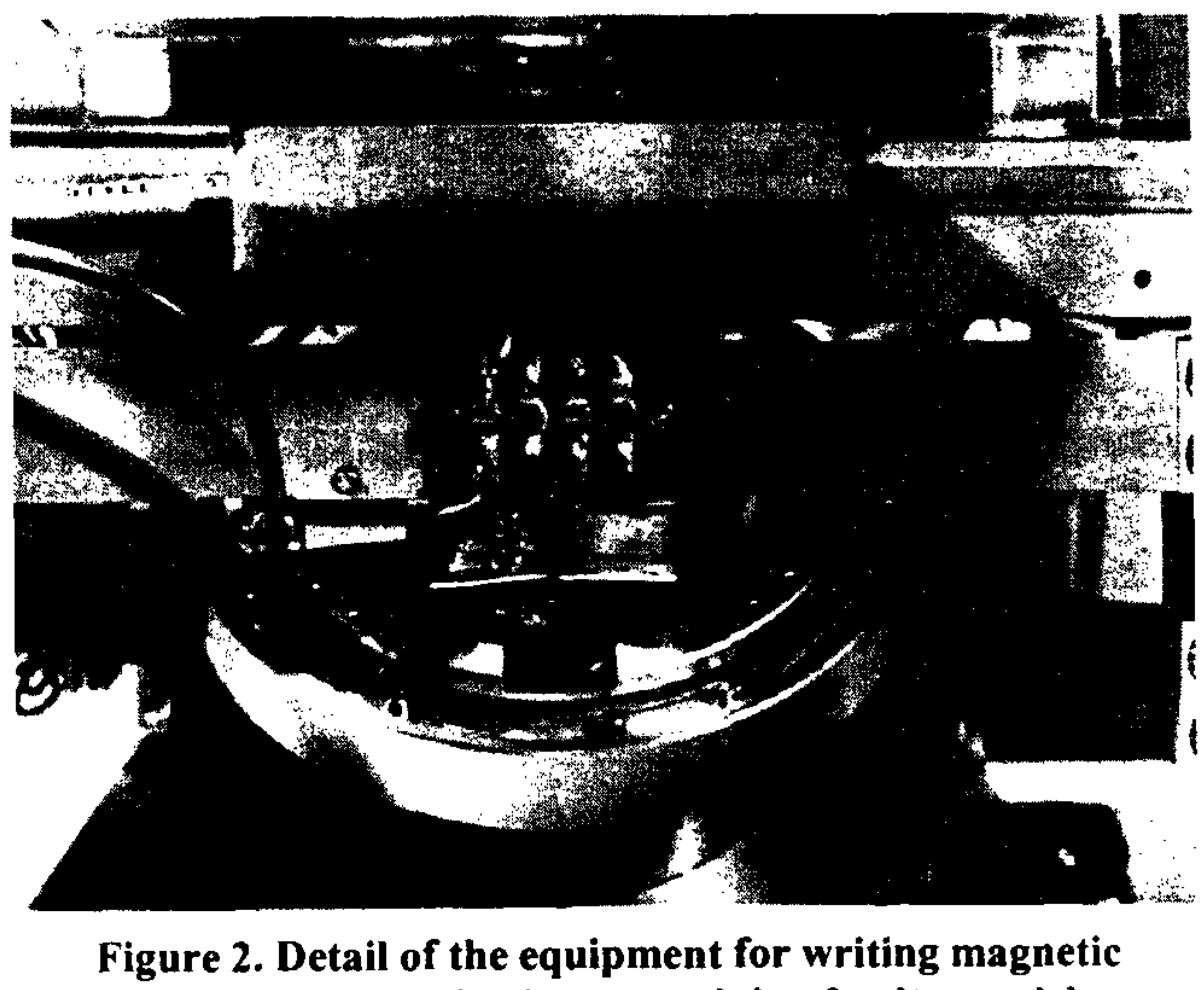

Figure 2. Detail of the equipment for writing magnetic correction profiles in rings containing ferrite particles.

The magnetic correction profile $M(\varphi)$, which is written into the ring, is a sum of sine and cosine functions:

$$M(\varphi) = \sum_{i=3}^{8} a_i \sin(i\varphi) + b_i \cos(i\varphi) \qquad (1)$$

in which:

i	the periodicity of the sine or cosine function
a_i, b_i	amplitude
φ	azimuth

Although higher periodicity, i.e. higher values of i can be used, the above set was found to correct all the convergence errors encountered in practice.

The calculation of the magnetic correction profile is performed using a table containing the measured convergence sensitivities $\vec{f}_i$ and $\vec{g}_i$ for each sine and cosine function:

$$\vec{f}_i(\sin(i\varphi)), \text{ and } \vec{g}_i(\cos(i\varphi))$$
$$3 \le i \le 8,\ 0 \le \varphi \le 360° \qquad (2)$$

These sensitivities are obtained by writing each function into the ring and measure the effect on convergence. An example of the convergence sensitivity of $\vec{g}_i = \cos(3\varphi)$ is given in Figure 3.

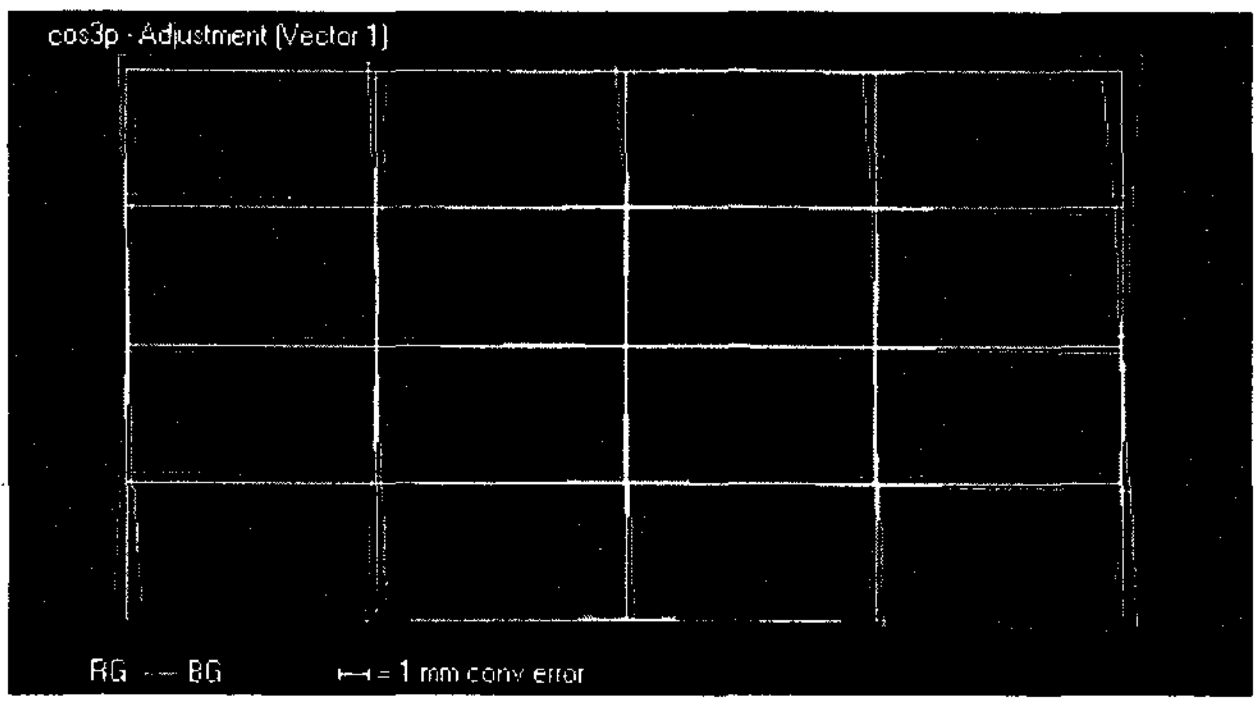

Figure 3. Convergence sensitivity of $f_3 = \cos(3\varphi)$. This function generates a 6-pole magnetic field.

The convergence performance $\vec{f}$ of a CRT can now be expressed as:

$$\vec{f} = \vec{f}_0 + \sum_{i=3}^{8} a_i \vec{f}_i + b_i \vec{g}_i \qquad (3)$$

In which $\vec{f}_0$ denotes the convergence performance of the uncorrected CRT.

The quality factor Q of a CRT is defined as:

$$Q = 100.\sqrt{\frac{\sum_{i=1}^{m} W_i . \sum_{j=1}^{6} X_{i,j}^2}{6.\sum_{i=1}^{m} W_i}} \qquad (4)$$

in which:

m	number of measuring positions
$X_{i,j}$	convergence errors per measuring point
W_i	weighing factor per measuring point i that can be tuned to a specific preference.

A combination of equations (3) and (4) shows that:

$$Q = f(\vec{f}, a_i, b_i) \qquad (5)$$

The magnetic correction profile is found by calculating the coefficients a_i, b_i so that the quality factor has a minimum value.

An example of a calculated magnetic correction profile is given in Figure 4.

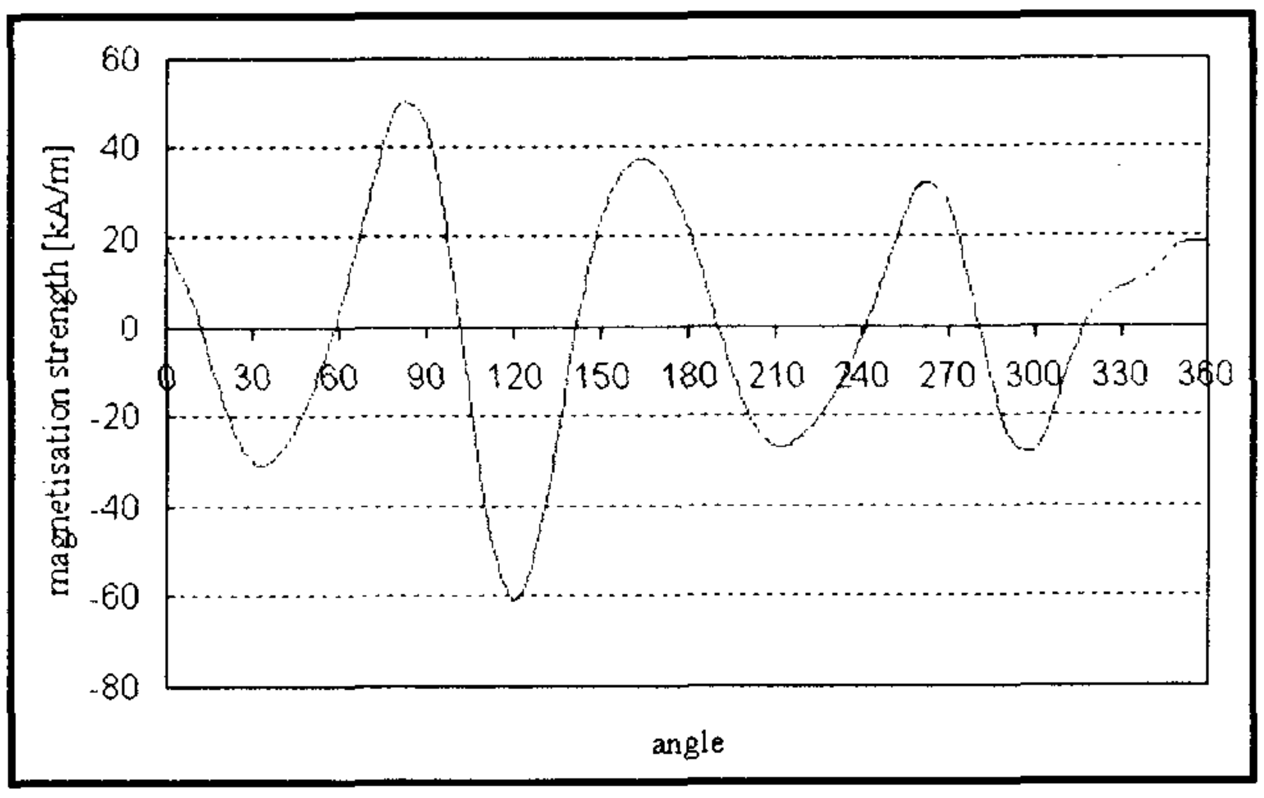

Figure 4. Example of magnetic correction profile that is written in the pasto-ferrite ring.

The optimization is not limited to the quality factor *Q*, any factor can be used that satisfies customer criteria.

2.2 Process

A schematic representation of the automated matching of a CRT is given in Figure 5.

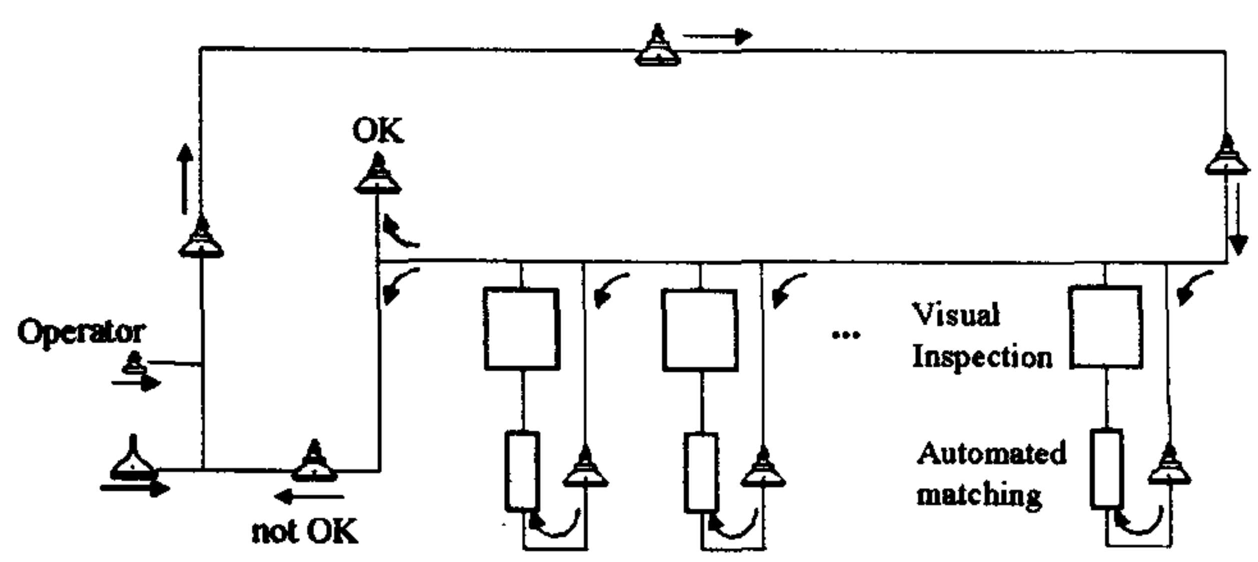

Figure 5. Schematic representation of the automated tube-coil matching.

The operator puts the deflection unit on the tube after which they are matched on one of the lines. During matching, it is detected whether the CRT is a reject or not. The rejected CRT is returned to the operator, which in this case performs a coil exchange. The CRT is then re-matched.

The repair process with MICA goes more or less in a similar way, i.e. without changing the existing infrastructure of the matching process. If, during matching, a convergence reject is detected, the convergence data is sent to a computer that calculates the magnetic correction profile. This correction profile is then written into the ring. If the rejected CRT arrives at the operator, the ring is inserted into the deflection unit and the CRT is re-matched. Any CRT that is successfully matched is also visually inspected.

By applying the MICA technology after matching, the convergence errors, resulting from both the tube and the deflection unit, are corrected. Previous trials, in which only the deflection unit was optimized, didn't show the same amount of improvement.

Summarizing, the advantages of this technology are:

- Operator independency. The actual corrections are calculated and written into the ring. The operator only has to insert the ring into the deflection unit.
- 'infinite' correction possibilities. As spoilers are only available in discrete values, they only weaken the electromagnetic field generated by the deflection unit. This technology enables the creation of virtually any magnetic correction field.
- (much) shorter process time. Calculation and writing of the magnetic correction profile takes less than 15 seconds, which is considerable shorter than the time required for spoilering.
- Efficiency. After the calculation, a prediction of the convergence performance is given. If this prediction indicates that the CRT is still out-of-spec, the repair is cancelled.

Low cost. The correction obtained by application of the MICA technology can also (partially) be achieved with expensive electronic circuitry.

3. Results

In Figure 6, the result of a trial held in one of the factories is given.

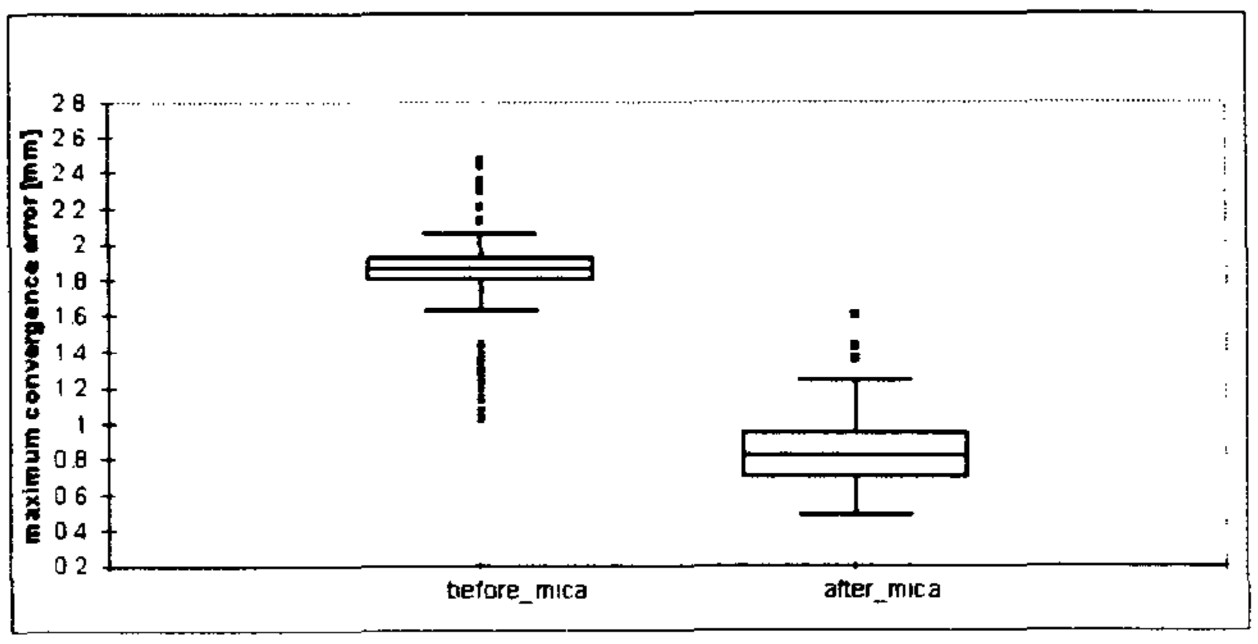

Figure 6. Maximum convergence error of rejected CRT's (left) and of repaired CRT's using the MICA technology (right).

The convergence performance of a CRT is expressed in terms of the maximum convergence error, which is the highest measured convergence error.

In Figure 6, the data is presented in a so-called 'box plot', allowing quick statistical analysis of the data. The 'box' represents the observations that are within the following range *r*:

$$r = \mu \pm 2.7\sigma \quad (4)$$

where μ is the average of the observations and σ denotes the standard deviation. The dots in the graph are the so-called outliers. Using 'box plots', it is easy to determine whether the average and the standard deviations of two populations are significantly different or not.

The average maximum convergence error of the rejected CRT's was 1.8 mm, with a standard deviation of 0.31 mm. After repairing, the average maximum convergence error was reduced to 0.8 mm, with a standard deviation of 0.2 mm. Both values are significantly different. This is a reduction of about 53% of the average maximum convergence error.

The MICA technology is also very efficient. Of all the rejects shown in Figure 5, 98% was repaired and within specification. This is significantly higher compared to the yield of the coil exchange process, which is about 73%.

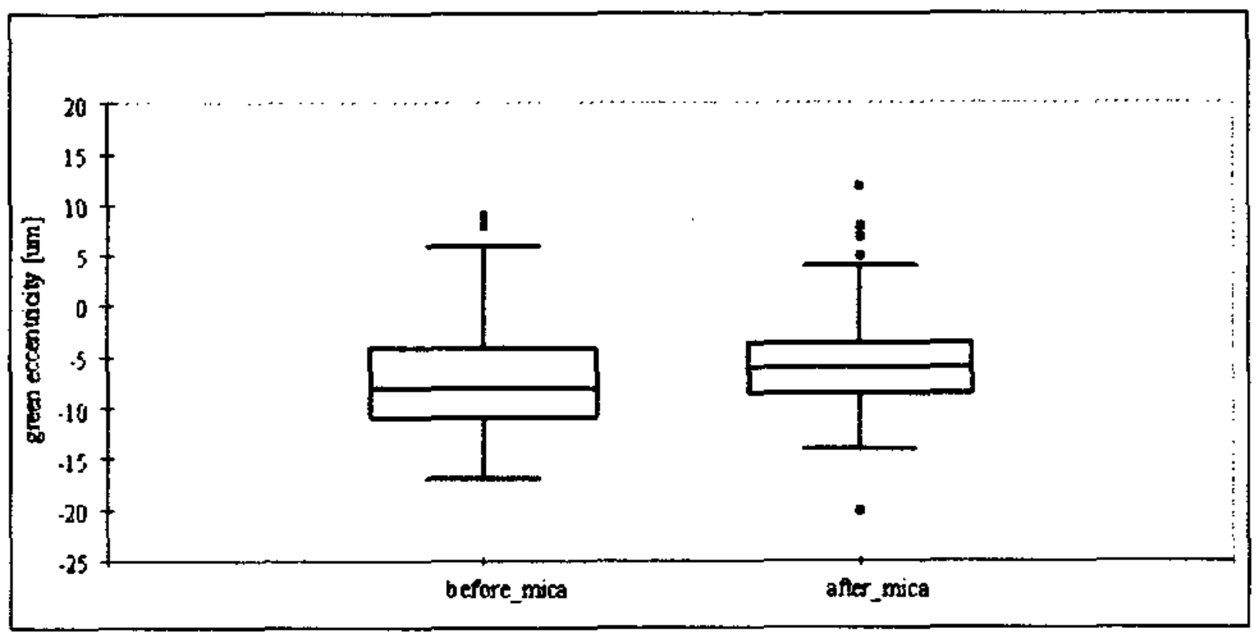

Figure 8. Green eccentricity before (left) and after (right) application of MICA.

4. Discussion

In the previous paragraphs, the improvement of the convergence performance obtained by the MICA technology is shown. Side effects of this technology, i.e. effect on the geometry and landing performance, are very limited. Analysis of the same population as above showed even a slight improvement of the geometry and landing performance.

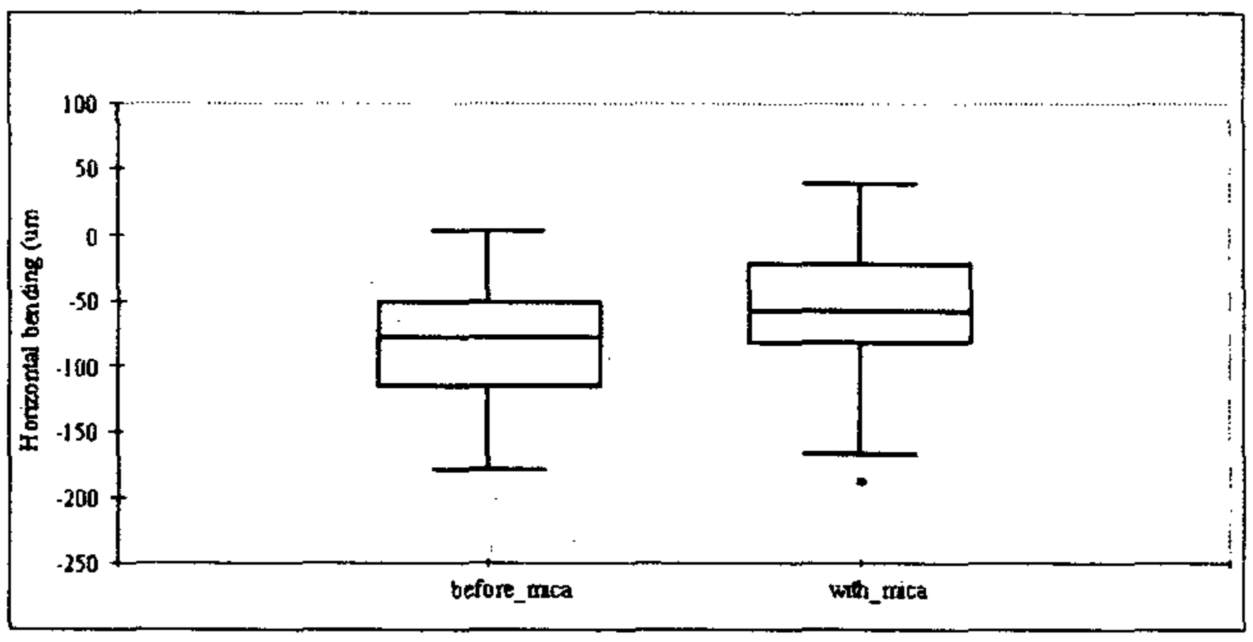

Figure 7. Horizontal bending before (left) and after (right) application of the MICA technology.

Apparently if the convergence of a CRT is corrected, it has also a positive effect on the landing and geometry performance.

5. Conclusions

With the MICA technology, the convergence performance of a CRT can be drastically improved by about 50% without affecting other important performance parameters such as geometry and landing.

Repairing convergence rejects with the MICA technology occurs at better yields compared to that of a coil exchange (98% instead of 73%).

In addition, the MICA technology offers:

- Operator independency resulting in predictable performance.
- 'infinite' correction possibilities at low costs.
- Tuning possibilities to meet customers' needs.

6. References

[1] Ruigrok, J.M, Vrinten, M.A., Verhulst, A, Smit, C.M., Method of manufacturing a magnetic device, United States Patent no. 5984755, , nov. 16, 1999.