

**UNIVERSITY OF WEST-HUNGARY
SOPRON**

THESES OF THE PhD DISSERTATION

GÁBOR VARGA

**FORMATION OF WEB ON PAPER MACHINES AND
SPECIAL WIRES WITH SPECIAL REGARD TO
MULTITONE WATERMARKS**

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Introduction and Aim of Work

During the evolution of mankind we used many subject to keep a record of speech and though while we got to the use of paper. Writing only becomes the real driving force of culture after the real usage of paper.

There are two main ages of the evolution of paper: the hand-made papermaking and the manufacturing of paper by machines.

The revolutionary changes in papermaking were the discovery of paper machine and cellulose making at the end of the XIX. century.

There are records of the hand-made paper usage in Hungary on the XIV. century for charters. After this the usage of paper become widely in Hungary.

With the newly developed paper machine paper become cheaper and there was no other obstacle of the mass production but new requirements came concerning paper quality, colours and other speciality paper properties.

The papers with watermarks date back to the XIV. century so its history much shorter than the papermakings' itself. But with 700 years of history the watermark play a significant role not only in culture and history but it is part of our everyday life. Everybody loves to meet one of its fine example, the banknotes, of course not for the watermark itself.

One can meet with many other cases apart from the above mentioned valuable example. By its nature the watermarks accompany us unnoticed. This neglected treatment is typical not only in everyday life but also in among experts too. This means that we can barely meet bibliography dealing with the properties of watermarks or making of watermarks and such papers.

The technology for making paper with watermark and the press dies doesn't changed so much there were no equal evolution inside this industry which development happened in the printing industry where these papers are used.

This is the reason for the wish of better understanding of watermarks and its effect on paper properties.

My goals were to study the modern methods of formation processes of papermaking and the effects of watermarks on the paper structure. Also my aim were to analyse and if possible find solutions for the printing problems caused by watermarks since one can find only a few researches in this matter both international and national bibliographies.

Likewise my aim were to study and overview the watermark as a security feature and one of the papers most important possibility for identification.

Bibliography review

After examining of possible and assessable bibliography it is clear that those studies dealing with the hydrodynamics of paper formation rarely mention the formation issues of wires with watermarks regarding the hydrodynamic and microturbulence effects and their connections in the paper structure.

All the issues related to the making of watermarks and moulds are confidential secrets and are rarely published. For this reason in this field I were compelled to reference my own papers.

The presence of the watermark in the paper causes thickness, grammage and opacity problems and these are the reasons for some of the printing runnability, evenness and fitting problems on the modern, high precision, special printing machines. I find only a few references for these problems in the bibliography and those were without any real solutions for the problem itself.

That is why I believe that the formation of web on paper machines and special wires with special regard to multitone watermarks within industrial conditions are a very important issue and hoping that besides the technological improvements I can achieve scientific achievements too. Also I can suggest solutions for the modern, high precision, special printing industry for the usage of papers with watermarks.

Summary of the New Scientific Achievements

During my research I have done several laboratory and industrial trials on the Diósgyőr Papermill Co. on the PM 2 machine. The goal were to produce such a sample banknote paper which is suits the state-of-the-art technologies used in the international printing industry and contains those security elements which exists on current banknotes and also include those security elements which is not is usage or rarely used.

During my trials I used high quality cotton cellulose and the security elements used in the paper were as follows:

- multitone watermark,
- elektrotype watermark,
- embedded security thread,
- windowed security thread,
- hologram foil,
- colourmark (special optically variable ink),
- security fibres visible in daylight,
- security fibres visible under UV light (black light),
- other special security elements (confidential covert features).

I produced watermark dies for the trial production according to the list above.

The cylinder mould used for the web formation was suitable to test the new solutions developed by me. These are the “off-watermark”, the “shift-watermark” and the “patch-watermark”.

During the trials I produced a significant amount of paper in industrial circumstances. After production I tested them according to the international standards and finished them for printing and other special trials.

With the “off-watermark” and the “shift-watermark” I were able to compensate the waviness of the watermarked paper which is a problem on the precise printing machines during the processing of papers with watermarks.

The usage of the “patch-watermarks” proved that the paper is less compact in the area of the negative watermarks during calendering while one can notice high compactness at the area of the positive watermarks causing bright surfaces. This effect can be seen considerably on multitone watermarks. This effect has a negative influence for the printing quality. Therefore I give advice for the safely usable maximum and minimum watermark heights and depths in my work. As a result of my work the printing problems can be avoided in this field.

Theses

First thesis

I point out that in those cases “off-watermarks” should be used where the evenness of sheets in pile and their runnability that is affected by the thickness differences caused by the positive watermarks. These also positive watermarks should be positioned in order to equalise the evenness caused by the other watermarks along the edge of the paper where the sheets first meet the printing machines.

My studies prove that parallel to the edge of the paper 10 to 15 mm from it the usually 5×15 mm in size “off-watermarks” should be positioned.

Second Thesis

My researches prove that papers containing windowed security threads the windowing watermark cause waviness in the piled sheets. In these tracks positioning recursively in shifted position the windowing watermark along the mould cover could reduce the waviness.

Third Thesis

Based on my investigations it can be settled that although the height of the positive watermarks were only just (+0.5 mm) half of the negative watermarks' maximum depth (-1.2 mm) in the change in volume of the paper were significantly higher in the first case compared to the base. It can be stated that the bad ink transfer on security papers with multitone watermarks thus poor print quality over the negative watermark areas, the problem is not by all means that the printing plate doesn't touch the paper surface properly so even with increased printing force the required quality cannot be reached but the problem is due to the loose paper structure causing distortion derive from elastic deformation.

I verified with the "patch-watermarks" that the polished surfaces occurring during the calendering are due to the maximum volume of the paper namely the highest positive watermarks.

Fourth Thesis

My scientific investigations proven that in order to perfectly simulate papers with watermarks made on paper machines, in laboratory conditions one has to make 15 to 20 g/m² higher grammage papers from the same cellulose and raw materials.

Scientific Publications from the Topics of the Thesis

Announcements

Regarding some part of my study that is confidential only a few announcements were published in writing. These are as follows.

Presentations

Some of my presentations were held in front of exclusively invited audience and on those occasions both parties signed mutual non-disclosure agreements in advance.

Exclusive presentations

- Security Papers with Multitone Watermark, Pisec 2000, 1-6 April 2000, Lisbon, Portugal
- Properties of Security Papers with Watermark, 30 Aug-01 Sept 2000, Milan, Italy
- Watermarks Made by The Diósgyőr Papermill, The Watermark Route, 20-22 Oct 2000, Barcelona, Spain
- Multitone Watermark Production Technologies, 1st Security Printing Conference, 29-31 Jan 2001, Moscow, Russia
- How to Produce Security Papers With Custom Made Watermarks, 24-26 April 2001, Fürth, Germany
- Combining Electrotype and Multitone Watermarks, Fabricia Nacional Modena y Timbre, 4-6 July 2001, Madrid, Spain
- New Properties of Custom Made Watermarks, 2nd International Security Printing Conference, 30-31 Jan 2002, Budapest, Hungary
- Watermarked Papers with Electrotype, 18-20 July 2002, Miskolc, Hungary
- Security Papers With Watermark: Web or Sheet Feed Printing?, 10-11 Oct 2002, Celje, Slovenia
- Security Papers With Multitone Watermark: The Advantages of Sheet Feed Printing, 12-16 Nov 2002, Neuffen, Germany

- Banknotes With Multitone, Electrotype and Barcode Watermarks: The Challenge, 12-13 March 2003, Wien, Austria
- Printing Issues of the Security Papers with Watermark, Intergraf, 12-17 May 2003, Montreaux, Switzerland
- Banknotes With Barcode Watermark, BPC Conference, 21-23 May 2003, Budapest, Hungary
- Watermarks and Windowed Security Threads, 1-3 July 2003, London, England
- New Possibilities with Watermarks, 29 Sept-01 Oct 2003, Konstanca, Romania

Public presentations

- Cylinder Mould Made Security Papers, Drupa, 25-29 May 2000, Düsseldorf, Germany
- Security Papers at the Diósgyőr Papermill, PrintExpo, 19. Oct 2000, Budapest, Hungary
- New Security Elements in the Papermaking, 23-24 Sept 2002, Lillafüred, Hungary
- New Security Elements in the Papermaking, PrintExpo, 3 Oct 2001, Budapest, Hungary
- New Features of the Security Papers, 10-11 July 2003, Bratislava, Slovakia
- New Watermarks at the Diósgyőr Papermill, PrintExpo, 02 Oct 2002, Budapest, Hungary

Other Publications

Announcements

- Gábor Varga: The old-new Paper Museum, Magyar Grafika, XLVI. évf. 5. sz., oct 2002, 73-74.p.

Presentations

- Covert Features in Security Papers, 17-19 May 2001, Sofia, Bulgaria
- How to Sort Security Papers, 15-16 April 2002, Hausmening, Austria
- Security Papers with Iridescent Print, 17-19 June 2002, Chavornay, Switzerland