Definition and Measurement of Lay-flat Degree for Books

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Keywords: binding, book, calculation method, quality control

Abstract

The evolution of communications technologies exercises substantial influence on graphic communications products. In the world of printing, one group of the iconic products, notably books need to adapt to the challenges posed by digital developments of the 21st century.

Novel solutions surface from time to time to enable readers to associate printed information in books with further information that is available in the digital world. The use of smartphones as a basic device to have access to information seems to be a general trend nowadays, especially among people of younger generations. Such devices are suitable for using certain special symbols, QR codes, passive or active electronic elements that are inserted in the books to become connected to the world of virtual and/or augmented reality. These solutions raise new demands for binding technologies, as well.

In the context of a development effort made to create novel binding technologies, the authors found it necessary to work out a definition for the unit of measurement that describes the degree of the lay-flat character of book pages.

It is possible to specify and calculate the values with the application of photo engineering and graphical methods. Nevertheless, the authors have also devised a measuring instrument that measures the discrete function values with the use of measuring laser diodes, and results in the lay-flat value after numerical integration and calculation.

The definition of lay-flat values (as a new quality assessment factor) related to books offers assistance and guidance to the evaluation of new binding methods and research results.

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Introduction

The evolution of communications technologies exercises substantial influence on graphic communications products, too. In the world of printing, one group of the iconic products, notably books need to adapt to the challenges posed by digital developments of the 21st century (Pal et all, 2018).

The emergence and the extremely swift spread of photo books clearly demonstrate the synthesis and synergy of the two systems.

Novel solutions surface from time to time to enable readers to associate printed information in books with further information that is available in the digital world. The use of smartphones as a basic device to have access to information seems to be a general trend nowadays, especially among people of younger generations. Such devices are suitable for using certain special symbols, QR codes, passive or active electronic elements that are inserted in the books to become connected to the world of virtual and/or augmented reality (Margaritopoul and Georgiado, 2019).

These solutions raise new demands for binding technologies, as well. Photo books call for special binding solutions that allow or at least approximate full lay-flat binding (see Figure 1).

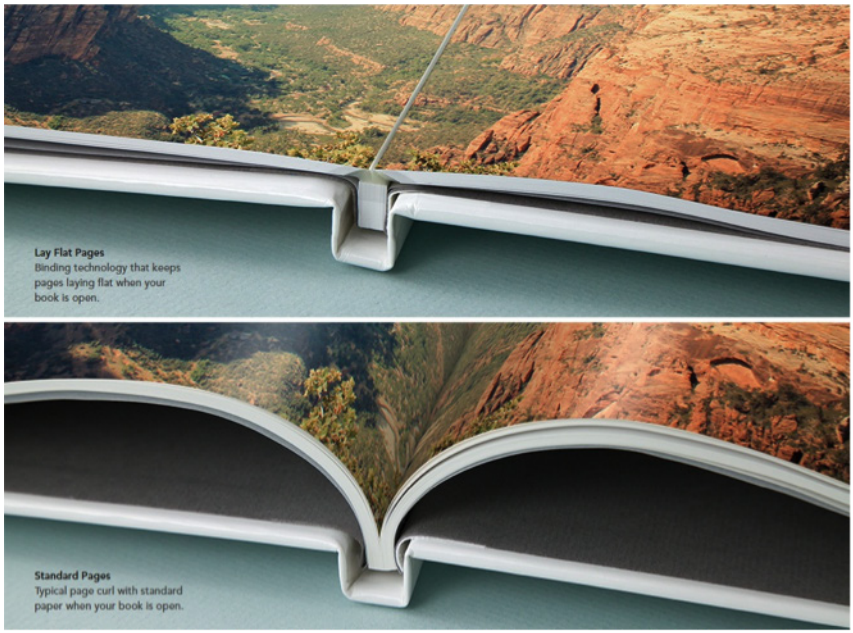

Figure 1: *Lay-flat binding and stitched binding (https://photo-books.bestreviews.net)*

The expensive technologies used for photo books to produce lay-flat pages are not necessary for the above-mentioned applications designed to link books to the digital world, and it also holds true for photo and art books offering plenty of visual information. Still, the creation of lay-flat pages – as far as it is possible – is certainly required (Kiphan, 2001).

In the case of smartphone applications related to books, the best achievable lay-flat binding is necessary to facilitate handling, because in general both hands are busy with these applications.

In addition, the quality of lay-flat binding is also important when smartphones are used to reduce the number of erroneous links (erroneously scanned information), particularly in the case of codes that are incorporated in images to create links.

In the context of a development effort made to create novel binding technologies, the authors found it necessary to work out a definition for the unit of measurement that describes the degree of the lay-flat character of book pages.

Figure 2: *Handling of the smartphone to read the QR code from a book*

Definition of lay-flat character of books

When determining this unit of measurement, the authors relied on the assumption that in the sections that were perpendicular to the spine of the book the lay-flat degree was identical. For this reason, it seems to be sufficient to determine the value only for a single section (top edge/head), as it is characteristic of the entire body of the book.

When a book is opened in the middle, and laid on a flat surface, the geometry describing the middle pages of the book defines the lay-flat degree based on Figure 3 and the (1) correlation.

The section that is perpendicular to the spine of the book is interpreted as the square featuring a size (a) that combines the nominal width of the book (b) and half of the spine of the book (c/2). In this square, the geometry of the middle page lay determines the F(x) function. This function is interpreted to have 0 (zero) value outside of the page size. The lay-flat degree is defined by the area over the values of the function within the square.

The lay-flat value is determined in % based on the (1) correlation. In this interpretation, the lay-flat value in total corresponds to 100%. This latter factor is shown in Figure 1 (lay-flat photo book).

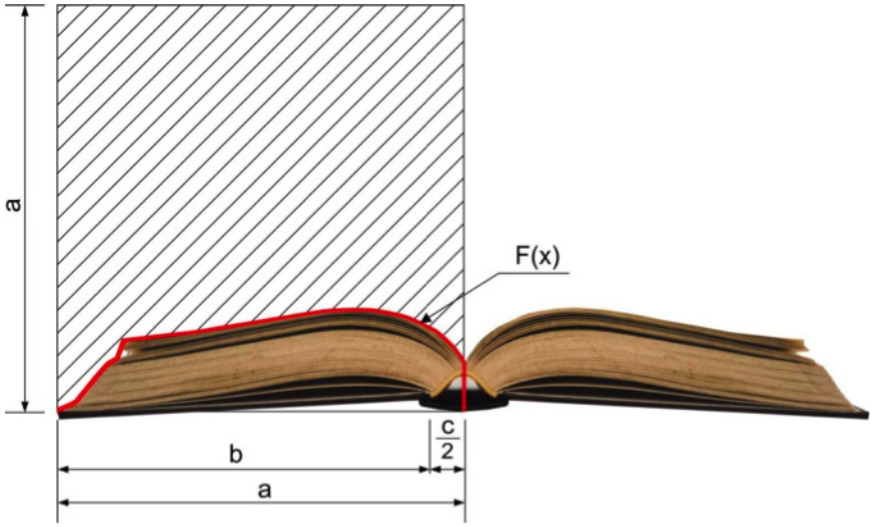

Figure 3: *Explanation for the definition of the lay-flat degree of books*

$$\text{Lay-flat [\%]} = \frac{a^2 - \int_0^a F(x)dx}{a^2} \bullet 100 \qquad (1)$$

Although the lay-flat positions of the two middle sheets are typically identical, following the precision and unambiguity principle the calculation needs to be made for both sides, and the average should be considered as the lay-flat value of the book.

As per our definition described herein, the lay-flat value can be interpreted solely for books that remain open after they have been opened in the middle and laid on a horizontal surface.

Measurement and calculation of the lay-flat value for books

According to the definition above, to define the lay-flat value it is necessary to calculate or specify the definite integral of the (0-a) values of the F(x) function. The calculation itself can be performed with the use of a variety of numerical methods that have also been developed by the authors.

The real difficulty lies in determining the values of the F(x) function. The authors also propose methods for calculating the discrete values that approximately define the function, and consequently for calculating the definite integral value (Paripas and Beres, 2018).

It is possible to specify and calculate the values with the application of photo engineering and graphical methods. Nevertheless, the authors have also devised a measuring instrument that measures the discrete function values with the use of measuring laser diodes, and results in the lay-flat value after numerical integration with trapezoidal rule (2),

$$\int_0^a F(x)dx \approx \sum_{i=0}^{n-1} \frac{1}{2} (x_{(i+1)} - x_i) \bullet [(F(x_i) + F(x_i+1)] \quad (2)$$

what is the simplest numerical integration scheme (Figure 4).

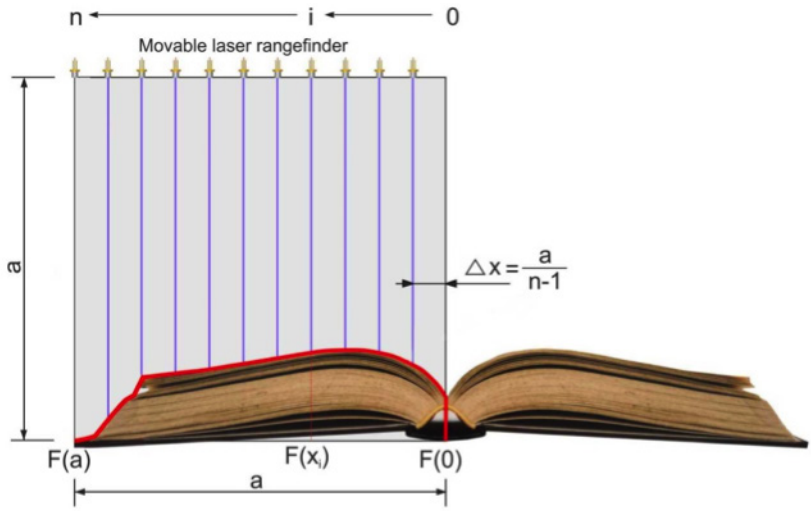

Figure 4: *Measurement model for the calculation of the lay-flat degree*

As we mentioned above, it is possible to calculate the lay-flat degree with taking a photo from the about opened book from head side. You can measure the needed distances on the printed picture and then calculate the lay-flat in %. But it is a very slowly method and not so accurate.

There is much better to use measure equipment. The hart of this method is a movable sensor to measure the needed values.

The cheaper solution is a high precise rangefinder like Bosch GLM 50C. Its measurement accuracy – less than 1 percent - is generally enough. We have designed and manufactured a measurement equipment. You can see it on the Figure 5.

If more accuracy is needed, it is possible to use a smart laser triangulation displacement sensor. The optoNCDT 1420 type of sensor has less than 10 micrometers accuracy.

Both measure sensors have elements to fix them to slide bars. This solution results in a step by step high precise moving of the sensor to measure of distances over the pages.

Both sensors have digital outputs to send the data to a computer or tablet.

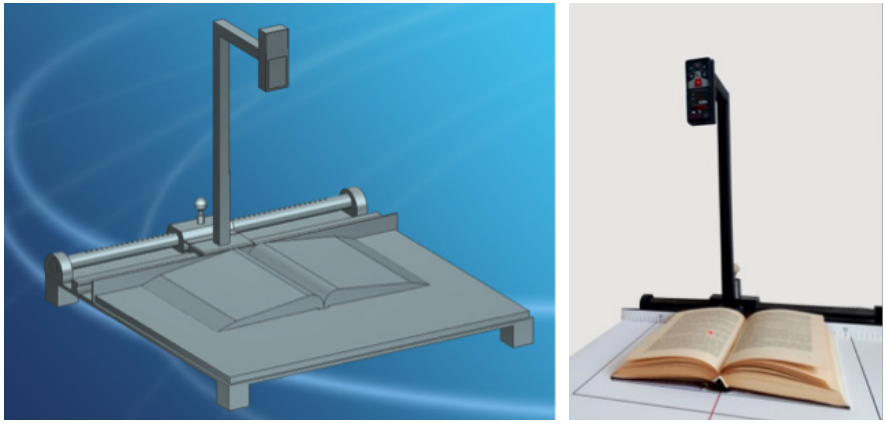

Figure 5: *Lay-flat degree measurement equipment for books with one laser rangefinder and stepping device. 3D design (left) and manufactured equipment (right).*

The best – and the most expensive – solution to measure the lay-flat of books is shown on the Figure 6.. The maximum scanner range of the 2D laser is 142 mm. That's way it is needed to use two ones. This measure model results in a fast and precise complex equipment to measure the lay-flat of books in the future.

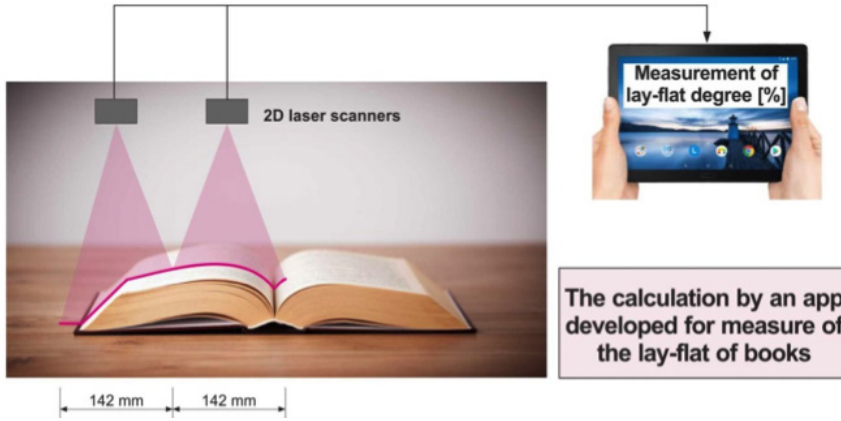

Figure 6: *Lay-flat degree measurement model with 2D laser scanners*

We assembled a complex experimental measurement model with 2D laser scanner. The measure head – fixed on a holder bar – can measure a wide range of the curl of pages and send the data to the laptop computer. The software can display the curve of lay-flat (Figure 7).

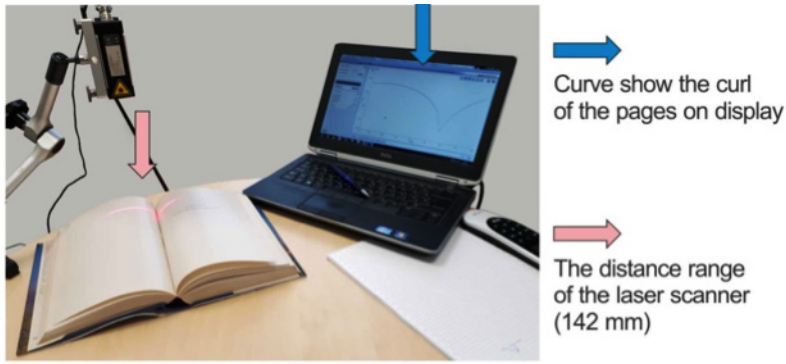

Figure 7: *Complex experimental lay-flat degree measurement model*

Conclusion

The definition of lay-flat values related to books offers assistance and guidance to the evaluation of new binding methods and research results, and at the same time it can also be considered as a new quality assessment factor.

We are working on the measurement model to make it more accurate and outline a relative cheap and fast solution to measure the degree of lay-flat of books and we are going to patent it very soon. It is the reason way I didn't detail the different measurement models.

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To Lay Flat or Not to Lay Flat?, (Last request: March 3, 2020)