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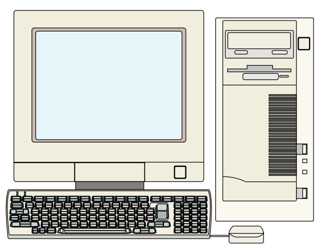

MORPHOLOGY AND IDENTIFICATION OF FIBRE FURNISH COMPONENTS OF PAPERS USED IN THE PRODUCTION OF CORRUGATED BOARD

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Abstract

The structure of liners and flutings-medium commonly used by the corrugated packaging industry in Greece were determined on the basis of compositional analysis and morphology of their fibres. Standard fibre analysis techniques and microscopy were employed to identify the fibre components as regards their origin (softwood, hardwood, nonwood) and pulping methods, and to quantify them by using appropriate weight factors. Morphological characteristics of fibres including fibre dimensions, fibre length classes, coarseness, curl, kink, fines content, and fibrillation were assessed by a MorfiTrac device. As a result of the increasing share of recycled raw materials, the papers proved highly variable incorporating a large number of wood and nonwood fibre types. Softwoods and chemical pulp were the most important components in kraftliners, while hardwoods and semi chemical and chemi mechanical pulps were dominant in testliners and flutings. The paper grades were also varied greatly in the morphological characteristics of their fibre components. Kraftliners had the highest fibre dimensions, while kink, curl, fibrillation and fine content were higher in the recycled paper grades within liners and flutings. The quantitative distribution of fibre length classes further revealed the structural differences among the papers as the small fibre class 0.2-0.5 mm had a major contribution in the recycled based testliners and flutings, the fibre class 0.5-1.2 mm had the highest share in semi chemical flutings composed by relative short hardwood fibres, and the large classes 2.0-3.2 mm and 3.2-7.6 mm were found in higher percentages in kraftliners composed by long softwood fibres. Such data, combined with the physical-mechanical paper testing, can be useful in evaluating the performance of paper products which is needed for a sustainable packaging manufacturing.

Key words: *Liners, Flutings, Fibre composition, Fibre morphological characteristics, Fibre length classes*

Rezumat

Structura sortimentelor de hârtie miez şi capac utilizate în producția de ambalaje din carton ondulat din Grecia a fost determinată pe baza analizei compoziționale şi a morfologiei fibrelor componente. Tehnicile standard de microscopie şi analiză a fibrelor au fost folosite pentru a identifica fibrele componente cu privire la specia lemnoasă (răşinoase, foioase, plante anuale), la metodele de obținere şi la cuantificarea factorului de greutate. Caracteristicile morfologice care includ dimensiunea fibrei, lungimea, gradul de ondulare şi încrețire, finețea, conținutul de material fin şi gradul de fibrilare au fost evaluate cu ajutorului echipamentului Morfi Trac. Ca rezultat al creşterii cantității de material reciclat, hârtiile obținute au prezentat un număr mare de fibre din lemn sau material nelemnos. Fibrele din celuloză de lemn de răşinoase au fost principalele componente în sortimentele de hârtie kraftliner, în timp ce fibrele din foioase, semiceluloză sau pasta chimico-mecanică au fost predominante în hârtiile miez. Sortimentele de hârtii testate au prezentat variații mari în ceea ce priveşte caracteristicile morfologice ale fibrelor componente. Astfel, hârtiile kraftliner conțin fibrele cu cele mai mari dimensiuni, în timp ce hârtiile miez conțin cantități mari de fibre reciclate, înalt fibrillate, de material fin şi de fibre ondulate şi încrețite. Distribiuția cantitativă a fibrelor pe clase de lungime a scos în evidență diferențe structurale între diferitele tipuri de hârtii testate, clasa de fibre cu lungimea de 0,2 – 0,5 mm fiind prezentă în hârtiile din fibre reciclate, clasa de fibre cu lungimea de 0,5 – 1,2 mm având cea mai mare pondere în hârtiile din pasta semichimică din fibre relative scurte din foioase, iar clasa de fibre cu lungimea 2,0 – 3,2 mm şi 3,2 – 7,6 mm având ponderea cea mai mare în hârtia kraftliner cu fibre lungi din lemn de răşinoase. Aceste rezultate combinate cu proprietățile fizico-mecanice ale hârtiei testate pot fi utile în evaluarea performanțelor hârtiei necesare pentru o producție sustenabilă de ambalaje.

Cuvinte cheie: *Hârtie capac, Hârtie miez, Compoziție fibroasă, Caracteristici morfologice ale fibrelor, Clase de lungime ale fibrelor*

I. INTRODUCTION

The manufacture of corrugated board containers (boxes, trays, etc.) involves a production chain integrated by paper, corrugated board and container manufacturers, the majority of which are SMEs in Europe. Nowadays, corrugated board containers are mostly manufactured with recycled fibres, their share being up to 82% in Europe (FEFCO 2012). The greatest threat faced by the mentioned production chain is related to the lack of quality of recycled fibres as raw material. Pulps made from recycled paper are generally associated with some degradation of fibre properties or more fibre breakage relative to virgin fibres, and use of recycled materials also introduces contaminants (Ince 2004). One of the most important properties of packaging paper is its mechanical strength, which depends mostly on the length of the fibres it is composed (Howard 1995). Fibres are longer in virgin pulps (those coming from papers obtained from wood, i.e. not yet recycled). However, the high pressure on their demand - as well as the current economic and ecological restrictions in the use of forest based materials - has led to a situation in which very little quantity of virgin fibre enters the recycling chain. This means that the strength quality of recycled fibres - and by projection of the papers - is constantly decreasing with the on-going recycling cycles. In addition, packaging papers present a very high variability, which constitutes an obstacle when it comes to manufacturing containers having homogeneous properties fixed by the customers at specified costs.

The difficulty of predicting the properties of paper products produced from heterogeneous sources puts several limitations, which therefore lead to severe economic losses. The project “RF-CORRUG – Quality control of raw materials from recovered fibres for the production of corrugated board” under the National Strategic Reference Framework 2007–2013 ARCHIMEDES III deals with this common technical problem of the corrugated board industry. Specifically, the main objective of the project is to support the competitiveness of the corrugated board companies (mainly SMEs) by creating a software tool based on practical models that can predict packaging grade paper properties from data on fibres (qualitative, quantitative, morphological) used in their production.

Lumiainen and Oy (1997) have shown that inherent fibre characteristics including wood species, origin, age, and chemical composition significantly influence the final properties of paper. Görres et al. (1996) proposed that in order to predict the properties of sheets made from mixtures of pulps, the fibre characteristics of the component pulps rather than the properties of sheets made from these pulps should be used. Recent studies on a variety of papers available in the market for the production of corrugated board in Spain have shown that, besides physical-mechanical testing, fibre analysis techniques may be also used to analyse both their time-varying structure and quality (Adamopoulos 2006, Adamopoulos and Oliver 2006).

This papers presents information on fibres (qualitative and quantitative analysis, morphology) used for corrugated packaging production in Greece. The data will be used thereafter to develop predictive models based on advanced statistical methods for the properties and performance of packaging papers.

II. MATERIALS AND METHODS

Thirty two (32) papers used by the corrugated packaging industry were used to analyse their fibre composition and morphological characteristics. The papers represent different qualities of liners (8 brown kraftliners, 8 brown testliners) and flutings-medium (8 semi chemical flutings, 8 recycled flutings) available in Greece for the production of corrugated board. The papers were provided by different paper suppliers from the global market coming from 11 European countries, Turkey, and USA. Information on the papers can be seen in Table 1.

Table 1 Information on the selected packaging grade papers

Paper ID	Grammage (g/m^2)	Origin	Classification[1]
Liners			
KL	125…190	France, Norway, Portugal, Switzerland, UK, USA	*Brown kraftliner:* predominantly made from primary kraft pulp
TL	120…170	Greece, Portugal, Romania, Spain, Turkey	*Brown testliner:* predominantly recycled fibre based, substance equal or over 120 g/m^2
Flutings-medium			
SC	110…160	Bulgaria, Croatia, Finland, Romania, Sweden, Switzerland, Spain	*Semi chemical fluting:* predominantly made from semi chemical primary fibres pulp
RF	100…130	Greece, Portugal, Spain, Turkey	*Recycled fluting – medium:* predominantly recycled fibre based, substance equal or over 100 g/m^2

[1] *according to CEPI Containerboard list of grades (2012)*

Qualitative and quantitative determination of the fibre components of the papers as regards the method of processing (chemical, mechanical, rag, semi-chemical and chemi-mechanical pulp) was carried out according to the Herzberg staining test method (ISO 9184-3: 1990). Maceration was possible after boiling in water of small paper pieces and shaking in glass tubes. Microscope slides were prepared with fibres according to ISO 9184-1: 1990. After their staining with the Herzberg stain, fibres were viewed and systematically counted under an Eclipse 50i light microscope equipped with a digital Sight DS-5M-L1 camera (both Nikon). The fibres were classed into softwood, hardwood and nonwood fibre categories based on their morphology (Ilvessalo-Pflaffli 1995). Weight percentages of different fibre categories were calculated by using predetermined weight factors recommended by ISO 9184-1: 1990.

Fibre morphology of papers was evaluated by a MorfiTrac device (MFA-5000 Morphology Fiber & Shive Analyzer, BTG Sales) in duplicate samples of 1 g solids in 600 ml of water. The disintegration of the paper materials was made by an adaptation of ISO 5263-1: 2004. For obtaining the parameters of fibres (fibre morphology, curl, kink, fines, etc.) the following standards were followed: TAPPI T 233 cm-06, T 234 cm-02, and T 261 cm-00

III. RESULTS AND DISCUSSION

Origin of fibres and weight percentages

Microscopical identification of fibre components in pulp is a difficult task which involves several constrains. These are associated with the absence of morphological features employed in solid wood identification and the presence of similar species that are closely related in anatomical structure in the pulp mix. Also, the degradation (cutting and shortening, tearing, fibrillation, etc.) of fibres due to processing and repeated recycling puts additional restrictions. Therefore, the identification was limited to softwood and hardwood genera while nonwood components were grouped to the grasses, leaf and bast fibres, and cotton categories (Figure 1).

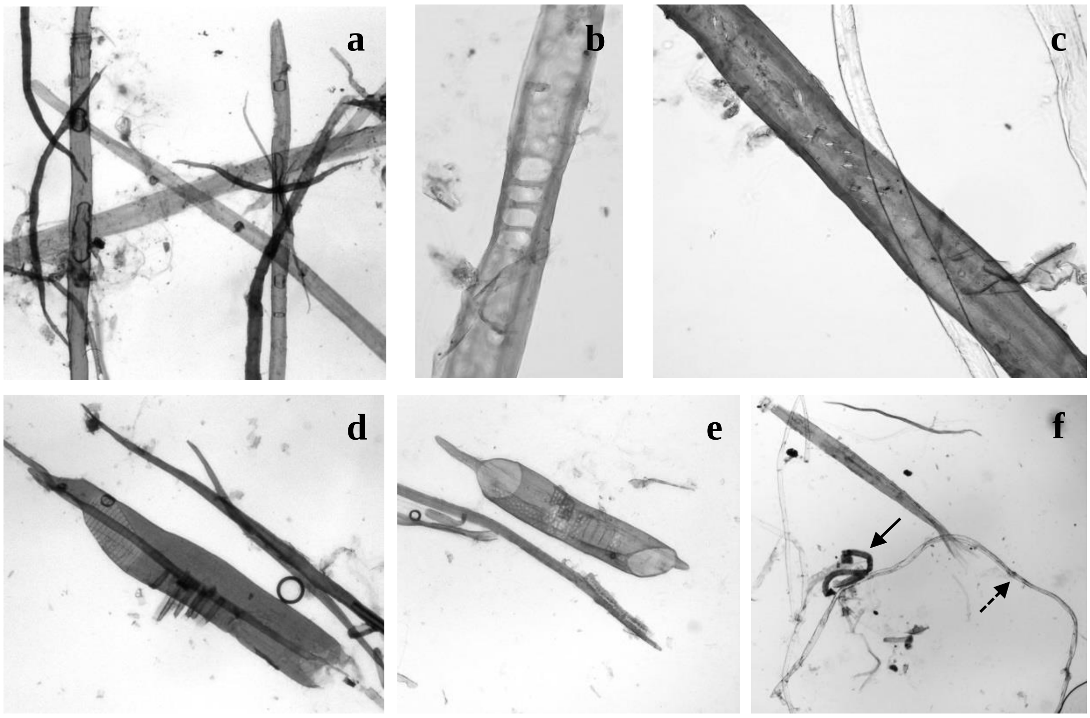

Fig. 1 Examples of different fibre types identified in the papers: softwood and hardwood fibres (a), Pinus (b), Abies (c), Betula (d), Populus (e), cell component (spiral vessel element) of a grass pointed with arrow and cotton pointed with dashed arrow (f)

All paper grades were highly variable containing 14-18 different wood and nonwood components (Table 2). Kraftliners and semi chemical flutings, predominantly made from primary fibres pulp, were less variable as compared to the recycled based papers, testliners and recycled flutings. Softwood fibres of *Pinus* and *Larix* or *Picea* were found in abundance in all papers. All other genera (*Abies*, *Pseudotsuga*, *Tsuga*) were present in small amounts. The major hardwood component in the papers was fibres of *Betula* followed by *Populus* and *Eucalyptus*. *Fagus* and *Tilia* were also frequently observed in testliners and semichemical flutings, respectively. Due to the recycling process, other hardwood genera such as *Acer*, *Alnus*, *Castanea*, *Nyssa*, *Liriodendron*, *Liquidambar*, and *Quercus* were identified in the papers but in very small numbers. Finally, all papers contained nonwood fibres in small amounts. Similar results showing a highly variable fibre furnish of the European packaging grade papers were reported previously (Adamopoulos et al. 2008).

Hardwood was the main fibre component of flutings (66.99% and 65.23% per weight in semi chemical and fluting papers, respectively) and testliners (61.69%), while softwood fibres with a weight percentage of 56.31% dominated in kraftliners (Table 3). Nonwood fibres were found to be a significant weight fraction in the papers, especially in the recycled flutings with a mean weight percentage of 8.58%. As expected, chemical pulp was the most important component in kraftliners (60.85%) and semi chemical pulp in semi chemical flutings (73.46%). Chemical pulp was as low as 30.10% in testliners as a result of the high amounts of recycled fibres used in their production, while the share of the two pulp types was almost equal in the recycled flutings. The results on the quantitative analysis are comparable with the weight percentages of fibre components (origin and pulping methods of fibres) for representative papers used for the production of corrugated board in Spain (Adamopoulos 2006, Adamopoulos and Oliver 2006) and Europe (Adamopoulos et al. 2008).

Table 2 Occurrence of softwood, hardwood and nonwood fibres in the papers[1]

Fibre categories/ Genera	Liners		Flutings-medium	
	KL	TL	SC	RF
Softwood				
Abies	*	*	-	*
Picea or Larix	**	**	**	**
Pinus	**	**	**	**
Pseudotsuga	*	*	*	*
Tsuga	*	*	*	*
Hardwood				
Acer	*	*	*	*
Alnus	-	*	*	*
Betula	**	**	**	**
Castanea	-	*	-	-
Eucalyptus	*	**	*	**
Fagus	*	**	*	*
Nyssa	-	-	-	*
Liriodendron	*	*	*	*
Liquidambar	-	*	*	*
Populus	*	**	**	**
Tilia	-	*	**	*
Quercus	*	-	-	*
Nonwood				
Grasses, leaf, bast	*	*	*	*
Cotton	*	*	*	*

[1] based on visual estimation of the relative amounts of different earlywood tracheids for softwoods, vessel elements for hardwoods, and fibres and associated cells for nonwood components
*** frequent occurrence: high or moderate numbers of the different fibre types*
** less frequent occurrence: small or very small numbers of the different fibre types*

The results on fibre composition reflected the differences in quality between the paper grades. The stiffer kraftliners, being less variable and having generally higher softwood and chemical pulp contents, represent better qualities of linerboard than the testliners. The exclusive use of recycled fibres in the production of recycled flutings places them as the most variable grade from both qualitative and quantitative standpoints.

Table 3 Weight percentages of fibre components in the papers[1]

Fibre categories	Liners		Flutings-medium	
	KL	TL	SC	RF
Origin of fibres[2]				
Softwood	56.31 (14.63)	33.19 (9.89)	29.63 (12.76)	26.19 (7.05)
Hardwood	38.89 (13.93)	61.69 (7.12)	66.99 (12.18)	65.23 (7.09)
Nonwood	4.80 (2.02)	5.12 (4.44)	3.38 (2.83)	8.58 (1.81)
Types of pulp[3]				
Chemical	60.85 (5.89)	30.10 (20.18)	26.54 (12.64)	51.19 (3.64)
Semi chemical and chemi mechanical	39.15 (5.89)	69.90 (20.18)	73.46 (12.64)	48.81 (3.64)

[1] mean values and standard deviations in parenthesis
[2] based on their morphology
[3] based on the colour reactions of fibres stained by the Herzberg stain. Mechanical and rag types of pulp were regarded as traces as their percentages were less than 2% in all papers

Fibre morphology

As a result of the diverse raw materials used for their production, the different paper grades varied greatly in the morphological characteristics of fibre components (Table 4).

Table 4 Morphology of fibre components in the papers[1]

Fibre properties	Liners		Flutings-medium	
	KL	TL	SC	RF
Fibre length, mm				
Arithmetic	0.75 (0.11)	0.49 (0.01)	0.63 (0.11)	0.51 (0.03)
Length weighted	1.68 (0.27)	1.05 (0.03)	1.01 (0.10)	1.12 (0.09)
Weight weighted	2.49 (0.27)	1.78 (0.08)	1.42 (0.12)	1.90 (0.25)
Fibre width, µm	24.38 (2.11)	20.60 (0.32)	24.16 (0.80)	21.04 (0.61)
Cell wall thickness, µm	6.20 (0.49)	5.42 (0.19)	5.72 (0.43)	5.66 (0.13)
Cross sectional area, µm²	431.04 (40.25)	360.80 (19.91)	382.30 (45.27)	383.28 (11.95)
Fibre volume index, 10^6 µm³	0.64 (0.13)	0.35 (0.01)	0.36 (0.05)	0.37 (0.01)
Coarseness, mg/m	0.20 (0.02)	0.19 (0.01)	0.16 (0.02)	0.18 (0.01)
Curl, %	12.12 (0.64)	12.62 (1.12)	9.48 (2.04)	11.74 (0.84)
Kink index, l/m	551.5 (155.3)	913.9 (162.3)	507.1 (201.6)	794.6 (126.1)
Fibrillation, %	11.18 (2.50)	13.71 (0.97)	11.90 (2.11)	13.19 (1.42)
Fines, %	29.30 (3.55)	33.94 (1.07)	23.30 (7.53)	33.17 (2.34)
Fibres per mg	6,659 (1,506)	10,858 (106)	10,217 (1,602)	10,635 (531)

[1] *mean values and standard deviations in parenthesis*

Kraftliners, containing a significant amount of larger and thicker softwood fibres, had the highest fibre dimensions. Especially, the length weighted length, which is directly correlated to paper properties (Clark 1985), had a mean value of 1.68 mm and was much higher than the values 1.01-1.12 mm in the other grades. Semi chemical flutings, composed mainly by hardwood fibres, had the lowest coarseness mean value than the other grades. The stiff hardwood fibres were also provided semi chemical flutings with high mean fibre width (24.16 mm). Kink, curl, fibrillation and fine content were higher in the recycled grades than the respective virgin based within the liners and flutings categories. This was due to refining and beating during the repeated recycling cycles, which also helped to straighten the fibres at some extent. Fibrillation increases the bonding ability of recycled fibres but there is a limit (Kang and Paulapuro 2006). Fines adversely affect paper structure and properties (Xintong 1998) but as all the grades incorporate recycled fibres in their furnish it was rational to find relatively high fines content values, especially in the recycled based testliners (33.94%) and recycled flutings (33.17%). Fibre population is associated positively to a great number of fibre and paper properties (Foelkel 2009), but this parameter when viewed alone cannot explain the differences in paper quality. For example, kraftliners have fewer fibres per mg (6,659) than the testliners (10,858) but their quality is better.

Table 5 Distribution of fibre length fractions in the papers

Paper ID/ Fibre length type	Distribution, % 0.0-0.2 mm	0.2-0.5 mm	0.5-1.2 mm	1.2-2.0 mm	2.0-3.2 mm	3.2-7.6 mm
KL						
Arithmetic	29.32	23.58	27.28	10.28	7.28	2.32
Length weighted	3.78	10.90	29.34	21.04	23.46	11.48
Weight weighted	0.30	2.46	15.38	20.12	35.18	26.56
TL						
Arithmetic	34.44	29.28	28.80	4.82	2.16	0.50
Length weighted	6.54	20.16	44.00	14.66	10.92	3.70
Weight weighted	0.78	6.80	32.74	21.02	25.56	13.10
SC						
Arithmetic	23.18	22.18	44.14	9.00	1.20	0.28
Length weighted	3.96	12.80	57.36	19.64	4.54	1.72
Weight weighted	0.52	4.80	49.28	27.84	10.94	6.64
RF						
Arithmetic	31.80	28.65	31.15	5.33	2.38	0.65
Length weighted	5.70	18.35	45.00	14.93	10.98	5.00
Weight weighted	0.63	5.83	32.20	20.03	24.38	17.05

The structural differences of the papers were reflected by the quantitative distribution of fibre length (arithmetic, length weighted, weight weighted) fractions in the range 0.0-7.6 mm (Table 5). The percentage of fines was represented by the fibre class 0.0-0.2 mm. Arithmetically, the share of fines is quite high in all papers, especially the recycled based. However, the quantity of fines is not related directly to paper properties but rather to bonding of the fibre network (Paavilainen 1990). The dominant fibre class in all papers was the class 0.5-1.2 mm, especially in semi chemical flutings which are composed mainly by virgin hardwood fibres with lengths falling within this range. The small fibre class 0.2-0.5 mm has a major contribution in testliners and recycled flutings, which are mostly made by fibres reduced in length by repeated recycling. Fibre class 1.2-2.0 mm has a significant share in all papers, while the large fibre classes 2.0-3.2 mm and 3.2-7.6 mm were found in higher percentages in kraftliners due to the high presence of softwood fibres.

IV. CONCLUSIONS

The compositional analysis (qualitative, quantitative) and morphological characterisation of fibre components of packaging grade papers provided essential information on the recycled raw materials used in their production. Such diagnostics assessing the potential quality distribution of fibres available for the production of liners and flutings are highly needed to utilize the available heterogeneous resources in an optimal manner. The reliable characterisation of raw pulp materials is not only useful for a continuous control of packaging fibre sources but can be also used to evaluate the influence it has on the final properties and performance of paper products.

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ELECTRICAL DRIVES AND CONTROL SYSTEMS IN PAPER INDUSTRY – A REVIEW

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Abstract

This paper presents the achievements and results obtained during the long term involvement of the authors in research, design, and commissioning of electrical drives and control systems in paper industry. These activities result in realization of complete electrical drives and control systems for board machine with 44 frequency controlled drives with 1100kW of total installed power, paper machine for packaging paper production with 21 frequency controlled drives with more than 3MW of total installed power, and three tissue machines with 16 drives with 560kW of total installed power. Moreover, the references include drives and control systems for three cross cutters, as well as the two rewinders. All listed facilities are in successful and continuous operation.

Key words: *Electrical drivers, Paper machine, Control systems, Energy savings*

Rezumat

Lucrarea prezintă rezultatele obținute de autori de-a lungul timpului în cercetarea, proiectarea şi punerea în funcțiune a acționărilor electrice şi a sistemelor de control în industria de hârtie. Aceste activități s-au concretizat în realizarea acționărilor electrice şi sistemelor de control complete pentru o maşină de carton cu 44 unități de acționare cu frecvență controlată cu putere instalată de 1100 kW, o maşină de hârtie de ambalaj cu 21 unități de acționare cu frecvență controlată şi peste 3 MW putere instalată şi trei maşini tissue cu 16 unități de acționare cu frecvență controlată şi 560 kW putere instalată. În plus, sunt prezentate sistemele de acționare şi control pentru trei cuțite plane şi pentru două bobinatoare. Toate aceste sisteme prezentate sunt în funcțiune.

Cuvinte cheie: *Acționare electrică, Maşină de hârtie, Sisteme de control, Economii de energie*

I. INTRODUCTION

The main objective of paper industry production is a continuous production of high quality paper. To achieve this, raw materials, water, electrical energy and heat (thermal energy) are necessary. In order to take part in the highly competitive business environment, factories strive to achieve the minimum cost of production, while maintaining the quality of produced paper and board. Development of equipment and techniques for control, power electronics and electrical drives enables direct energy savings in driving of a production process. Thermal energy savings are achieved with the application of supervisory systems which enable optimization of hot steam consumption beside other features. Reduction of production cost can also be achieved trough decrease of number and duration of stoppages. This could only be accomplished with the application of modern control systems which enable reliable and detailed diagnostics of all components of the system.

In order to obtain proper time utilization of a production process, the maximum reliability of operation of electrical drives is required. Modern control systems of electrical drives offer insight into state, operation data and variables and detailed diagnostics of all elements of the system, from the motor and frequency converter to the components of the control system and supervision system itself. Control systems applied in the paper industry provide diagnostics and insight into the state of applied actuators, valves, and various sensors, such as pressure transmitters, volumetric flow and other process values sensors, limit switches for moving parts, et cetera. Additionally, control system modules and components possess self-diagnostic procedures for detection of their own faults.

This paper will present the achievements and results obtained during the long term involvement of the authors in research, design, and commissioning of electrical drives and control systems in paper industry. The next section presents the options for implementation of drives and control systems for stock preparation section of the paper or board machine. Requirements for successful implementation and reliable use of electrical drives in large paper or board machines are presented in Section III. PLC based control system of a rewinder, with tight integration of modern electrical drives, has been proven to offer some features that were not possible before. The operation with reduced number of sensors significantly improves the reliability of operation of a rewinder, therefore the reliability of the complete paper or board production process is improved. Implementation of such control system is presented in Section IV. Section V presents the characteristics and requirements of basic subsystems of the paper-board cross cutter from the control system perspective. In section VI, two similar realizations of drive and control systems for tissue machines are presented. Conclusion is given in Section VII, followed by the list of references.

II. ELECTRICAL DRIVES AND CONTROL SYSTEMS IN STOCK PREPARATION

Electrical drives in the stock preparation can be classified as speed controlled drives, which provide regulation of process (process values) and constant speed drives. Disposition, installed power and type of electrical drive (controlled or constant speed) are determined by the characteristics of the technological process.

Typically, control of numerous drives in the stock preparation is performed from the centralized operator’s desk in the control room. Development of distributed systems for supervision and control provide that control panel with computer system for supervision and control of technological process in stock preparation can be placed near paper machine, accompanied by several local control units with the manual override option. During the design of control system in stock preparation, special attention must be paid to safety of employees (crew), as the starting of each drive is performed without operator’s direct visual contact. Proper optical and acoustical signalization (light and sound) must be provided in the vicinity of driven parts, such as belt conveyors, mills, pulpers, and the like.

Second characteristic of drives in stock preparations is that energy savings can be achieved with the speed optimization of electrical drives. Adjusting the pump speed to actual (current) process requirements is the characteristic example of energy efficiency improvement. Considering that squirrel cage induction motors are generally used in stock preparation, rational and energy efficient speed regulation is gained with the application of frequency converters. While analyzing potentials of energy savings, one has to consider that increased investments in the equipment (frequency converter) are not always returned (in each particular drive in stock preparation) trough reduced energy bills.

Drives which operate with constant speed, close to rated motor speed dictated by the requirements of the technological process, cannot achieve energy savings with the simple application of frequency converters. It such cases, application of motors with increased energy efficiency is recommended, where decreased motor losses reduce electrical energy consumption, and consequently return relatively small increase of investment compared to standard motors. In drives which are frequently started, if the load type permits, semiconductor devices named soft-starters can be applied. Soft-starters provide motor starting with decreased starting current and consequently reduce the negative impact on supply network. Application of adequate soft starter (soft-starters of reputable equipment manufacturers) enables better and more detailed monitoring of the drive operation, as well as more accurate diagnostics in the case of failure within the facility. With the application of communication protocols, remote control (start and stop) exists as an option in the case of soft-starters application as well as in the case of direct on-line motor starters. The price of the drive with soft-starter is not significantly higher than the

price of classical drive equipped with approximately the same control, supervision and communication features, therefore these drives are widely applied in the Stock preparation of the paper industry.
Application of distributed control systems with parts of the system connected trough high performance communication protocols, takes the leading position in the number of installations, especially in the case of distant locations of technological system parts. Reduction of classical wiring (for signal and power cables) is the main reason for distributed system popularization. Numerous communication protocols exist in the offers of different manufacturers, but due to different communication performances, one has to be very careful while selecting the adequate equipment. Standardized communication protocols, such as PROFIBUS or Industrial Ethernet are supported by almost all equipment manufacturers and also provide adequate performances, which are all the facts that simplify the choice of the proper one.

III. PAPER AND BOARD MACHINES

Depending on the production date of the paper machine, the distribution of driving energy to certain points of the machine was accomplished in different ways. Frequently in the past, the solution was found by using fewer drive motors of higher power, sometimes only one motor, and the mechanical energy was transmitted by line shaft. Technological evolution of electric drives, especially the utilization of power electronics, enabled the use of sectional drives. Line shaft drive has a number of disadvantages compared to sectional drives [1]. Therefore, the manufacturers of paper machines have started, a few decades ago, to apply the sectional drives concept, in the design of newly made machines. However, to achieve the coordinated motion of many sections of the paper machine, the implementation of control algorithm required some form of interconnection of controlled drives used in each section. Elaborate control systems based on analog electronics were often found in motor control rooms for paper machines.
Digitalization of drive’s control electronics enabled speed control of individual drives with higher accuracy, and avoided the change of parameter values caused by temperature drift and component aging. The widespread of digitally controlled drives, has led to the development of customized boards for control of coordinated motion of the drives, implemented in the control system of the drive itself, and configured by the drive engineer. Digital implementation of such systems with virtual master-slave connections can still be found in many paper mills.
Based on the principle of line shaft drives, the significant achievement for coordinated motion of paper machine sections using sectional drives was presented in [2] and [3]. The procedure for commissioning of such system is presented in [4].
The application of PLC systems was limited to start/stop control of the individual sectional drives, since paper machine application requires the interchange of multiple numerical (with at least 12-bit precision) signals between individual sections, or between the higher process level and the sectional drives.
The next important change of the configuration of the paper machine control and drive systems occurred when the high speed communication protocols entered the field of industrial control and drives. When equipped with the high speed communication protocol adapter, the drive is controlled by sending the reference and control word over the network, and reading the drive’s status and actual values back in each communication cycle.
The sensors and I/O points (both analog and digital) required for control and operation for the paper machine can be integrated into the control system using the data interchange over the same communication lines.
The configuration of control system where the sensor and actuators are connected with the CPU over some form of communication is known as the network control system. Very high speed of communication enables the exchange of high data volumes between the control system and the individual drives. This shifts the complexity of interconnecting of drives to the control algorithm implemented in an industrial computer, process control system or the PLC. As all the processing is done by the process controller or the PLC, the hardware of the drives can be unified. Instead of the special control boards with specially designed software, only a communication module is required in the drive. Spare parts requirements are thus further reduced.
To ensure the quality of paper machine’s control system, and to keep the software development procedure straightforward, universal software blocks for control of drives needs to be applied.

Description of the Control System

The control system of a typical paper machine with sectional drives is generally realized with the PLC. Functions programmed into PLC include:

- Evaluation of external conditions required for proper operation of paper machine. The conditions include, but are not limited to: Central lubrication system, compressed air supply, power supply, etc.
- Check of the operating state of all drives, for the alarm and warning conditions.
- Execution of the sequence of blocks used for control of each sectional drive.
- Communication with the supervisory control and data acquisition systems, for trending and logging of operating data.

On a large scale paper or board machine, many sectional drives are utilized. With the unified configuration of drives, control blocks for the sectional drives should provide a set of basic functions common to all drives. Moreover, if the functions for all sections existing on a paper machine are identified and generalized, the engineering process for control software development becomes straightforward, and the time for software development can be reduced.

This section presents the application of the developed universal control blocks suitable for control of all sections of the paper machine, based on the unified approach for drive configuration. This offers several important advantages:

- Unified drive configuration offers reduced stock for spare parts.
- In the event of drive malfunction, no configuration or programming of the drives is required by maintenance personal
- New versions and generations of converters are easily introduced in the drive system.
- Upgrade of the control system is straight forward.
- Expansion of the drive system, introduction of new sections or omission of a section is easy.

The interface of the universal control block with the operator and the drive in the first place needs to be carefully planned. The control of individual sections of a paper machine could be done centrally, with a single operator panel controlling several different sections. The other approach would be to place a dedicated operator panels near each section of the machine, to display the readouts from the drive and control a single section. The choice of the principle of the interface should be done with respect to the configuration and size of the paper or board machine, having in mind the experience and the skills of the operators. In large scale paper machines, consisting of many sections, the second approach with dedicated panels offers the advantage of visual overview of the controlled section from the operator stand-point.

Besides operator control signals, the universal control block needs to be interfaced with external signals for adequate operation. Besides conditions for running of the section, there exists an interface with other control blocks for adjacent sections (the previous and the following in machine direction). The principle of interfacing of the universal control block with the overall control system is shown in figure 1.

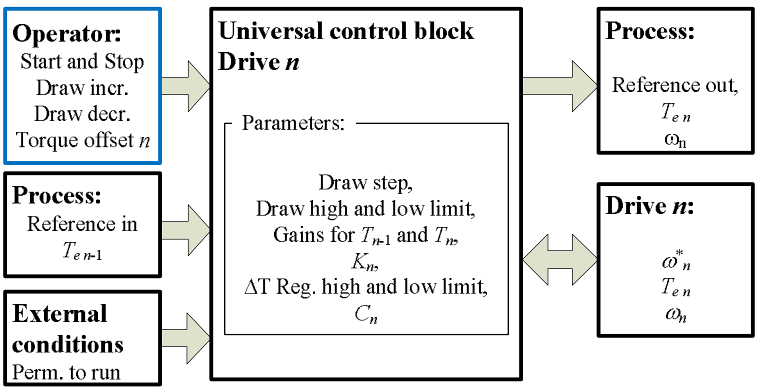

Fig. 1 The principle of interfacing the universal control block for a sectional drive with the overall control system

To accommodate application of different roll diameters, and different gear ratios in different sections, single main or “master” reference should be scaled to achieve same peripheral speed of paper machines rolls. This allows the configuration of each drive to be exactly the same, with only the motor and power dependant data individually adjusted. Scaling of reference is expressed by the constant C_n shown in Fig. 2. Figure 2 shows the detailed structure of the universal control block, where the blue rectangles represent the operator inputs. Besides start and stop for the section, the operator can adjust the draws of each individual section, with the predetermined precision (the Draw-step constant). The operator input is limited, and the influence of the set draws is relative. In the dry-end of the paper machine, the as the moisture content of the web becomes smaller, the elastic properties of the web needs to be accounted for. The tension developed in the paper web influences the speed control loop as a disturbance, acting as an external torque. However, the tension torque component depends on the paper stretching (elongation), which in turns depends on the difference in speed between the successive sections. The tension torque component produces salient coupling between the drives. The drives that are saliently coupled by the material, such as paper machine drives, need to have precise speed control before and especially during the threading of the paper. After the paper is threaded, and the coupling is established, the system is "over-regulated", as only one speed controller is required. The existence of separate speed controllers (with integrative action) on all elastically coupled sectional drives is not only unnecessary, but the controllers conflict with each other, leading to unstable operation or operation on torque limits. As a consequence of this, improper load distribution exists among the sectional drives; usually one drive covers the total load, while other drives operate in breaking regime. Unwanted and unnecessary tension in the paper produce wrinkles or over-stretched sections, ultimately leading to web break. Many different solutions for this problem exist. One possible method is the change of structure of the controlled drives, disabling all but one speed controllers. The decision for blocking the speed controllers could be based on the photo-cell signal, or on the operator input. The solution often found in engineering practice is to keep the speed controllers on all drives, and apply droop [5], on the (follower) drives, saliently coupled to the main drive (master). The solution where all drives remain with the same structure, but with the load distribution controller, superior to the speed controller is illustrated in Fig. 2. The load distribution control is based on the existence of the drives torque signal, which is readily available in both DC (armature current) and AC drives (estimated torque), with sufficient precision. The load distribution controller is integral part of the universal control block. It can be shown that stable operation can be achieved if only P type load distribution controller is used [6, 7].

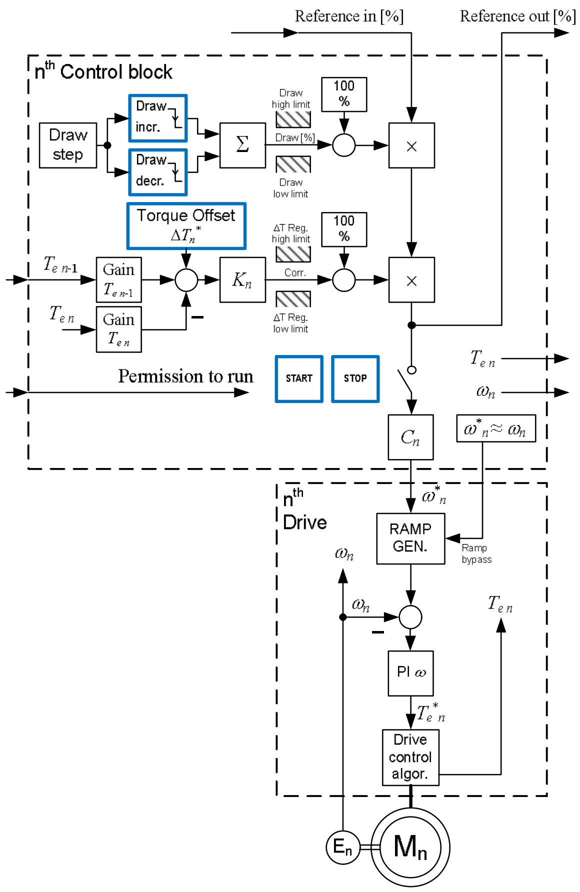

Fig. 2 Detailed block diagram of the universal control block for the sectional drives of the paper machine

The described universal control block was implemented in the control system of a large paper-board machine in Serbia. The machine consists of 44 sectional drives, with the total installed power greater than 1 MW. The machine is controlled by three PLC's communicating with the frequency controlled drives and between themselves using PROFIBUS protocol. The basic configuration of the board machine is displayed in Fig. 3. All drives were realized with standard frequency converters, with identical configuration. The drives are equipped with PROFIBUS communication modules, to enable the integration in the control system with minimum wiring and maximum flexibility. All drives are controlled by their own instance of the universal control block, and all modification of the structure necessary to accommodate different drive requirements are done in the software.

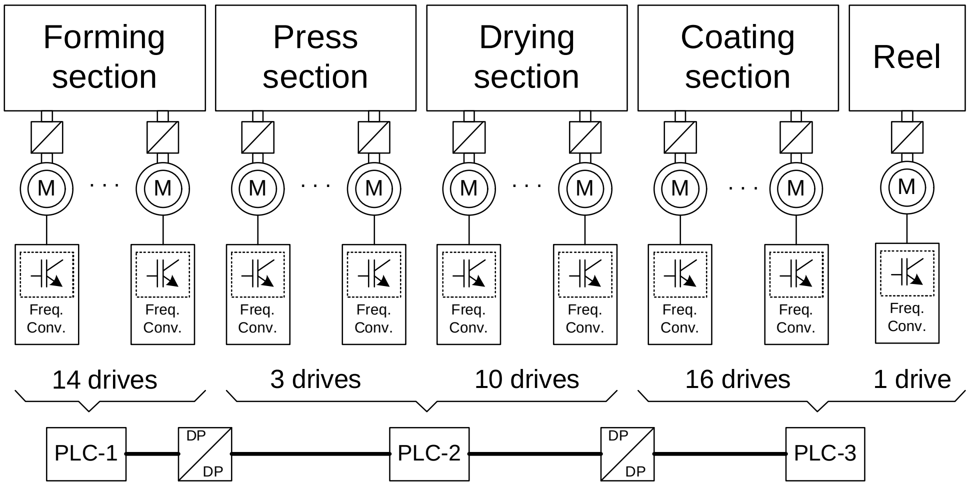

Fig. 3 Configuration of a large paper machine where unified software blocks has been successfully applied

IV. REWINDERS

When adequately maintained the mechanical system of the rewinder and similar machines in paper industry may have a significantly longer service life than its electrical and control systems. Over the lifetime of the facility, a rewinder may experience several major maintenance cycles, and these generally include significant upgrades to the electrical drive and control system. These upgrades present an opportunity to modify the design of the control system to eliminate some of the sensors, or to provide signal redundancy by using state estimation.

Description of the Rewinder Drive

The rewinder drive is an elastically coupled multi-motor drive with the elastic coupling via the paper-web being processed. Ordinary multi-motor drives require special consideration in control design to suppress the effects of coupling torques and to ensure even load distribution between the motors [7]. In contrast, a typical rewinder design uses the winder drives to pull the paper-web, and the unwinder drive to provide the web tension control – the unwinder thus operates at a braking torque that keeps the tension force at the desired set point. The tension force control is necessary to achieve properly formed output rolls and to prevent the situation when the tension force exceeds the maximum permitted values for the material being rewound which leads to web break. The disposition of the main parts of the two drum rewinder described in this section is presented in Figure 4.

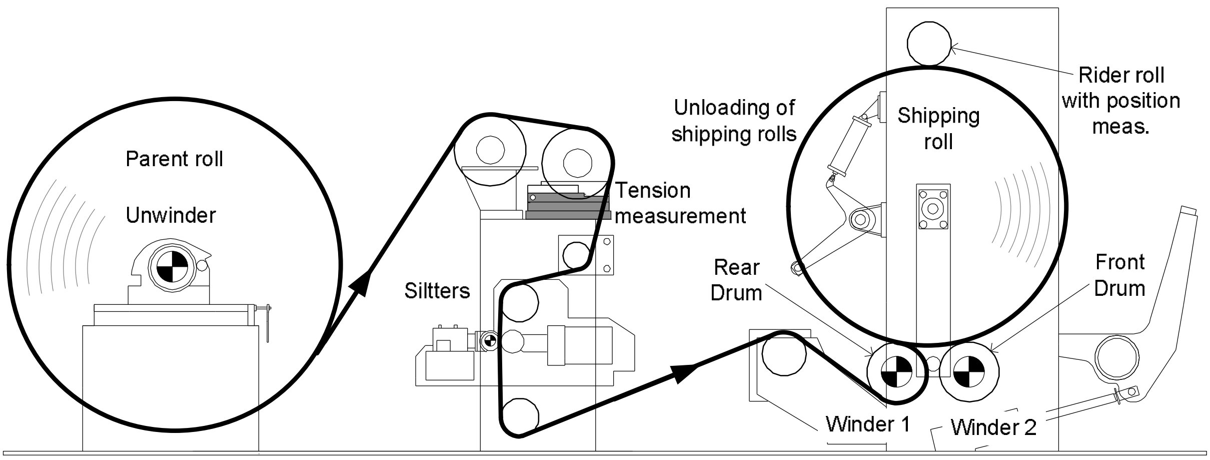

Fig.4 Disposition of the main parts of the tangent rewinder

Before the reconstruction, winder drives were based on controlled DC drives, and the sheet tension was provided by mechanical brake acting on a parent roll spool. Adjusting and maintaining the required web tension was inaccurate and difficult, as well as energy inefficient. During the reconstruction this mechanical brake was replaced with the new unwinder drive that enables precise control of the motor braking torque, thus keeping the web tension at the required value, regardless of changes in the parent roll diameter. The two DC drives for the winder drums were also replaced – all three drives now use squirrel-cage induction motors with incremental encoders, and are supplied from the frequency converters. The converters are connected to the common DC bus which provides significant energy savings, as the energy from the unwinder motor (operating in regenerative braking mode) is used to supply the inverters of the winder drives (operating in motoring mode). Due to the cyclical mode of rewinder operation, with trapezoidal speed profiles of the machine, stops for unloading of the shipping rolls occur regularly. During the slow-down period, all three drives decelerate, feeding the converted kinetic energy to the DC bus. To achieve highest standards in energy efficiency, the recuperator unit was employed to feed this energy back to the supply grid. Such design ensures that the power consumed for the rewinding cycle covers only the electrical and mechanical (friction) losses.

Description of the control system

The present status of technology shows that control systems used on rewinding machines are realized with programmable logic controllers (PLCs), usually with a graphical operator interface. To achieve reduced wiring, the distributed I/O is often used to introduce discrete signals into the control system. A block diagram of the whole system is presented in Fig. 5, starting from reference values entered by the control panel, through the control system in the PLC to the frequency converters and motors of the unwinder and winder drives. The selector switch for use of estimated or measured signal as a feedback for tension control is shown in Fig. 2. Use of the estimated signal for shipping roll diameter can also be selected by the operator, as indicated in Fig. 2.

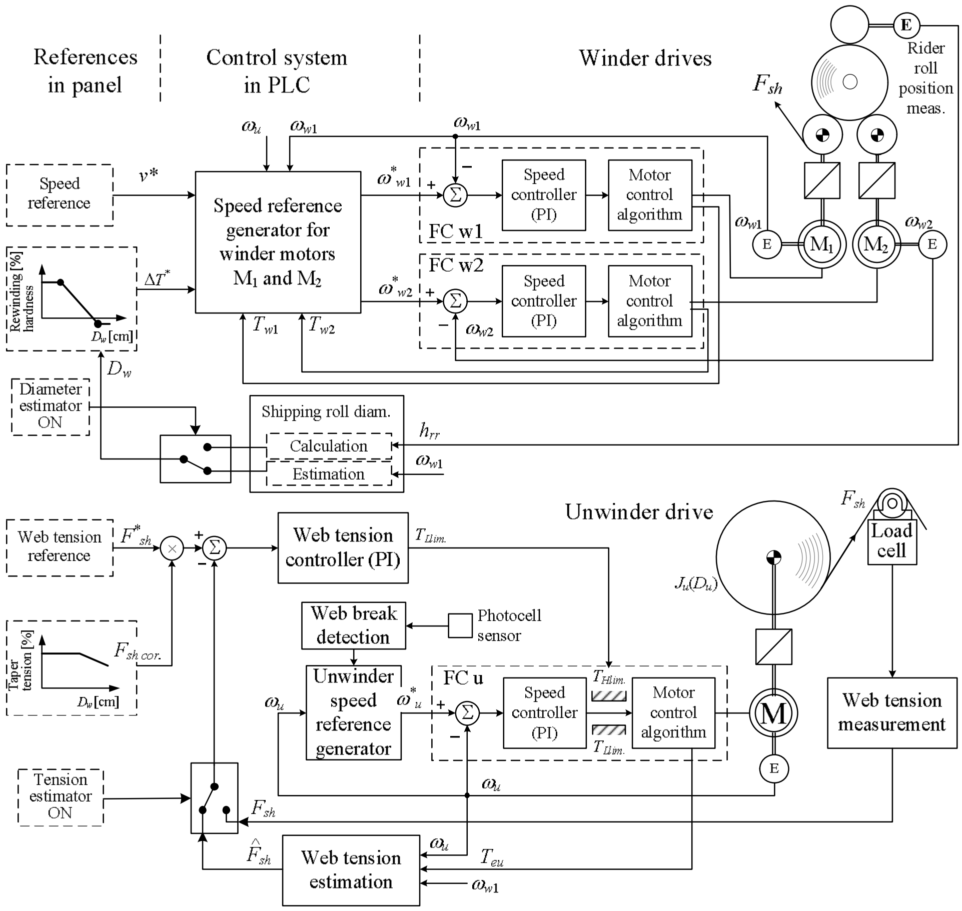

Fig. 5. Block diagram of the rewinder control system and drives

The control system of the rewinder described in this section was realized with a standard industrial PLC with medium processing performance in binary (100 ns per single bit operation) and floating point arithmetic (3 μs for floating point arithmetic operation). The controller uses a high speed (12Mb/s) PROFIBUS communication protocol to exchange information with the frequency converters, load cell, absolute encoder, and distributed I/O modules. With a relatively small number of nodes and a single master on the network, with all communication nodes present and without diagnostic data, the communication cycle lasts 0.366 ms. Given that the internal time for update of parameters for the drives in this application is 40 ms, a flexible and elegant design using distributed I/O modules is possible, with ample bandwidth available for any future reconfiguration.

Attention has been paid to sample times and the control loop bandwidths. For fast changing signals, such as motor current and torque, a higher control bandwidth is required. In the described system, closed loop control of the motor current, torque and motor speed is handled by the frequency converters. The internal control systems of the frequency converters provide the motor torque information used for roll structure and web tension control.

For closed loop control of process variables with lower dynamic requirements, such as tension control, special purpose control boards integrated in the drives are the usual choice in commercial applications. In such cases, connection of process sensors to the boards is limited to either voltage or current analog signals which are susceptible to noise, sometimes reducing the accuracy of the measured value. Furthermore, such boards require special programming skills and knowledge of the dedicated programming language developed by the drive’s manufacturer. To avoid the use of such hardware closed loop control of low-bandwidth signals can be implemented in the PLC where standardized programming languages can be used. The part of the control algorithm for closed loop tension control, executed by the PLC, requires exact timing. The cycle time of the task is chosen based on two criterions: to be short enough to satisfy the requirements of the process dynamics, but long enough to allow the execution of the communication cycle and the functions of the control system (operator interface, digital I/O, etc.) that do not require the exact timing. Satisfactory performance of the control system was obtained with the cycle time for closed loop control and the estimators for the tension and shipping roll diameter set to 100ms. With a cycle time which is relatively long compared to the period of communication, synchronized read and write PROFIBUS commands were not necessary.

The control algorithm of the rewinder can be separated into three main parts, elaborated in the following subsections.

Roll structure (hardness)

To achieve the prescribed roll structure on a two drum surface (tangent) winder, the winder drives must operate with the torque difference as a function of the shipping roll diameter. The commonly used configuration with the front drum drive in torque control mode, with the sum of the rear drum drive's actual torque and the required torque difference as a reference, has a disadvantage when slipping of the front drum occurs and the drum achieves high speeds. Certain special measures should be taken in such cases, and if unsuccessful, the rewinder is required to be stopped, causing unwanted interrupt in production.

The control algorithm described in this paper offers precise control of the torque difference, i.e. the required hardness, by influencing the speed reference of the front drum drive. In this way, the torque difference of the mechanically coupled winder drives in speed control mode can be controlled, while inherently preventing the slippage of the front drum. The limits on the output of the torque difference controller should be set to a sufficiently low value in order to prevent the occurrence of roll slippage. The detailed block diagram of this control subsystem is shown in Fig. 6. As a consequence of the indirect torque difference control, the internal speed reference ramps in the frequency converters should be set to minimum values. This, in turn, dictates the use of a common speed reference ramp, realized in the PLC. An S-type ramp has been selected for winder drives since its acceleration/deceleration profile produces a minimum influence on the tension force control loop. The block diagram of the control algorithm shown in Fig. 6 shows two more features implemented in the control of winder drives. The first feature limits the angular speed of the unwinder drive regardless of the reference web speed set by the operator. As the parent roll diameter grows smaller, for the given line speed, its angular speed grows larger. Based on the difference of the maximum allowed unwinder angular speed ω_{umax} and the measured speed by the encoder, the integrator either saturates to zero below max speed or reduces the winder reference speed, keeping the unwinder speed at maximum value. The second feature shown switches the reference line speed to a constant low value when the parent roll diameter falls below 0.5 m. In this way, as the unwinding parent roll approaches its end, the speed is reduced, making it easier to stop the unwinder at the end of the parent roll.

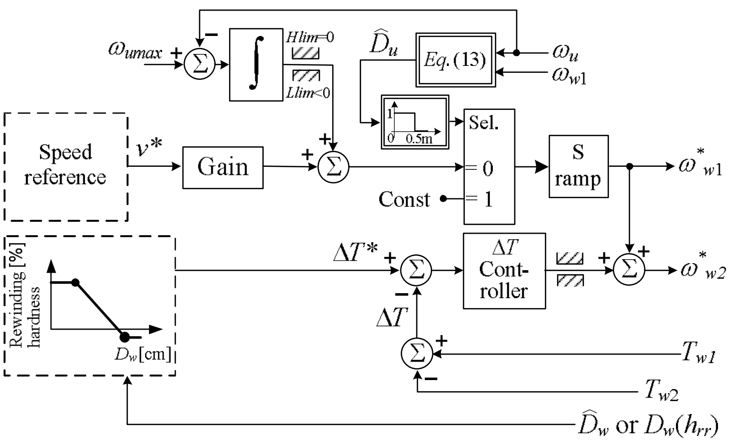

Fig.6. Block diagram of winder speed reference generator and torque difference control

Web tension control

Closed loop tension control is implemented in the control algorithm of the rewinder. The tension force set-point and the tension profile as a function of the shipping roll diameter [8] is set by the operator, as shown in Fig. 5. The tension feedback is obtained either from the load cell measurement or from the tension estimator. The output of the web tension PI controller is used as the variable low torque limit (T_{Llim}) for the speed controller of the unwinder drive. The speed controller of the unwinder drive is saturated to that variable limit by generating an adequate unwinder speed reference signal, shown in Fig. 7. Operation of the speed controller at the lower

limit T_{Llim}, is achieved by using the negated actual speed.
Detection of web break is implemented in the control algorithm based on the signal from the photocell sensor. Web break is always detected at the end of the parent roll or on the occasional occurrence of a flaw or any other damage on the sheet. In both cases, the unwinder drive must be rapidly stopped.
In case of web break, the feedback signal of the tension force controller immediately ceases to exist (becomes zero), which leads the controller output to the upper limit. Effectively, this cancels the influence to the unwinder drive torque limit, thus making the operation of the unwinder drive in speed control mode possible.
The signal from the web break detection block changes the state of the two selectors shown in Fig. 7. The upper selector block annuls the negated unwinder speed signal, such that the reference speed becomes equal to the output of the soft start block, which is at that moment equal to the actual speed of the unwinder drive. The lower selector block switches the input of the soft start block to zero, leading the speed reference of the drive to zero, with controlled and adjustable deceleration. The speed controller is not saturated during the ramp-down and it generates the required torque reference to achieve a controlled deceleration.
The winder drives also stop following their own deceleration ramp, thus winding the remaining sheet length onto the shipping roll.

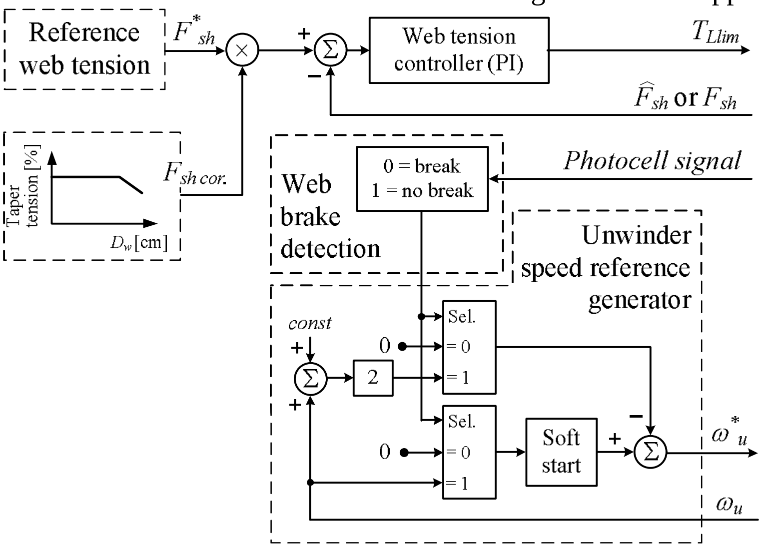

Fig.7. Block diagram of the tension control and unwinder reference generator

Pressure control of the rider roll

To achieve the desired nip profile of the shipping roll, the pressure control of the rider roll is implemented in the control system as a function of the shipping roll diameter. The operator sets the shape of the function on the graphical control panel. The proportional valve is used to control the pneumatic system for variable counterbalancing of the weight of the rider roll.
The vertical position of the rider roll measured by an absolute encoder corresponds to the shipping roll diameter. Based on the geometry shown in Fig. 8, the equation for calculation of the shipping roll diameter from the measured position of the rider roll is:

$$D_w\left(h_{rr}\right)=\frac{\frac{L_{wd}^2}{4}-\frac{D_{wd}^2}{4}+h_{rr}^2}{\frac{D_{wd}}{2}+h_{rr}} \qquad (1)$$

The nonlinear dependency (1), illustrated on the right-hand side in Fig. 8, must be programmed into the PLC control algorithm. As an alternative, the shipping roll diameter can be obtained from the estimator.

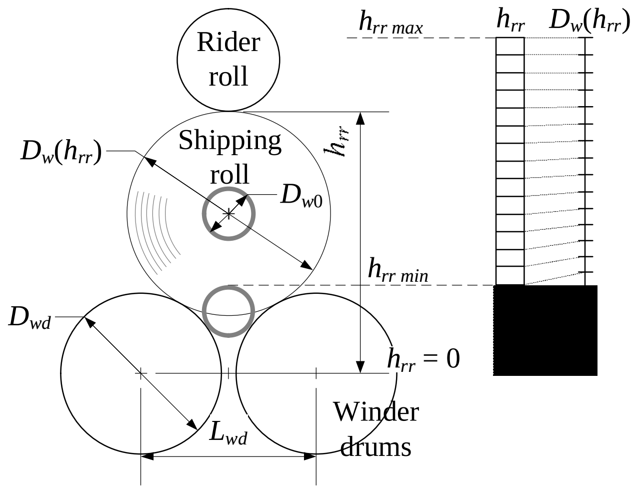

Fig.8. Geometry for determination of shipping roll diameter from the rider roll position measurement

The authors have recently participated in the major reconstruction of the tangent rewinder in a paper-board factory. During the preparation phase, the simulation model was developed to investigate the performance of the system, including the situations of interest for practical application like threading, web break or an emergency stop. The simulation model included all the characteristics of the selected equipment that significantly affected the structure of the control algorithm.

Our control implementation on the commercial rewinder included the measurement of the web tension force by the load cell and diameter of the shipping roll by means of absolute encoder. After a successful commissioning, the control with a reduced number of sensors was implemented in the test mode, and evaluated in detail. We found that the measured signals of the rider roll position and of the web tension force could be substituted by the estimated values based on the measurements from the drive control system. Furthermore, we found that the estimators can be accurately tuned by relatively simple measurements of no-load torque. The use of estimated signals increases the overall reliability of the rewinder, as the probability of mechanical failures due to vibrations is reduced, and there is no loss of accuracy associated with temperature drift or component aging.

The successful application on a real production rewinder verifies the proposed concept of the control and estimator algorithm. The estimated quantities deviate from the measured quantities by less than 5% which is acceptable for this type of plant.

Since the reconstruction of the rewinder, several faults of the encoder and the mechanism for rider roll position measurement occurred, and one on the tension force sensor. This forced the user to use the estimated signals instead of measured values from the sensors. Besides the listed faults, problems exist on the encoders for speed feedback of the drives. The existing solutions of sensor-less speed control does not offer sufficient precision required for this application. Finding the solution to this problem will be the topic of our future research.

V. CROSS CUTTERS

Cross cutter for paper or board is a facility that produces sheets of the desired length from a reel of web coming from the paper or board production line. Reliable operation, high speed of the web during cutting, and high accuracy of the sheet dimensions are common requirements. Mechanical assemblies of many existing machines are in good condition, offering possible extension of the service life, provided that drives and control system are modernized. This section presents the characteristics and requirements of basic subsystems of the paper-board cross cutter from the control system perspective.

Depending on the type of the material being cut, its speed and the desired accuracy of the sheets length, several possible solutions exist for synchronization of the cutter drives [9-11]. Paper industry requires high speed and great accuracy of the sheet length, therefore the synchronous cutters are often used [12]. In this type of cutter drives, special mechanical assembly is required to provide the necessary speed profile of the blade drums, for continuous cutter motor speed.

Asynchronous cutter, with drives directly coupled to the blade drums are mainly used in the corrugating industry, and in “folio sheeters”. Such drives require, beside low inertia of the motor and the blade drums, dedicated controller executing at high speed to provide exact speed and position profile for the motor coupled with blade drums [13-15]. Such controllers are often realized as a separate control system, requiring specific knowledge and programming skills, dictated by the controller manufacturer [16]. It can be shown that accurate sheet length can be achieved with the structure known as position control with moving target [17, 18].

Beside this main difference in the cutter drives, both types of cross cutters for paper or board incorporate various systems for roll preparation, quality inspection and sheet processing, often considered as separate systems and sometimes even delivered from different suppliers. Integration of these separate systems in one facility is not always done in such a way to take advantage of all features offered in these subsystems.

This section presents the holistic view of a paper board cross cutter with synchronous cutter drives. Requirements of individual subsystems are highlighted and analyzed in control system's perspective. It is shown that besides synchronization of cutter drive, there exist numerous challenges in practical realization of typical cross cutter for paper-board processing.

Typical cross-cutter in paper or board industry performs a technological process of cutting the roll into sheets by integrating the following subsystems:

- Roll loading, preparation and positioning
- Unwinding with tension force regulation
- Decurling station
- Web movement with optional slitting
- Cutting
- Reject station
- Conveyor section
- Stacking on skids

The listed basic subsystems are shown in Figures 9 and 10.

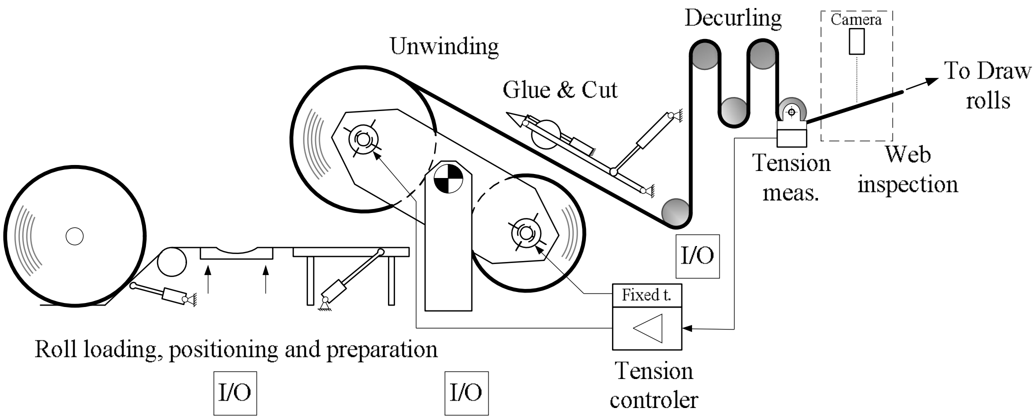

Fig. 9. Basic subsystems of a typical cross cutter for paper and board – first part: roll preparation, unwinding and decurling

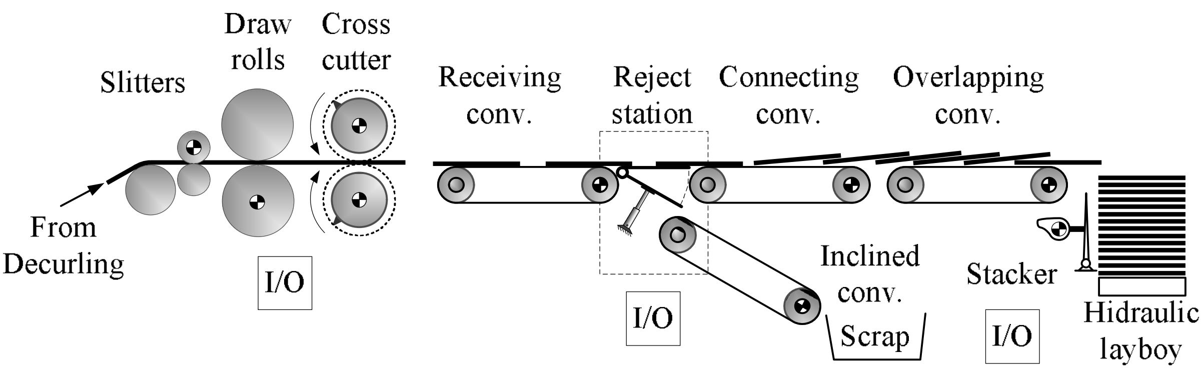

Fig. 10 Basic subsystems of a typical cross cutter for paper and board – second part: slitting web transport, cutting and stacking

Control System

Control and monitoring of the complete cross cutter is performed by the Programmable Logic Controller (PLC) based control system. All controlled drives (11 drives) are equipped with communication module for PROFIBUS protocol. All control signals, references and feedback information are exchanged over the PROFIBUS network. This reduced the necessary cabling and wiring for control of frequency converters to a single signal for *emergency stop*. PROFIBUS communication protocol was used for exchange of information with three absolute encoders, used for reading of unwinder angle, position of the drag-link mechanism and actual vertical position of the layboy.

The control system is realized with a single standard high performance PLC controller, with distributed input/output (I/O) modules. I/O modules are placed in three operator's desks, close to the signal sources, grouped to reduce the length of control wiring. Graphical control panel is placed in the main operator's desk (+P7), while auxiliary control panel with lower performance capabilities, placed in electrical room, simplifies the detection of faults.

Principal block diagram of the control system is shown in Fig. 11.

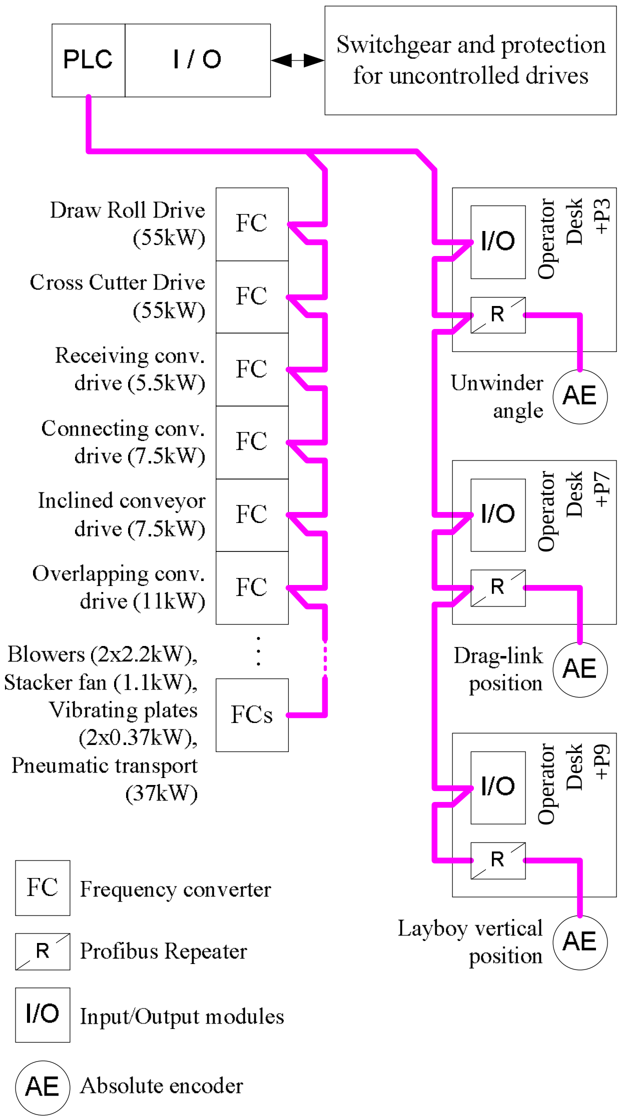

Fig. 11 Principal block diagram of the control system for cross cutter

Measurement of the actual sheet length after cutting is also performed by the PLC; dedicated technology module is used for that purpose. In this way, computational load of the main PLC processor is significantly reduced. The measured sheet length is used for correction of the reference speed for the cross cutter drive. The block diagram of the algorithm for coordinated operation of the draw rolls and the cutter drive is shown in Fig. 12. The correction calculation is based on the difference of the reference length and actual achieved length. The correction is introduced as a relative reference for the cutter drive. The parameters of the PI controller for calculating the correction are chosen to provide slow change of output, in relatively small range. The main purpose of this block is to correct small discrepancy in the actual position of the drag-link mechanism form the desired position determined by the reference sheet length (L^*).

In Figure 12, v^* is the reference line speed, given by the operator. Constant C_d scales the reference line speed to the draw rolls motor reference speed ($\square_{md}$), as defined in (2).

$$C_d = \frac{2I_d}{D_d} \quad (2)$$

The cutter drive motor reference speed (ω_{md}) is also calculated from the reference line speed. The speed of this drive also depends of the desired format, set by the operator, and determined by the position of the drag link mechanism, as measured by the absolute encoder. The value for the speed scale constant is calculated according to (3).

$$C_c(L^*) = \frac{2I_c}{D_c} I_{dl} \frac{L_k}{L^*} \quad (3)$$

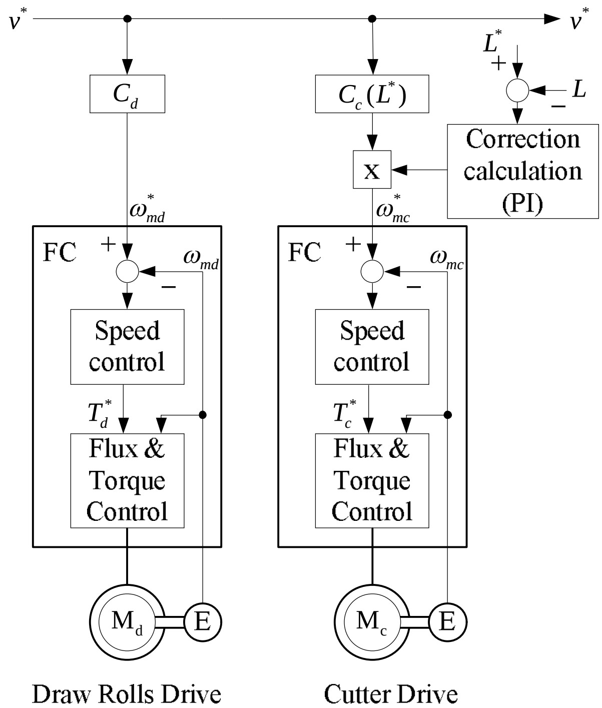

Fig. 12. Block diagram for coordinated operation of the draw rolls and cutter drive

During recent reconstruction and modernization of the cross cutter for paper board, new drives and control system were installed, while using most of the existing mechanical structures. Before the reconstruction, a single drive was coupled with mechanical line shaft that supplied mechanical power to all sections of the machine, from drive roll, cutter mechanism and all conveyors. Mechanical speed variator provided variable speed to match the desired sheet length. DC motor supplied by thyristor rectifier was used. Sectional drives with induction motors supplied by frequency converters were installed during the reconstruction for all identified sections, shown in Figs. 10 and 11. This rendered the speed variator obsolete, leading to significant savings in maintenance cost and associated down-time. For drives that do not require variable speed operation, new protection and contactors were installed, and existing motors were kept.

During constant line speed operation of the cutter, as well as during acceleration or deceleration, the achieved accuracy completely fulfills the requirements. For paper board cross cutter for sheet lengths 600 < L < 2000 mm, the required accuracy [12] is given in Table I.

Table 1 Accuracy of paper and board cross cutters

Achieved error in length	Tolerated error in length	Sheet length
max 0.5 mm	±1.0 mm	600 < L < 1000 mm
max 0.8 ‰	±1.0 ‰	1000 < L < 2000 mm

Experimental results obtained show that high accuracy of the sheet length can be achieved by using induction motor drives supplied from the frequency converters.

VI. TISSUE MACHINES

The disposition of main parts of the tissue machine in Papirpak, Čačak, Serbia is shown in Fig. 13. There are four drive sections: wire, lower press, Yankee cylinder and reel [19-21]. During the reconstruction of the drives and control system, with the goal of modernization and increase of maximum speed from 170m/min to 250m/min, four frequency converter drives were installed with rated powers 22kW, 37kW, 55kW and 7.5kW, respectively. All motors are four-pole induction motors with adequate rated power. For two drives, the existing motors and gears were used, while the other two drives were equipped with new geared motors. Drives are realized with closed loop speed control, with speed feedback from incremental encoders. With increase of the line speed, the headbox capacity had to be increased as well. This was achieved with the installation of the new headbox feed pump with frequency controlled drive, with the rated power 30 kW. The drive is capable of operation above nominal speed, to satisfy the increased flow at higher speed.

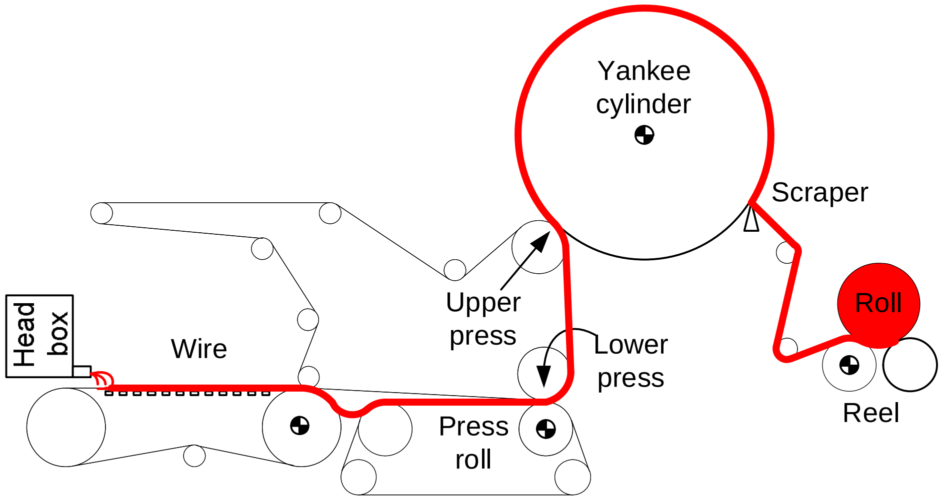

Fig. 13. Disposition of main parts of paper machine in factory „Papirpak” Čačak

The disposition of main parts of the tissue machine in Komuna, Skopje, FYR Macedonia is given in Fig. 14. Five drive sections can be indentified: wire, lower press, Yankee, drying section and reel [19-21]. The concept of reconstruction of drives and control system described in the above was applied. The maximum speed was increased from 80m/min to 120m/min, the rated powers of frequency controlled induction motor drives is 55kW, 37kW, 55kW, 11kW and 7,5kW. In this case, only one of the existing motors was used. The headbox capacity had to be increased, therefore the new headbox feed pump with frequency controlled drive (rated power 45 kW) was installed. The drive is capable of operation above nominal speed, to satisfy the increased flow at higher speed.

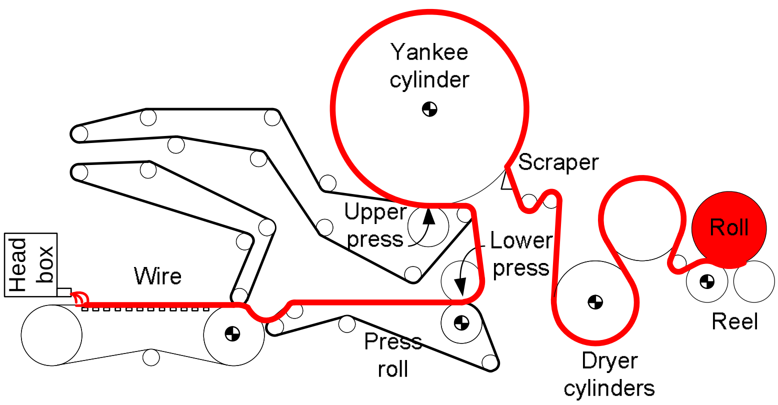

Fig. 14. Disposition of main parts of paper machine in factory „Komuna” Skoplje

VII. CONCLUSION

In all described facilities electrical drives with induction motors supplied from frequency converters were applied, and the control systems solutions are based on implementation of modern PLC systems. All described facilities successfully operate after reconstructions, confirming the validity of applied control concept with electrical drives with induction motors supplied from frequency converters.

It should be emphasized that all control algorithms are authors' original solutions highlighting their expertise in the field of paper production technology, therefore they are capable to design these and similar facilities. Projects are realized trough cooperation of investor's technical services and Laboratory for electrical drives of the School of electrical engineering, University of Belgrade, Serbia. This approach significantly reduces investments compared to the engagement of international contractors. It should be emphasized that maintenance costs during the system exploitation are also significantly reduced trough this concept of realization, due to successful training of investor's maintenance personnel with the applied technologies.

ACKNOWLEDGEMENT

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INNOVATIVE BIOTECHNOLOGY OF DEVELOPING ORGANIC BIOCOMPOSITES (PROTEIN AND CELLULOSE)

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Abstract

All the industries, including leather and cellulose industry, are forced to face high costs for waste treatment and disposal. Therefore, the aim is to treat organic waste (protein and cellulose) by biochemical processes in order to be recycled in industry and agriculture. All treatments applied to waste mainly aim at substantially reducing environmental pollution. Worldwide research on leather recycling is directed towards obtaining protein composites by biochemical treatments using microorganisms/enzymes and obtaining protein hydrolysates and protein binders with different uses. Leather, even in the form of waste, is a valuable protein source for many areas: leather industry, automotive industry, agriculture, animal husbandry, pharmaceuticals, cosmetics, etc. Organic biopolymers are a source of raw materials for agriculture, as protein waste composition provides sufficient elements to improve the composition of and remediate degraded soils, and plants can benefit from elements such as nitrogen, calcium, magnesium, sodium, potassium, etc. The process for obtaining organic biocomposites involves compounding protein biopolymers with cellulose biopolymers.
This paper presents a new pilot-scale technology for biochemical hydrolysis of tannery waste and obtaining protein biocomposites - multicomponent systems of protein and cellulose biopolymers with application in the footwear industry and in agriculture for the remediation of degraded soils. The paper presents the structural characterization of obtained biocomposites through modern instrumental analyses (FT-IR-ATR, UV-VIS-NIR microscopy etc.).

Keywords: *Biotechnology, Biopolymer protein, Cellulose, Leather waste, Soils, Enzymes*

Rezumat

Toate industriile, inclusiv industria de pielărie şi celuloză, sunt nevoite să facă faţă unor costuri foarte ridicate pentru tratarea şi eliminarea deşeurilor. În consecinţă, se urmareşte tratarea deşeurilor organice (proteice şi celulozice) prin procedee biochimice în vederea reciclării lor în industrie şi agricultură. Toate tratamentele aplicate deşeurilor urmăresc în principal reducerea substanțială a poluării mediului. Cercetările pe plan mondial pentru reciclarea deşeurilor de piele sunt direcționate spre obținerea de compozite proteice, prin tratamente biochimice cu microorganisme/enzime şi obținerea de proteine hidrolizate şi lianți proteici cu diverse utilizări. Pielea, chiar sub formă de deşeuri reprezintă o sursă proteică valoroasă pentru numeroase domenii: pielărie, construcții de maşini, agricultură, zootehnie, farmacie, cosmetică etc. Biopolimerii de natură organică reprezintă o sursă de materii prime pentru agricultură, întrucât compoziția deşeurilor proteice oferă suficiente elemente care să îmbunătățească compoziția şi remedierea solurilor degradate, iar plantele pot valorifica unele elemente: azot, calciu, magneziu, sodiu, potasiu etc. Procedeul de obținere a biocompozitelor organice se face prin compoundarea biopolimerilor proteici cu cei celulozici. Lucrarea prezintă o nouă tehnologie pilot pentru hidroliza biochimică a deşeurilor proteice din tăbăcării şi obținerea de biocompozite - sisteme multicomponente de biopolimeri proteici şi celulozici cu aplicații în industria de incălțăminte şi agricultură la remedierea solurilor degradate. In lucrare este prezentată caracterizarea structurală a biocompozitelor obținute prin analize instrumentale moderne (FT-IR-ATR, UV-VIS-NIR, microscopie, etc.).

Cuvinte cheie: *Biotehnologie, Proteină biopolimerică, Celuloză, Deşeuri din piele, Sol, Enzime*

I. INTRODUCTION

The paper aims to apply innovative biotechnologies to recover wastes from the leather industry. In addition to the favourable environmental impact, the developed innovative biotechnologies will also have an effect on rationalizing water, energy and raw material resource consumption. At present, in our country, remediation technologies in tanneries are based on the classical chemical treatment process with high consumption of reagents, resulting in large amounts of waste [1,2].

Over the past years, the demand for high quality leather has increased, which enforces continuous upgrade of manufacturing technologies; thus, biotechnology becomes increasingly important in various phases of the leather processing technology [3].

Leather processing involves a large amount of liquid and solid waste.

It is known that out of 1000 kg of raw hides (raw material), 250 kg are found in finished leather and the rest of 750 Kg are leather wastes. Given that, at present, 99% of leather wastes are stored in the landfill and the amount of processed hides in a tannery is about 10 tons / day, recovery of protein wastes is a necessity for clean, eco-friendly technologies, as only 25% of the raw hide becomes a finished product [4,5].

Pollutant quantities range from one tannery to another, depending on the type of leather processed and the types of processes used. It should be noted that from a ton of raw hide, only 240-250 kg of leather for uppers are obtained (Figure 1).

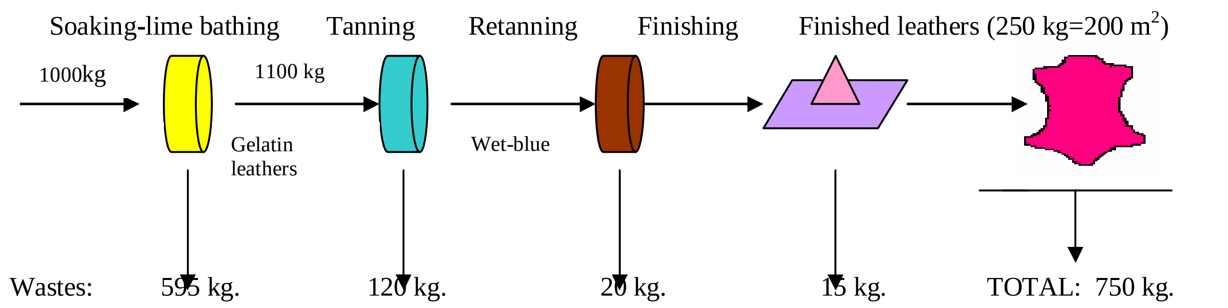

Fig. 1 Balance for a typical process of tanning with basic chromium salts

The best way to eliminate these is to recover proteins by means of biotechnologies. [4,6]

II. EXPERIMENTAL

Studied samples were protein wastes resulting from various leather processing phases in tanneries.

Biochemical treatment applied to protein waste consists in processing untanned leather wastes using a commercial enzymatic product - a set of enzymes, co-enzymes and natural breeders with “starter” liquids, which modify toxic reactions of the protein hydrolysate with a corresponding exhaustion of hydrogen sulphide emissions, mercaptans, of ammonium odours and other specific odours.

Three types of enzyme mixtures were used in this study, namely: E1, mainly containing lipase and cellulase, E2, mainly containing amylase and protease and E_S, the starter solution.

P1 **P2** **P3** **P4**

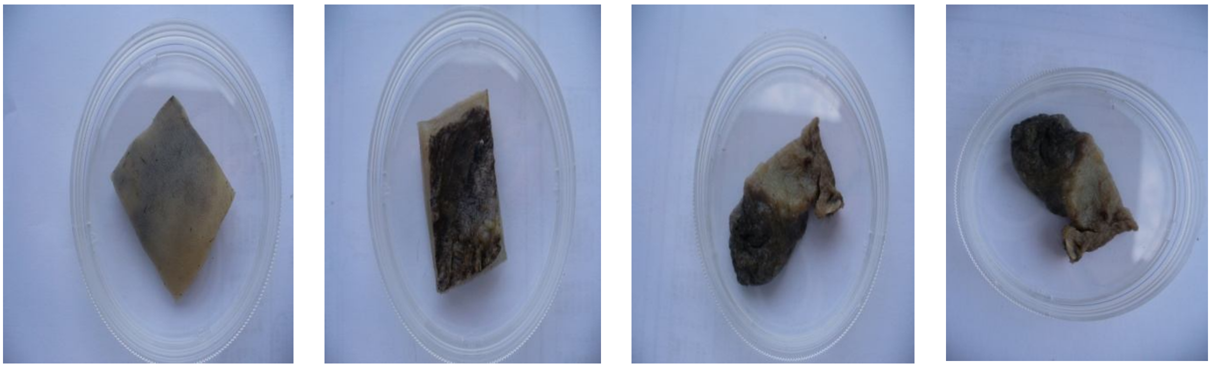

Fig.2 The macroscopic appearance of leather samples used in experiments

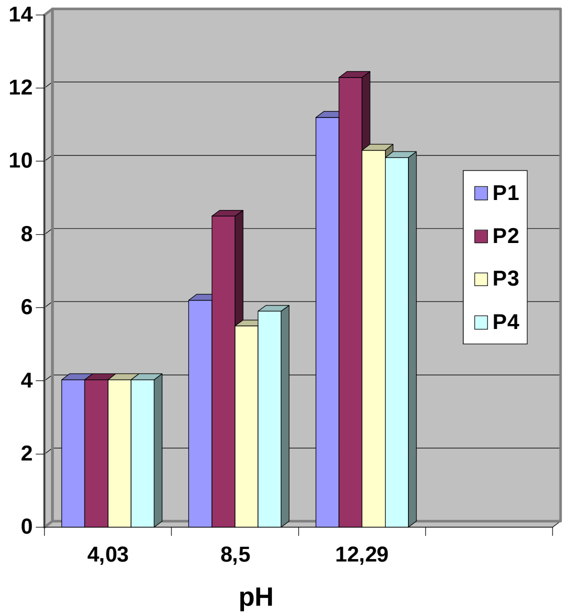

Fig.3 Relative activity of enzymatic preparation at a pH of 4.03-12.29

The performed study highlighted the influence of pH, the type and concentration of enzyme on each type of waste. The working pH range was 4.03-12.29, in order to protect the enzyme mixture from chemical degradation. Enzyme mixture E1+ E2+ E_S was used, with concentrations ranging from 1 ml - 10ml of E1 to one litre of distilled water, 1 - 10g of E2 and E_S, respectively, to one litre of distilled water, and a mixing ratio of 1ml:1g:1g for the above concentrations for the E1+E2+E_S mixture.

Samples were placed in Petri dishes and thermostated at 28°C. The experiment was carried out for 30 days and the most representative moment for the enzymatic activity was considered to be after 14 days.

III. RESULTS AND DISCUSSIONS

Results obtained in the first phase of the experiment have shown the fact that the enzymatic preparation had a high proteolytic activity, determining partial degradation of P1, P2, P3, P4 specimens.

P1 **P2** **P3** **P4**

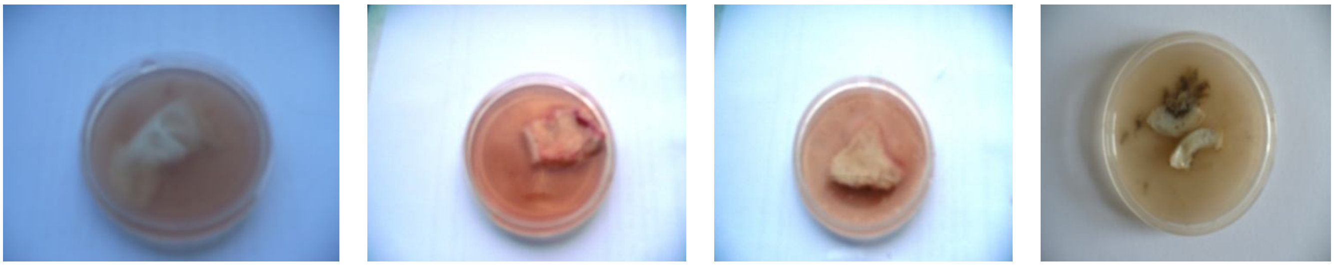

Fig. 4 Colloidal suspensions (containing biomass and/or leather scraps of various sizes) resulting from the degradation process of whole samples of P1,P2,P3,P4 specimens

After 30 days, it was found that samples of the 4 leather specimens have lost their structural integrity, degrading completely as a result of the action of the enzymatic preparation, resulting in suspensions with muddy appearance and particles of various sizes.

P1 **P2** **P3** **P4**

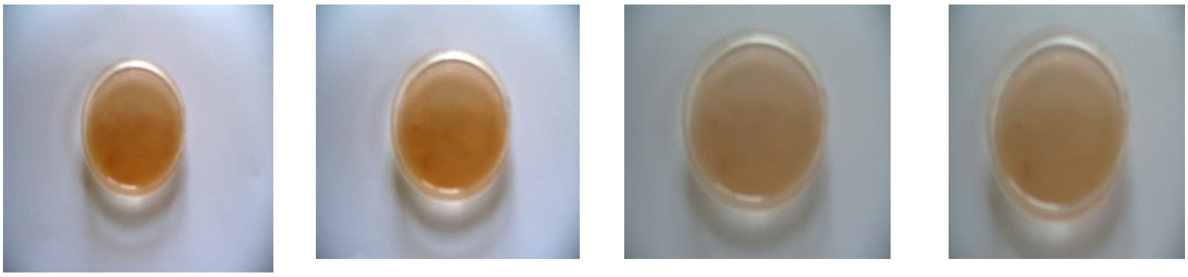

Fig.5 Colloidal suspensions (containing biomass and/or leather scraps of various sizes) resulting from the degradation process of whole samples of P1,P2,P3,P4 specimens

Based on results, it can be noticed that an alkaline pH, 12.29, favours enzymatic degradation of leathers.
The degradation ability was expressed as ratio between the initial waste mass, expressed in grams, and the degraded waste mass, expressed in mg.

Spectrophotometric and microscopic analysis of obtained organic biocomposites

Based on the main spectral characteristics of leather wastes in IR and UV/VIS/NIR range, attempts were made to identify significant bands for the amide structure, which may highlight structural changes that have occurred in the leather waste degradation process in the presence of destructive factors [7].

Attenuated total reflectance spectrometry (FT/IR-ATR)

FT/IR-ATR spectral characteristics of leather wastes for all 4 untanned leather samples analysed confirm the following:

- the 4000–3200 cm^{-1} range is attributed to stretching vibrations: O-H and N-H and is present for all studied samples.
- the 2500–2000 cm^{-1} range: the literature indicates the presence of stretching vibrations given by $X \equiv Y$, X=Y=Z groups (where X, Y, Z may be: C, N, O, S and X may be replaced

with: Cl, Br, I), present for all samples. The use of additional analytical methods is required in order to draw correct conclusions.

- in the 680– 450 cm^{-1} range, a few low intensity absorption bands can be found, attributed to deformation vibrations of groups: CH, OH, NH and are present for all analysed samples.

UV/VIS/NIR spectral analysis of leather wastes

UV/VIS/NIR spectral characteristics of leather wastes for the 4 untanned leather samples analysed confirm the following:

In the UV/VIS/NIR range, the amide structure is identified through the $\pi \rightarrow \pi^* + \pi \rightarrow \pi^*$ transitions (260 – 400 nm). The band shift in leather wastes provides information related to the strength of the hydrogen bond, and water content, respectively. In the sample degradation process, changes of the initial colour also occur. Their evaluation by determining chromatic characteristics is correlated with the degree of the oxidation process.

Research may be extended to mathematical modelling of the elaborated analytical system, by coupling with gravimetric chemical analyses.

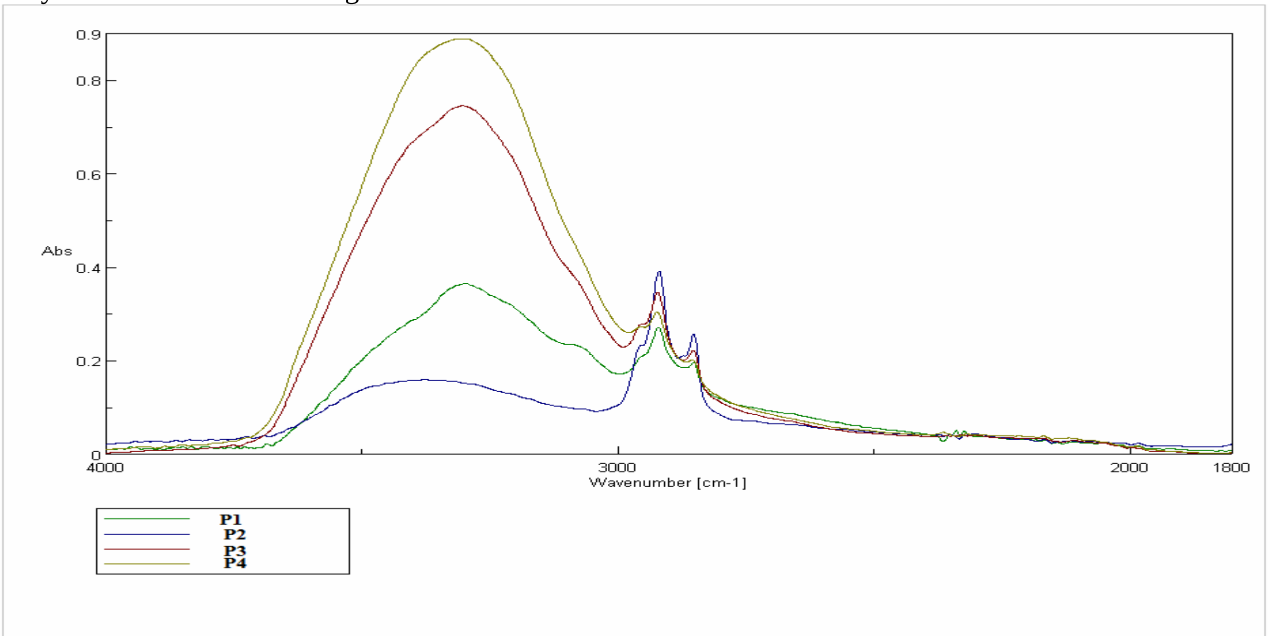

Fig.6 Spectral characteristics of leather wastes in UV/VIS/NIR range

Worldwide research on leather recycling is directed towards obtaining composites with similar texture to leather, by mixing with natural and/or synthetic elastomers, to be used as finishing materials, recycling chromium compounds and obtaining hydrolyzed proteins, developing compounds by means of which chromium is fixed to macromolecular compounds, for instance, polyisocyanates, composites incorporating other fillers, such as cellulosic materials.

The process for the production of biocomposites by defibering chrome leather waste and cellulose consists in the fact that defibration is done by grinding for 25...35 minutes in the presence of hydrochloric acid in concentration of 6...8% and boric acid in a weight ratio of 5:1, then it is
.
neutralized with sodium carbonate solution in concentration of 8...10% and 1% glycerol is added until reaching a pH of 4.8...5.1, and a mixture of natural rubber latex and synthetic latex based on acrylonitrile butadiene in a weight ratio of 60:40 and to the above mixture are added 0.5-1.3% tannin, 0.25-0.8% soda ash, 0.8-2.5% fish oil and 0.4-0.8% anti-foaming agent, stirring the mixture for 20...30 minutes, then the latex is precipitated with 2...3% aluminum sulphate to achieve a pH of 4.2...4.4, when the precipitation is considered to be completed and the bath is clear. To increase the resistance of composites in wet state (water resistance) a polyamide-epichlorohydrin resin is used.

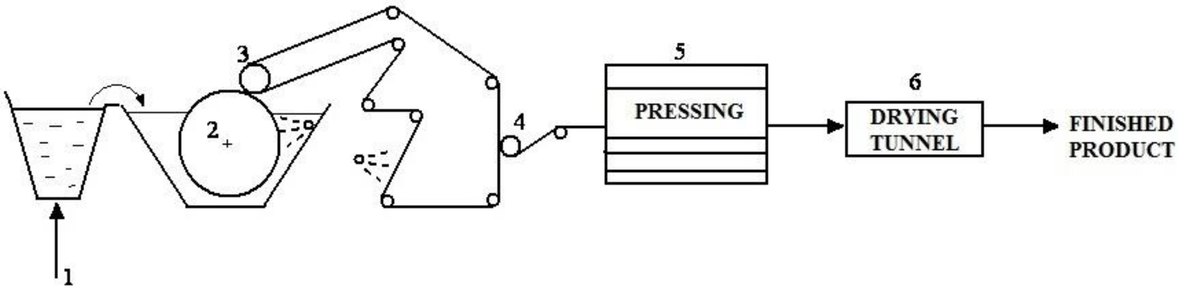

Fig. 7 Discontinuous installation for insole making

Physical-mechanical characteristics:		According to standard	Obtained values
Size variation %	Surface area	max.15	13,5
	Thickness	max.5	3,0
Elongation	Load 10N/mm^2	min.12	15
	Break	min.15	20
Tensile strength (N/mm^2)	Break	min. 9	11,1
Distilled water absorption, Kubelka after 2h, %		30….75	57,1-60,3

IV. CONCLUSIONS

This paper presents a new pilot-scale technology for biochemical hydrolysis of tannery waste and obtaining protein biocomposites - multicomponent systems of protein and cellulose biopolymers with application in the footwear industry and in agriculture for the remediation of degraded soils.

Leather, even in the form of waste, is a valuable protein source for many areas: leather industry, automotive industry, agriculture, animal husbandry, pharmaceuticals, cosmetics, etc.

Organic biopolymers are a source of raw materials for agriculture, as protein waste composition provides sufficient elements to improve the composition of and remediate degraded soils, and plants can benefit from elements such as nitrogen, calcium, magnesium, sodium, potassium, etc.

As the protein materials resulting from biochemical treatment of waste from tannery can be obtained in the small and medium industry specializing in natural leather processing, the potential beneficiaries of the developed technology are mainly tanneries, which, on the one hand, contribute to the environmental protection policy, and on the other hand, may thus widen their range of products and capitalize their activity, and the potential users of resulting products are companies in the leather industry and agriculture.

The technological process proposes the recovery and valorisation of leather waste into polymer compositions, obtaining "conglomerate products" by defibration and restructuring leather fibers starting from leather waste (vegetable and chromium tanned), their subsequent agglomeration with binder emulsions and then compacting and drying. The product thus obtained is recycled natural leather used for soles, automotive, footwear, handbags, bookbinding etc. Formulation and manufacturing parameters for the composite and quality control system of the resulting composition were established.

V. ACKNOWLEDGEMENTS

This article was elaborated within the Innovative biotechnology applied on leather wastes for use in industry and agriculture project, financed by the Ministry of National Education – state authority for scientific research, technological development and innovation, contract no. 10 N/2009, Addendum no. 4/2013and POS CCE Nr. 242/2010 Innovative technologies for leather sector increasing technological competitiveness by RDI, quality of life and environmental protection.

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WET END OPTIMIZATION TO BOOST WHITE TOP TESTLINER PRODUCTIVITY

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Abstract

In today's competitive market it is vital to make investments that continuously improve product quality and decrease production cost. At Hamburger Rieger Containerboard in Trostberg, Germany one of the most critical success factors is to decrease raw material cost. This is a challenge as prices for the waste paper raw material are increasing while at the same time the quality of the recovered material decreases. As a premium supplier for white top test liner, customer demands are high and product quality cannot be compromised. The objective of the customer was to apply online measuring technology of retention and charge leading to automatic control of chemical additives to achieve these goals.This paper will outline the optimization process by applying online measuring technology to the automation of additive dosages to achieve reduced basis weight and increased sheet ash without compromising product quality of the top layer. Actual mill data and a cost/benefit calculation will be provided to discuss the outcome of the project which was called "whiter lighter". The savings included less usage of fixative and retention aid chemicals. Furthermore, expensive furnish was replaced by less expensive filler. With higher filler content sheet printability was improved. Mill projects are usually characterized by particular goals defining the mill's requested outcome. However, very often the process reveals problems which are discovered during the project making it challenging for both parties. The project described in this paper could be finalized above its expectations due to the customer's willingness to work together.

Key words: *Wet end, Paper machine, Retention, Testliner*

Rezumat

Pe piața competitivă de astăzi este vital să se investească pentru îmbunătățirea continuă a calității produselor şi scăderea costurilor de producție. La Hamburger Rieger în Trostberg / Germania, unul dintre cei mai critici factori de succes îl reprezintă reducerea costurilor materiilor prime. Aceasta este o provocare având în vedere că prețurile pentru materia primă, deşeurile de hârtie, sunt în creştere, în timp ce calitatea acestora este în scădere. Fiind un furnizor premium pentru hârtia capac albă, cerințele clienților sunt extrem de ridicate, iar calitatea produselor nu poate fi compromisă. Ideea celor de la Rieger Karton a fost ca, pentru a atinge aceste obiective să aplice tehnologia de măsurare care să conducă la controlul automat al aditivilor. Hamburger Rieger Containerboard este situată în Trostberg, Bavaria. În mijlocul unui oraş curat, PM2 produce 140.000 t / an de hârtie capac cu partea superioară albă, cu luminozitate ridicată şi având cele mai bune proprietăți de imprimare. Având o lățime de 2,51 m şi o viteză de 1000 m / min, PM2 poate produce o gamă largă de produse. Materia primă utilizată este 100% fibră reciclată. Hârtia multistrat poate fi acoperită online, conform cerințelor clientului, într-o gamă a greutății ce este cuprinsă între 125 şi 230 g/mp. Produsele tipice pentru clienții Hamburg Rieger sunt cutiile albe pentru ambalarea produselor alimentare de genul fructelor şi vinului, precum şi hârtia folosită la copiator.

La sfârşitul anului 2011 au avut loc primele instalări de echipamente de control continuu al procesului, pentru a măsura sarcina, consistența totală şi consistența cenuşii. Începând cu anul 2012 au fost efectuate studii de laborator pentru produsele chimice de screening, în scopul de a selecta aditivii cu cele mai bune performanțe. De atunci, au fost făcuți primii paşi pentru a controla manual fixativii şi aditivii de îmbunătățire a retenției, în conformitate cu noile echipamente de control al procesului. Au fost pregătite planuri recente pentru un studiu intensiv al interacțiunilor părții umede şi al închiderii buclei de control, cu scopul de a reduce variabilitatea în cenuşa hârtiei şi greutatea de bază. Această lucrare va evidenția procesul de optimizare, începând cu aplicarea tehnologiei de măsurare la automatizare, pentru a obține astfel reducerea gramajului şi creşterea cenuşii din foaia de hârtie, făra a compromite calitatea stratului superior al produsului.

Cuvinte cheie: *Partea umedă, Maşină de hârtie, Retenție, Hârtie capac*

I. INTRODUCTION

The customer is located in the picturesque city of Trostberg in Bavaria, Germany. The mill's PM2 produces 140,000 t/y of white top test liner with high brightness and excellent printing properties. With a width of 2.51 m and a speed of 1000 m/min PM2 can produce a wide range of products with a raw material furnish of 100% recycled fiber. The basis weight range is from 125 to 230 g/m^2. The multilayer paper can be coated online according to customer requirements. Typical end-use products of Hamburger Rieger's customers are white boxes for food packaging such as for fruits and wine boxes. Copy paper is also produced.

The top layer is responsible for up to 20% of the total grammage and 42% of the raw material costs. Therefore, when targeting cost reduction it is clear that the mill would consider reducing the cost of this top layer. A stable and high ash level can help to reduce the content of the high quality recycled fiber in the top layer in relation to brightness and strength. Obtaining the raw material from one source is not possible, therefore variations in quality are common and these variations are then introduced into the process. How the process reacts and how big is the influence on the ash level in the final board? Those have been major questions that needed to be answered.

Other reasons for the mill to invest in this project were:

- Optimization of ash content in the top layer
- Reduction of deposits in the pre-dryer section to improve runnability and decrease downtime
- Maintain or improve testliner qualities such as formation and printability

II. PROJECT IMPLEMENTATION

To achieve these goals, continuous online measurement equipment from BTG for charge (PCT-20) and retention (RET-5503) has been installed at the end of 2011. Figure 1 shows the measurement locations required for control purposes. At the beginning of 2012, laboratory trials for chemical additives were conducted to select those that performed in the best way. The next step was to manually control fixatives and retention aids according to the new online measurements. Plans for an intensive study of wet end interactions and closed-loop control of additives were prepared with the goal to reduce variability in sheet ash and basis weight.

Additionally, a wet end survey has been conducted to understand the impact of various additives and select the fixing agent with the best performance. For the chemical supplier and the mill it was necessary to install a separate pump for the fixative to the top layer. Before the project started one pump distributed the fixative to all four layers.

As the project continued the automatic fixative control loop was implemented to stabilize charge variability. After that, the retention aid control loop was commissioned. When both control loops worked the last step was the increase of fresh filler addition.

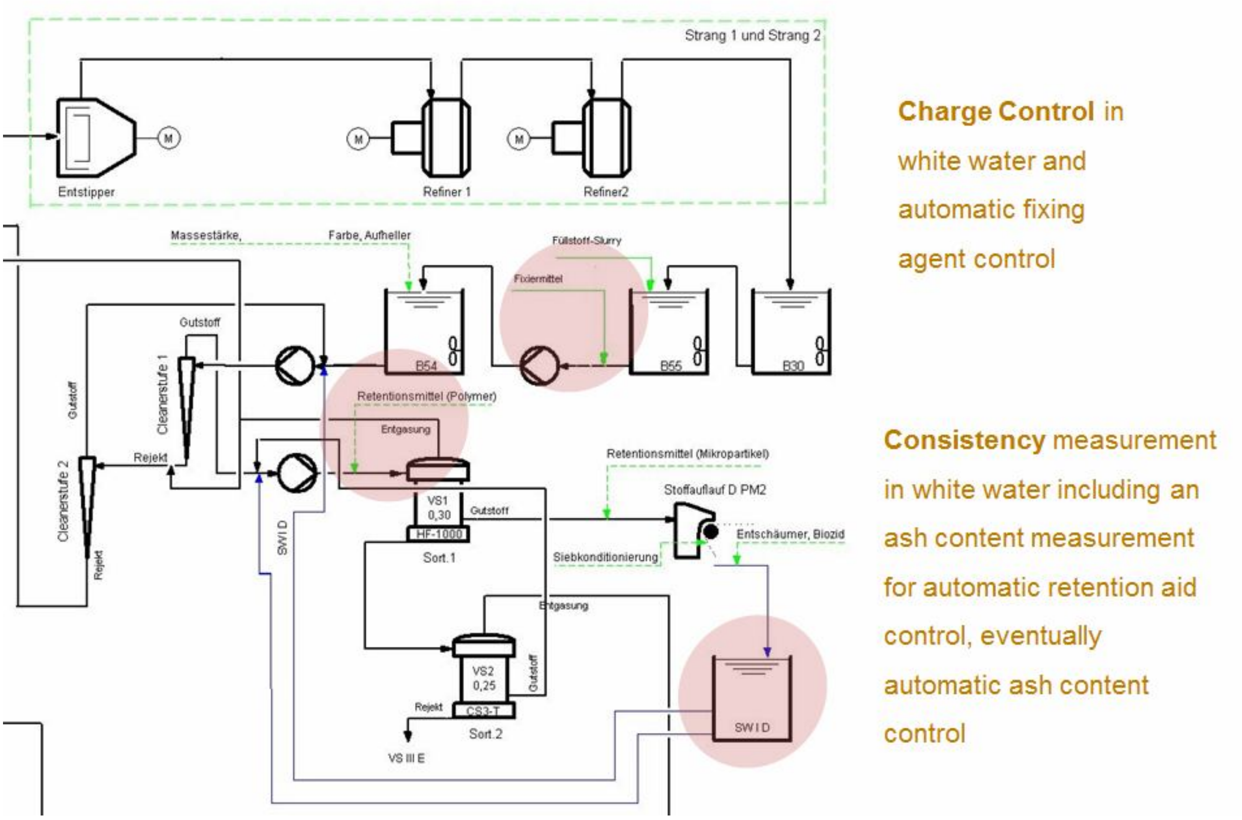

Fig. 1 Online measurement locations for consistency, ash and charge controls

The online charge measurement system has been installed in the white water system to control the fixative after the machine chest. The retention measurement system was a single consistency and ash measurement installed in the white water to control a conventional 2-components retention system with a polyacrylamide dosing point before the screen and a micro-particle silica after screening.

Soon after the installation of the measuring equipment a process analysis confirmed previous observations. Figure 2 shows that an increasing cationic demand level (yellow line), typically due to changes in raw material quality, is leading to a loss in retention, thus resulting in increased white water consistency (grey line) and reduced brightness in the final sheet. The polymer was dosed at a fixed level (black line). By increasing the fixative dosage it was possible to compensate for retention loss, returning to the previous level. Dosage of the retention aid was between 500g/t and 800g/t.

The question has been raised if the current fixative is suitable for charge control. Tests in the mill's laboratory in cooperation with the chemical supplier revealed that a Polyamine had more impact on charge and therefore seemed to be more suitable for charge control. This has been confirmed with trial runs on the machine.

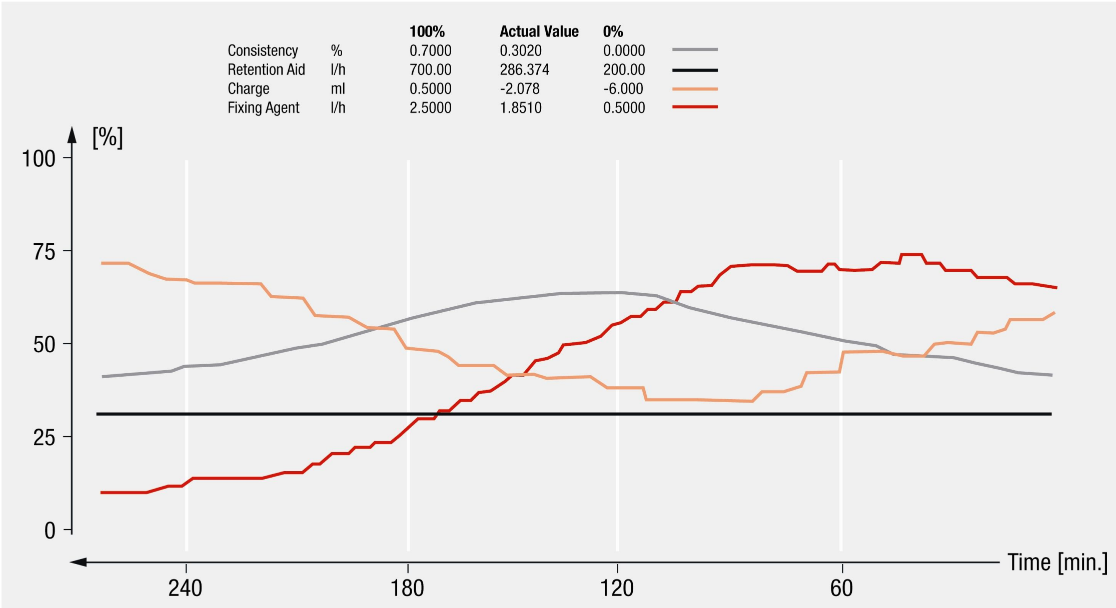

Fig. 2 Negative impact of charge on retention

III. FIXATIVE PERFORMANCE EVALUATION

The web inspection system has proven to be a good tool to observe the performance of the fixative as it shows the number of sheet flaws such as holes and spots. Two dosing points for the fixative have been tested with a conclusive outcome. By dosing the fixative after machine chest the dwell time is short and that results in sudden abrupt change in the furnish system. With the collection of anionic trash agglomerates are formed resulting in stickies (red dots) that form holes at the coating blade. On the other hand, by dosing the fixative before machine chest, the dwell time is longer and homogenization in the chest is better. There are no sudden changes to the system with negative quality consequences. The results of this evaluation are shown in Figure 3.

When the fixative is added before the machine chest, it allowed charge control reaction time to be quicker. Additionally, it became clear that a minimum fixative dosage should be applied.

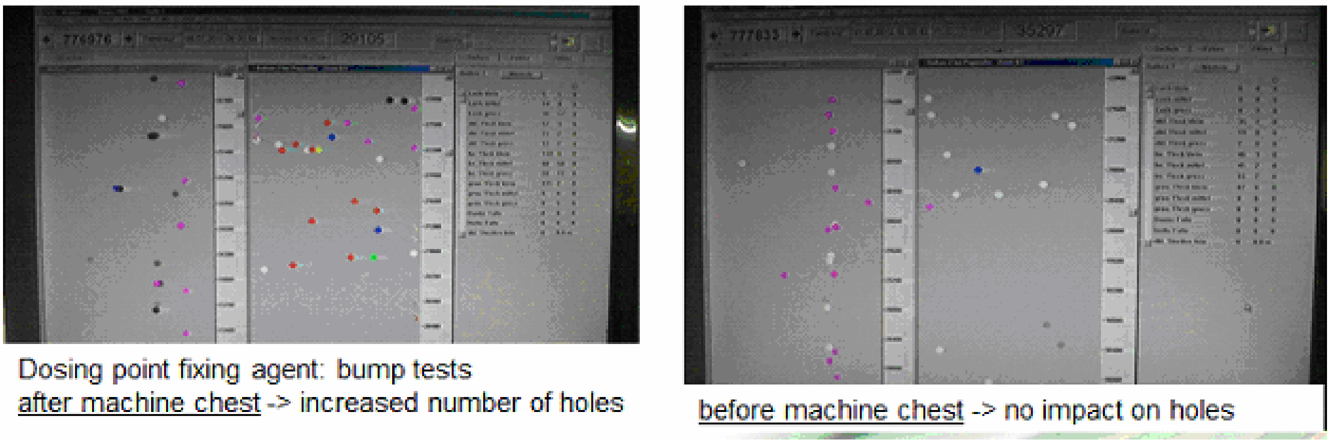

Fig. 3 Selecting optimum dosage point by looking at web inspection faults

IV. LOOP TUNING

After selection of the dosage point, the next step was to tune the charge control loop. At the beginning, an increase of the fixing agent dosage resulted in an unexpected increase in the white water consistency in a bump test. However, shortly after the cationic demand decreased because the anionic trash of the raw material was concealed by the fixative, resulting in an improved retention. A disadvantage of measuring charge in the white water and dosing the fixative before the machine chest is the long reaction time which needed to be considered when the parameters for the control loop were set.

Figure 4 shows that charge control keeps charge and retention at consistent levels with fewer peaks. Adding the fixing agent in right amount also controlled charge deviations.

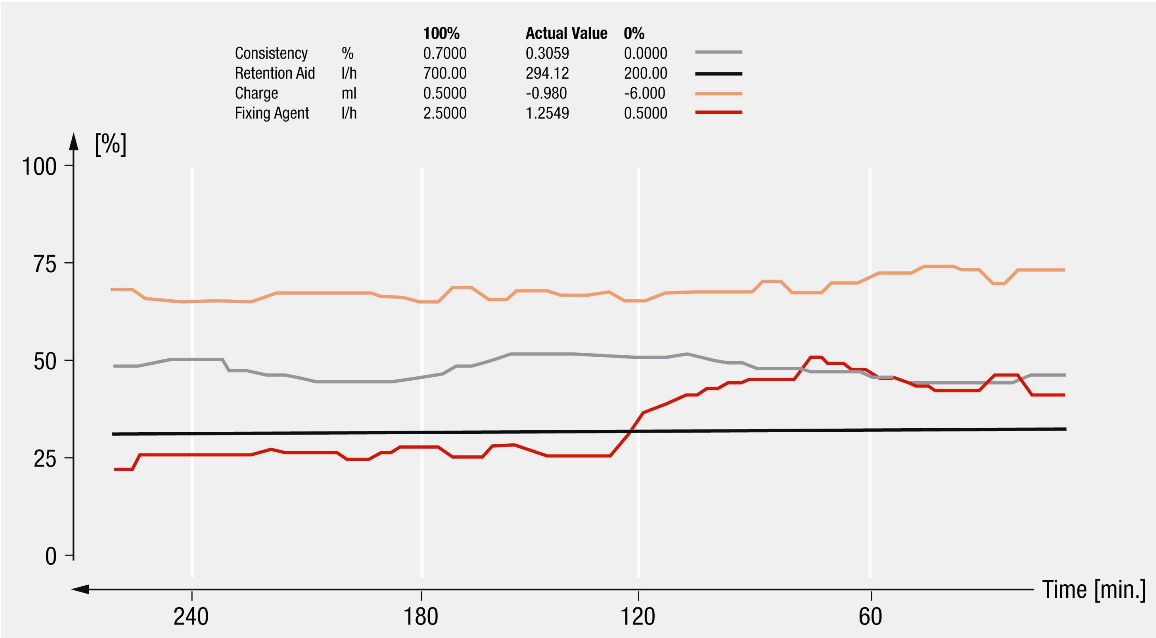

Fig. 4 Charge controller in automatic control

Tuning of the retention controller was critical as drainage and flocculation had to be watched at the same time. To avoid over-dosage and keep the drainage from drifting off, the retention aid flow was kept within close limits. For white water consistency a level was chosen where the controller can work most of time within its given range.

With the control described in this article the charge and retention controller worked independently and kept the control strategy simple. As a result, both controllers were able to even out variability in charge and white water consistency. The result is shown in Fig. 5. Charge level and white water consistency was kept stable whereas fixative dosage and retention aid varied in response to changes.

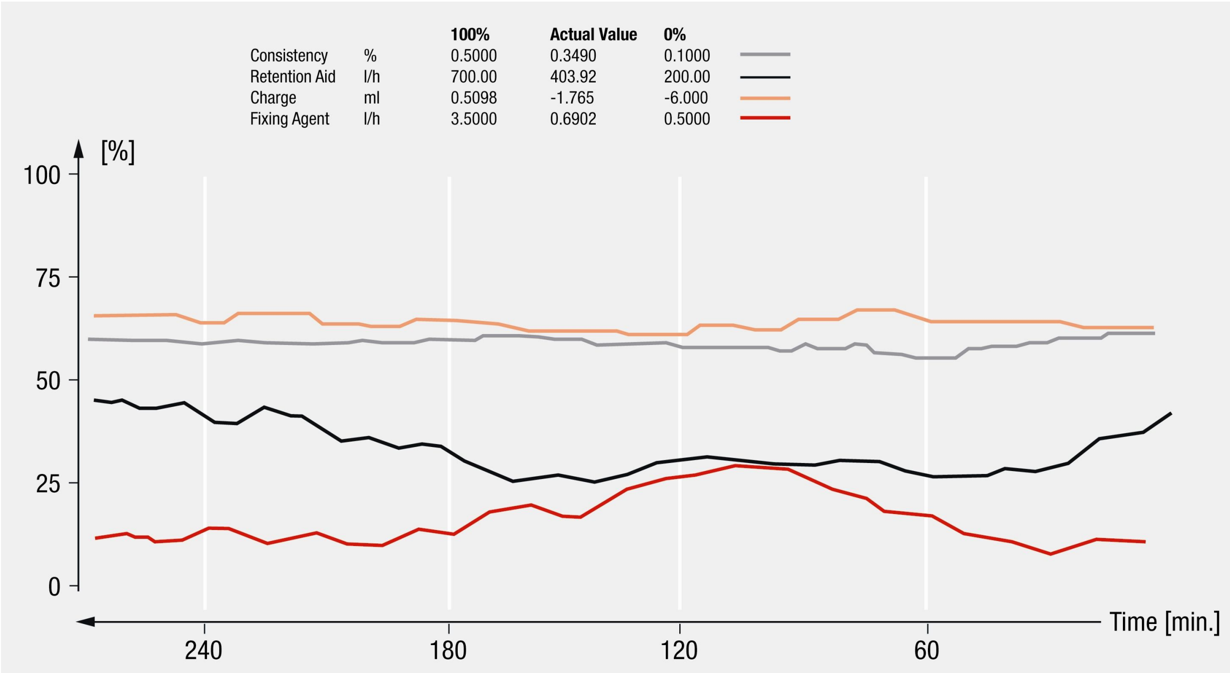

Fig. 5 Charge and retention controller at work stabilizing the levels by changing fixative and retention aid flows

V. ASH DOSAGE INCREASE

Once these control loops were set and working properly, the next step of the project could be started. That was to increase ash level and save fiber to reduce costs. Figure 6 shows the increase of ash which was achieved. As a result, the mill decided to set an even higher target of 10% ash dosage. This was only possible with an increased retention as shown in Figure 7.

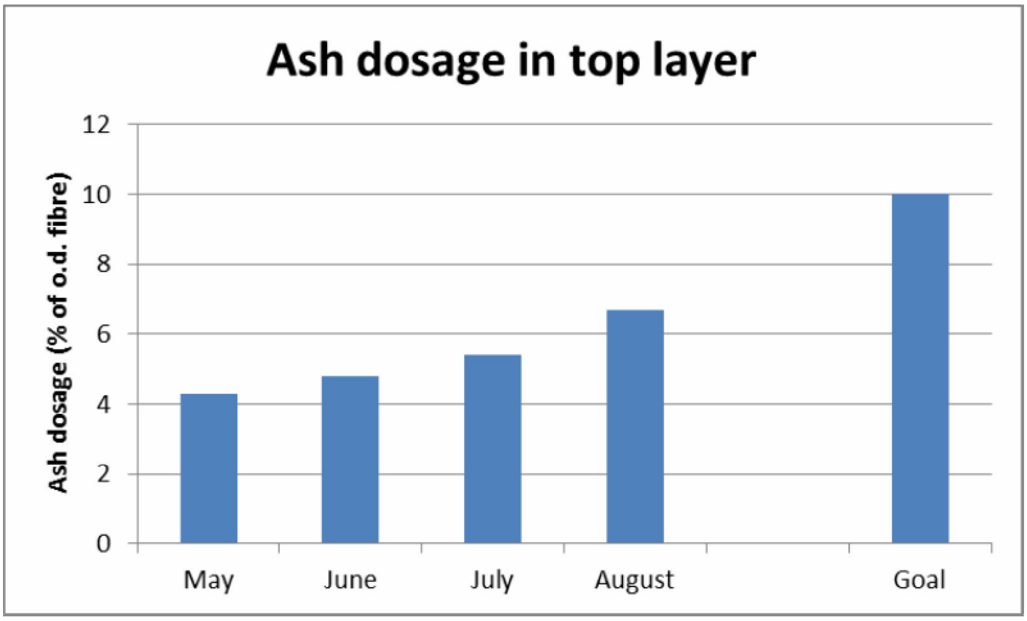

Fig. 6 Ash dosage in top layer increases as a result of better control

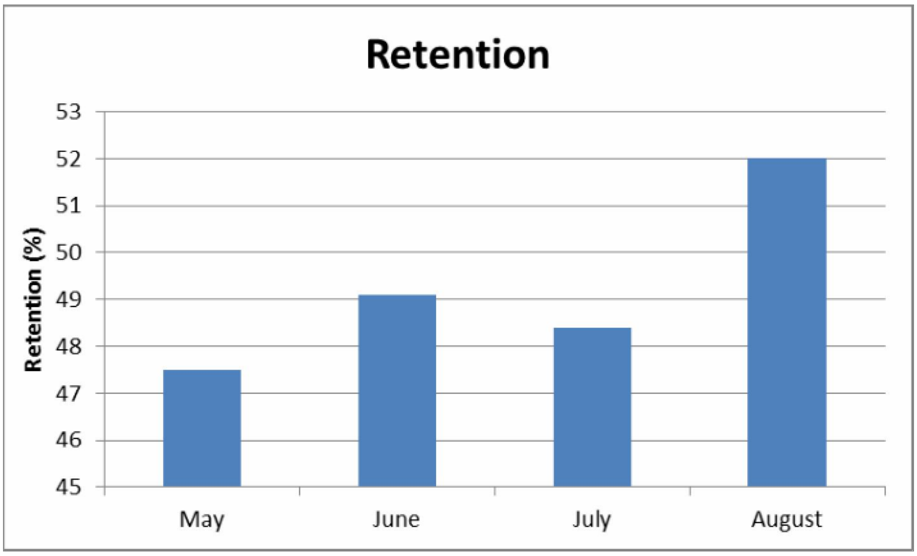

Fig. 7 Retention over four months

VI. CONCLUSIONS

When the project was closed the mill's set goals where compared with the results. The cost savings could be clearly identified as shown in Table 1. Fixative and retention aid use was reduced considerably and expensive fiber was replaced by less expensive filler in the sheet. With higher ash content the sheet's printability improved.

Table 1 Cost savings of the project

	Before Control	After Control	Yearly Savings in €
Fixing Agent Use, l/day	50	32	7,200
Retention Aid Use, g/t	750	650	16,500
Fiber Replacement by Filler	-	1% less	86,000

VII. ACKNOWLEDGMENTS

We would like to thank Hamburger Rieger Trostberg and especially Ms. Karras and Mr. von Eichhorn for their openness and full support in the project.

HÂRTII DE AMBALAJ SPECIALE. TESTUL DE COROZIUNE

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Rezumat

Utilizarea produselor papetare pentru ambalarea şi depozitarea diverselor piese şi componente metalice, ridică o serie de probleme legate de coroziunea indusă, atât de activitatea chimică şi electrochimică, cât şi de activitatea biochimică a mediului înconjurător. De regulă, hârtia anticorozivă asigură protecție ridicată împotriva formării ruginii. Totuşi, s-a constat că, în condiții nefavorabile de depozitare (pH, temperatură, umiditate), sunt favorizate anumite fenomene de coroziune. Lucrarea de față analizează o hârtie anticorozivă, din punct de vedere al rezistenței la coroziune, prin utilizarea testului "viteza de coroziune". Determinarea vitezei de coroziune, ca indicator de calitate pentru acest sortiment de hârtie, oferă pe de o parte informații privind stabilirea rezistenței la coroziune, iar pe de altă parte alegerea celei mai potrivite metode de tratare a hârtiei pentru asigurarea unui efect de protecție cât mai ridicat.

Cuvinte cheie: *Hârtii de ambalaj, Protecție anticorozivă, Viteza de coroziune*

Abstract

Use of stationer products for packaging and protection of various metallic components and parts, rises a series of issues related to induced corrosion both chemical and electrochemical activity, and biochemical environmental activity. As a rule, the antirust paper ensures protection against rust formation. However, it was found that under unfovourable storage conditions (pH number, temperature, moisture) are favoured corrosion phenomena. This paper examines an antirust paper, in terms of corrosion resistsance, using test "corrosion rate". Determination of corrosion rate as a quality indicator for this grade of paper, on the one hand provides information on determining corrosion resistance, and on the other hand, choosing the most suitable method of treating paper to provide a protective effect as high.

Key words: *Packaging papers, Anticorrosive protection, Corrosion rate*

I. INTRODUCERE

Dezvoltarea producției de ambalaje este stâns legată de extinderea producției de materiale şi a bunurilor de larg consum. Ambalajul constituie un element economic important, având implicații profunde asupra folosirii raționale şi eficiente a resurselor de materii prime şi materiale în sfera producției şi circulației mărfurilor. Nevoia de protejare a produselor a apărut din timpuri imemorabile, odată cu grija de a se conserva şi păstra surplusul de produse.

Hârtia este un compozit de natură fibroasă, cu un gramaj cuprins între 7-150 g/m^2, care poate fi utilizată la ambalarea diverselor produse.

Protecția temporară anticorozivă în timpul transportului şi depozitării echipamentelor, utilajelor şi pieselor metalice, precum şi a unităților electronice reprezintă, în ultimii ani, o preocupare permanentă, atât a societăților comerciale producătoare de asemenea produse, cât

şi a producătorilor de ambalaje, printre care şi producătorii de hârtii şi cartoane anticorozive.
Protecția temporară anticorozivă necorespunzătoare atrage după sine, pe de o parte reclamații serioase din partea clienților, iar pe de altă parte poate conduce la pierderea unor piețe de desfacere sau chiar la excluderea din start la patrunderea pe acele piețe.
Coroziunea metalelor se defineşte prin distrugerea spontană a acestora, în cursul interacțiunii lor cu mediul ambiant [1].
După mecanismul de desfaşurare, se pot destinge trei feluri de coroziune: chimică, electrochimică şi biochimică. Coroziunea chimică este cel mai des intâlnită în practică când, sub actiunea oxigenului, substanțele chimice atacă metalul, atât la temperatura ambiantă, dar mai ales la cald, iar produsele de coroziune sunt de obicei oxizi (de ex.: oxizi de fier) şi rareori sulfuri, cloruri etc. Coroziunea electrochimică are loc cu paralelă generare de curent electric. Coroziunea biochimică este cauzată de activitatea microbiologică a unor specii de microorganisme care folosesc metalul ca mediu de cultură, sau elimină compuşii care atacă metalul.
După întinderea fenomenului coroziunea poate fi: generală, pe suprafață sau locală.
Dintre cauzele care determină fenomenele de coroziune, două prezintă interes major, şi anume: umiditatea relativă a aerului şi impuritățile din aer.
Umiditatea relativă a aerului până la valori de 40% - 50 % nu produce pagube substanțiale. La valori mai mari de 60% umiditatea relativă creşte semnificativ posibilitatea declanşării proceselor de coroziune.
Impuritățile din aer, datorate factorilor industriali şi naturali, cum ar fi dioxidul de sulf, sulfatul de amoniu, cenuşa, funinginea, aerul salin, microorganismele, conduc la accelerarea proceselor de coroziune.
Metodele clasice de protecție anticorozivă care presupun utilizarea unor conservanți de natura uleiurilor, grasimilor etc, sunt din ce în ce mai puțin agreate, pe de o parte datorită costurilor ridicate, iar pe de altă parte datorită problemelor de mediu pe care le generează, şi anume poluarea cu substanțe şi preparate toxice şi periculoase.
In prezent, pentru combaterea fenomenelor de coroziune din timpul transportului şi depozitării produselor metalice şi electronice se folosesc două metode unanim acceptate pe plan internațional, respectiv: protecție anticorozivă temporară cu ajutorul tehnicilor de ambalare VCI (Volatile Corrosion Inhibitor sau Inhibitor Volatil de Coroziune) şi protecție anticorozivă teporară cu ambalare uscată (metoda scăderii umidității relative).

a) Utilizarea materialelor impregnate cu VCI – hârtie VCI sau folie VCI – a fost introdusă pentru prima dată în timplul celui de al doilea război mondial de către armata americană. Metoda presupune impregnarea materialelor suport (hârtie sau folie de polietilenă) cu un reactiv chimic (amestec de amine in soluție alcoolică), care în timpul utilizării se evaporă în cantități foarte mici generând un gaz protector care împiedică pornirea coroziunii la apariția impurităților din aer de genul: noxe gazoase industriale, aer salin, acizi lemnoşi, alți agenți corozivi. Eficacitatea se păstrează timp îndelungat, chiar şi câțiva ani (dar pentru aceasta este iportant ca ambalajul să fie ermetic închis). Protecția anticorozivă VCI funcționează şi în condiții climatice extreme, respectiv 100% umiditate relativă a aerului. Avantajele acestei metode constau în: simplificarea ambalării, utilizarea imediată a mărfii livrate din cauză ca nu necesită degresare, costuri scăzute deoarece nu implică şi alte costuri suplimentare, cum ar fi gresarea materialelor ambalate, nu poluează mediul inconjurător, deoarece materialele impregnate cu VCI sunt reciclabile [2]. <u>IMPORTANT:</u> Deoarece metalele reacționează diferit la coroziune, fiecare în parte necesită un alt tip de substanță activă cu care să fie impregnat ambalajul.

b) Utilizarea metodei scăderii umidității relative este o metodă foarte simplă care presupune utilizarea unor ambalaje sau înveliş închis ermetic unde se adaugă o substanță absorbantă in aşa fel încât, pe perioada transportului şi a depozitării, umiditatea relativă a aerului să nu depăşească valori de 45 – 50%. Materialul absorbant este un material microporos din care a fost evaporată apa la temperaturi înalte şi se comercializează în pungi cu un anumit numar de unități. Deşi, materialul absorbant se pastrează într-un înveliş de siguranță care sa-i permită să fie activ până la utilizare, totuşi, există un anumit grad de risc ca materialul absorbant sa fi absorbit deja din atmosferă cantitatea de apă pe care o poate reține, până la data utilizării. Metoda se utilizează de regulă pentru transportul şi depozitarea produselor electronice [3].
Din practica industrială s-a constatat că, utilizarea materialelor impregnate cu VCI şi în special cele pe bază de hârtie se bucură de un interes deosebit datorită avantajelor pe care le prezintă, şi anume: hârtia este un ambalaj ideal pentru a fi impregnată cu VCI deoarece prin structura sa poroasă suprafața internă mare poate reține o cantitate ridicată de substanță activă, pe care apoi o poate elibera treptat în atmosfera de protecție; hârtia impregnată cu VCI poate fi supusă reciclării ca şi

hârtia obişnuită (este pusă în circulație cu simbolul RESY).
În funcție de necesitățile materialului care trebuie protejat, hârtia poate fi: hârtie simplă cerată sau acoperită cu polietilenă întărită cu plasă de plastic, la diferite tipuri de gramaj – pentru uz general; hârtie de tip ondulat sau ondulat acoperit cu polietrilenă – pentru acoperirea unor corpuri neuniforme; hârtie dublată cu polietilenă – pentru plăci greele sau suluri mari; hârtie imprimată.
Pentru o bună ambalare anticorozivă trebuie respectate următoarele cerințe: suprafața de protejat trebuie curățată de impuritățile care pot declanşa coroziune (ambalarea se execută imediat); hârtia VCI trebuie aşezată cât mai aproape posibil de suprafața de protejat; în cazul mărfurilor vrac (şuruburi, cuie) în lăzile de transport şi depozitare, trebuie introdusă, între straturi, hârtia VCI activă pe ambele părți; la ambalajele mari se ambalează doar piesele mari supuse coroziunii; în cazul transportului pe platformă, piesele care sunt supuse coroziunii trebuie acoperite cu o cantitate suficientă de hârtie VCI hidrorezistentă (rezistentă la apă).
Diversele metale reacționează diferit la coroziune şi prin urmare, fiecare în parte, necesită alt tip de substanță activă cu care să fie impregnat ambalajul.
Literatura de specialitate recomandă pentru aprecierea vitezei de desfăşurare a proceselor de coroziune (viteza de coroziune), utilizarea unor teste de laborator pe baza unor indici de coroziune, cum ar fi: indice gravimetric, indice de penetrație, indice volumetric de hidrogen şi indice volumetric de oxigen.

II. PARTEA EXPERIMENTALA

Partea experimentală prezintă rezultatele cercetărilor privind adaptarea metodelor de lucru pentru determinarea vitezei de coroziune in vederea stabilirii rezistenței la coroziune a suprafețelor metalice protejate cu hârtie VCI - impregnata cu solutie anticorozivă tip Dipro 118 - şi implicit stabilirea concentrației optime de soluție VCI pentru impregmnarea hârtiei care să asigure protecție maximă impotriva degradării.
Încercările au fost efectuate în laboratorul de cercetare - CEPROHART Sucursala Suceava utilizând hartie VCI fabricata în țară, impregnată cu soluție anticorozivă DIPRO 118 produsă de DIFFUTHERM B.V. Elveția.

Principiul metodei

Metoda utilizată a constat în verificarea la masa de laborator a metodei de lucru practicată de furnizorul solutiei VCI - DIFFUTHERM B.V. Elveția. Metoda reprodusă se bazează pe analiza vizuală a plăcuțelor de metal luate în lucru, menținute in atmosferă VCI, supuse acțiunii coroziunii acide, la temperatura de 40°C şi expuse la intervalele de timp de 24 h, 48 h, 72 h. Totodată, s-a determinat creşterea in greutate a plăcuțelor de metal, raportat la unitatea de suprafață, calculându-se viteza de coroziune.

Aparatură, reactivi chimici şi materiale

- Balanță analitică
- Etuva termoregrabilă
- Flacoane iodometrice de 500 ml
- Placuțe de metal OL37, de 5 x 5 cm, 9 bucați, fixate in suport de robalit
- Hârtie de ambalaj
- Acid acetic – 0,5%
- Solutie VCI – DIPRO 118, cu conținut difetit de clor: 1300 mg/l, 180 mg/l, 10 mg/l

Modul de lucru

Pentru fiecare gamă de concentrație a soluției DIPRO 118 s-au utilizat câte trei flacoane iodometrice, spălate şi uscate, în care s-au introdus câte 10 ml soluție de acid acetic 0,5%. S-au cântărit la balanța analitică trei placuțe din OL37, lustruite în prealabil şi s-au introdus în cele trei flacoane iodometrice. Plăcuțele au fost fixate in vasele de probă pe cate un suport din material inert pentru a evita contactul direct cu acidul acetic. In capacul fiecarui flacon s-a fixat hârtie impregnată cu 10 ml soluție DIPRO 118 (inițial, hartia după impregnare a fost uscată la aer timp de 3 ore), formându-se în acest mod un mediu de protecție anticorozivă în interior. Vasele de probă, astfel pregatite au fost introduse in etuva incalzită la 40°C. Prima a plăcuță s-a scos după 24 ore, a doua după 48 de ore, iar a treia după 72 de ore. După răcire la temperatura camerei timp de 2 ore, plăcuțele au fost din nou cântărite. S-a notat cu g_1 masa inițială a plăcuței şi cu g_2, masa plăcuței după ce a stat în etuvă, în grame. De asemenea, s-a constatat vizual dacă oțelul a ruginit sau nu.

Modul de calcul

Viteza de coroziune – V_{cor} – s-a calculat cu relația:

$$V_{cor} = \frac{x}{S \cdot t},$$ în care:

V_{cor} = viteza de coroziune, $g/cm^2 \cdot h$.
x = creşterea în greutate a plăcuței,g
S = suprafața plăcuței, cm^2
t = timpul de expunere, h

Pentru a putea stabili gradul de rezistență la coroziune a placuței de metal s-a utilizat o scară convențională de coroziune conform tabel 1, unde viteza de coroziune este exprimată în mm/an.

Tabel 1 Scala conventionala pentru stabilirea gradului de rezistență la coroziune

Nr. grupa	Grupa de rezistență	Viteza de coroziune, V, mm/an	Gradul de rezistență
I	Perfect rezistente	0,001	1
II	Foarte rezistente	0,001 – 0,005 0,005 – 0,01	2 3
III	Rezistente	0,01 – 0,05 0,05 – 0,1	4 5
IV	Rezistență scăzută	0,1 – 0,5 0,5 – 1,0	6 7
V	Puțin rezistente	1,0 – 5,0 5,0 - 10	8 9
VI	Nerezistente	10	10

Pentru calcularea vitezei de coroziune în mm/an s-a luat în calcul 8760 ore/an şi densitatea metalului de 7,8 g/cm^3.

III. REZULTATE ŞI DISCUȚII

Rezultatele obținute se înscriu in tabelele 2,3,4 şi figura 1.
Din analiza vizuală şi a datelor obținute s-au constatat următoarele:

- metoda de analiză aplicată permite aprecierea fenomenului de coroziune de pe suprafața metalului şi stabilirea dozei optime de substanță activă din produsul VCI pentru impregnarea hartiei;
- la toate probele luate în lucru s-a observat apariția fenomenului de coroziune, care s-a manifestat în mod diferit, în fucție de conținutul de clor din produsul VCI - DIPRO118;
- din punct de vedere al tratamentului hârtiei cu VCI s-a constatat că hârtiile tratate cu solutie DIPRO 118, cu conținut mare de clor, de circa 1300 mg/l, nu asigură protecție temporară anticorizivă; fenomenul de coroziune s-a manifestat intens chiar şi după cel mai mic timp de expunere, respectiv 24 h; suprafațele plăcuțelor de metal au fost complet acoperite cu rugină, gradul de rezistență 8 incadrează produsele în grupa de rezistență *„puțin rezistente”*.
- în aceeaşi categorie se înscriu şi hărtiile tratate cu soluție DIPRO 118, cu conținut de clor, de circa 180 mg/l; deşi s-au inregistrat viteze de coroziune mai mici, extinderea fenomenului de coroziune este tot pe întreaga suprafață a plăcuțelor la cei trei timpi de expunere;
- hârtiile tratate cu solutie DIPRO 118, cu conținut redus de clor, de circa 10 mg/l, extinederea fenomenului de coroziune este doar locală, de intensitate extrem de redusă, gradul de rezistență 4 incadrează produsele în grupa de rezistență ***”rezistente”***.

Tabelul 2 Gradul de rezistență la coroziune in mediul acid, la 40°C, protecție VCI (solutie DIPRO118 cu conținut de clor 1300 mg/l)

Nr. probă	g_1, grame	g_2, grame	t, ore	S, cm^2	x,grame	V_{cor}, g/cm^2 . h	V, mm/an	Gradul de rezistență
Plăcuța 1	56,206	56,308	24	25	0,102	0,00017	1,90	8-Putin rezistente
Plăcuța 2	55,523	55,871	48	25	0,348	0,00029	3,25	8-Putin rezistente
Plăcuța 3	55,307	56,017	72	25	0,710	0,00039	4,38	8-Putin rezistente

Tabelul 3 Gradul de rezistență la coroziune in mediul acid, la 40°C, protecție VCI (solutie DIPRO118 cu conținut de clor 180 mg/l)

Nr. probă	g_1, grame	g_2, grame	t, ore	S, cm^2	x,grame	V_{cor}, g/cm^2 . h	V, mm/an	Gradul de rezistență
Plăcuța 1	12,540	12,604	24	25	0,064	0,00010	1,10	8-Putin rezistente
Plăcuța 2	12,312	12,380	48	25	0,068	0,00011	1,27	8-Putin rezistente
Plăcuța 3	13,001	13,138	72	25	0,137	0,00022	2,56	8-Putin rezistente

Tabelul 4 Gradul de rezistență la coroziune in mediul acid, la 40°C, protecție VCI (solutie DIPRO118 cu conținut de clor 10 mg/l)

Nr. probă	**g_1, grame**	**g_2, grame**	**t, ore**	**S, cm^2**	**x,grame**	**V_{cor}, $g/cm^2 \cdot h$**	**V, mm/an**	**Gradul de rezistență**
Plăcuța 1	29,655	29,656	24	25	0,001	$0{,}16 \times 10^{-5}$	0,018	4- Rezistente
Plăcuța 2	29,420	29,421	48	25	0,001	$0{,}16 \times 10^{-5}$	0,018	4- Rezistente
Plăcuța 3	29,472	29,473	72	25	0,001	$0{,}16 \times 10^{-5}$	0,018	4- Rezistente

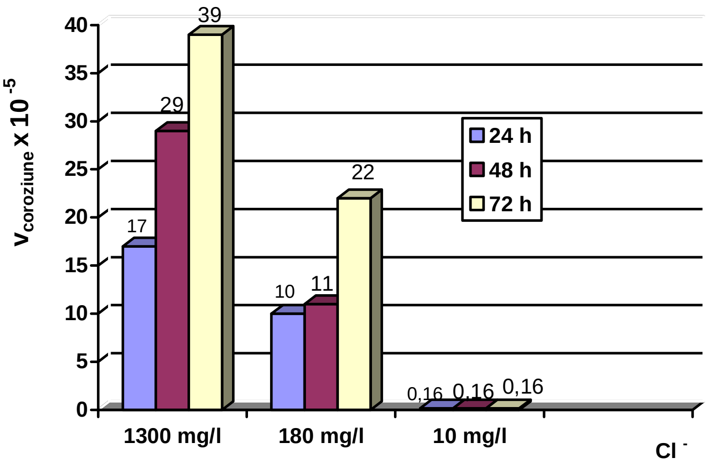

Fig. 1 Variatia vitezei de coroziune la utilizarea hartiei VCI cu continut diferit de Cl^-

IV. CONCLUZII

Datele din litaratura de specialitate şi experimentările prezentate evidențiază următoarele:

1. Pentru protecția anticorizivă a echipamentelor şi pieselor metalice utilizarea ambalajelor din hârtie, în special a hârtiilor impregnate cu VCI (Volatile Corrosion Inhibitor sau Inhibitor Volatil de Coroziune), constituie varianta ideală atât din punct de vedere tehnico-economic, cât şi din punct de vedere al protecției mediului (hârtia impregnată cu VCI poate fi supusă reciclării ca şi hârtia obişnuită fiind pusă în circulație cu simbolul RESY).
2. Pentru aprecierea calității hârtiei impregnate cu VCI, având în vedere gradul de rezistență la coroziune a produselor ambalate, s-a studiat şi adaptat metoda de analiză bazată pe determinarea vitezei de coroziune (indicele gravimetric), ca alternativă la stabilirea corectă a dozei de substanță activă din produsul VCI cu care se impregnează hârtia. Metoda de analiză este reproductibilă şi corespunde scopului propus.
3. Pentru obținerea hârtiilor VCI utilizarea inhibatorilor de coroziune cu conținut de clor ridică serioase probleme legate de coroziunea materialelor. Produsele pe bază de clor, chiar la concentrații mici, nu reuşesc să stopeze în totalitate fenomenele de coroziune.
4. Se recomandă extinedera cercetarii prin utilizarea si altor indicatori pentru determinarea vitezei de coroziune, cum ar fi indicele de hidrogen sau oxigen, indicatori care sa asigure o apreciere rapidă şi sigură a calitatii hârtie de ambalat în conformitate cu exigențele cerute.

V. BIBLIOGRAFIE

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2. AMB.RO – *Protecție temporară anticorozivă cu ajutorul tehnicii de ambalare VCI.*
3. AMB.RO – *Protecție temporară anticorozivă cu ambalare uscată.*

Al 7 – lea Simpozion Internațional

"TEHNOLOGII AVANSATE PENTRU INDUSTRIA CELULOZEI, HÂRTIEI ŞI CARTONULUI ONDULAT"

3 – 6 septembrie 2013, Brăila, Romania

În perioada 3 – 6 septembrie 2013, s-a desfăşurat la Brăila, sub organizarea Patronatului Industriei de Celuloză şi Hârtie din România, SC CEPROHART SA Brăila şi Universitatea Tehnică Gheorghe Asachi din Iaşi, cea de-a şaptea ediție a Simpozionului Internațional cu tema ***„Tehnologii avansate pentru industria celulozei, hârtiei şi cartonului ondulat".***

Aşa cum reiese din titlu, tematica simpozionului cuprinde aspecte privind ştiința şi tehnologia celulozei, hârtiei şi cartonului structurate în două secțiuni:

1. Tehnologia celulozei, hârtiei şi cartonului ondulat

- Procese şi materiale inovative pentru industria celulozei şi hârtiei
- Noi tehnologii şi echipamente pentru fabricarea cartonului ondulat
- Tehnologii şi echipamente pentru fabricarea ambalajelor din hârtie şi carton
- Reciclarea produselor din hârtie şi carton
- Managementul resurselor şi protecția mediului în industria celulozei, hârtiei şi cartonului ondulat

2. Hârtii şi cartoane speciale

- Metode de securizare a hârtiei şi cartonului
- Elemente de securizare cu aplicații în domeniul hârtiei şi cartonului
- Sisteme şi echipamente de detecție şi validare a hârtiilor speciale cu elemente de securizare
- Hârtii şi cartoane cu aplicații speciale

Simpozionul s-a bucurat de participarea a 144 de persoane din care 15 au reprezentat instituții din străinătate cum ar fi: Voith Austria, Metso Finlanda, Metso Germania, Bobst Franța, Universitatea din Belgrad, MFTI Republica Moldova, Fangl Technologies Austria, Institutul Tehnologic Larrisa Grecia, Fiscservinform Reublica Moldova furnizoare de servicii de consultanță, cercetare şi echipamente pentru industria celulozei şi hârtiei.

Din România au participat 129 de persoane, din: 3 universități (Universitatea Tehnică „Gheorghe Asachi" din Iaşi, Universitatea Aurel Vlaicu Arad, Universitatea Dunărea de Jos Galați), 4 institute de cercetare dezvoltare (INCD „Textile şi Pielărie Bucureşti, INCD pentru Protecția Muncii Alexandru Darabont Bucureşti, Institutul de Cercetare Dezvoltare Inovare în Ştiințe Tehnice şi Naturale din cadrul Universității Aurel Vlaicu Arad, Academia Română Filiala Timişoara), 12 agenți economici din sectorul de celuloză şi hârtie şi firme de consultanță pentru acest domeniu. Pe parcursul simpozionului s-a remarcat participarea reprezentativă şi interesul ridicat, manifestate de reprezentanții fabricilor din sectorul românesc de celuloză, hârtie şi carton care s-au regăsit în număr de 85 reprezentând următoarele fabrici: SC Vrancart SA Adjud, SC Petrocart SA Piatra Neamț, SC Ambro SA Suceava, SC Comceh SA Călăraşi, SC Thimm Packaging SRL Sibiu, SC Monte Bianco SA Târgovişte, SC Someş SA Dej, VPK Packaging SRL Salonta, SC Pehart Tec SA Petreşti, SC Ceprohart SA Brăila, toate membre ale Patronatului Industriei de Celuloză şi Hârtie din România – ROMPAP Bucureşti.

Pe lângă persoanele invitate cu lucrări, în deschiderea simpozionului au participat şi reprezentanți ai administrației locale: Primărie, Prefectură, Agenția de Protecția Mediului Brăila.

Pe parccursul simpozionului au fost prezentate 50 de lucrări, din care 4 (patru) conferinte plenare, **39 lucrări având ca tematică, tehnologii moderne de fabricare a celulozei, hârtiei şi cartonului (Secțiunea 1)** structurate pe:

- ambalaje din fibre celulozice şi carton ondulat pentru produse industriale şi alimentare
- aspecte privind utilizarea biomasei din lemn şi biorafinarea produşilor secundari de la fabricarea celulozei
- reciclarea hârtiei şi limitele utilizării fibrei reciclate în compoziția hârtiei şi cartonului
- tehnologii moderne de sortare a maculaturii

- aspecte privind factorii de degradare a materialelor pe suport celulozic
- aditivi biocompatibili şi biodegradabili cu aplicaţii în fabricaţia hârtiei
- echipamente de şi utilaje moderne de deshidratare şi sortare a pastei de hârtie
- valorificarea deşeurilor rezultate de la fabricarea hârtiei
- managementul energetic în fabricile de celuloză, hârtie şi carton
- ultimele investiţii în sectorul de celuloză şi hârtie

şi **11 lucrări** cu tematici specifice privind **tehnologiile de securizare a hârtiilor şi cartoanelor şi a elementelor şi sistemeleor de securizare (Secţiunea 2):**

- tehnologii de obţinere şi caracterizare a microfirelor cu proprietăţi feromagnetice utilizate la securizarea documentelor de valoare
- tehnici de control şi evaluare a elementelor de securizare
- elemente de securizare pe bază de pigmenţi şi nanoparticule cu proprietăţi magnetice
- hârtii cu proprietăţi magnetice pentru aplicaţii speciale
- hârtii cu nanoparticule magnetice

Pentru o mai bună dezbatere a lucrărilor şi pentru concentrarea interesului mai multor participanţi, lucrările au fost prezentate sub formă de conferinţe orale.

În urma audierii lucrărilor şi a discuţiilor care au avut loc între specialiştii din universităţi, institute de cercetare şi cei din industria de profil s-au conturat principalele direcţii şi politici de urmat pentru sectorul de celuloză, hârtie şi carton din România în vederea alinierii la practicile europene şi asigurării participării la satisfacerea principiilor dezvoltării durabile, după cum urmează:

- utilizarea aditivilor biocompatibili şi biodegradabili în procesul de fabricare a hârtiei şi cartonului;
- studii şi cercetări cu privire la limitele utilizării fibrelor secundare la fabricarea sortimentelor de hârtii şi cartoane
- folosirea fibrelor secundare (maculaturii) reduce poluarea şi conservarea resurselor forestiere, motiv pentru care trebuie concentrate eforturile pentru creşterea gradului de recuperare şi sortare a maculaturii
- orientarea către fabricarea ambalajelor din carton ondulat cu masă redusă şi implicit a fabricării hârtiilor componente cu gramaj redus şi rezstenţe mecanice corespunzătoare
- funcţionalizarea ambalajelor din hârtie şi carton
- identificarea şi implementarea unor elemente şi tehnologii de securizare a hârtiilor şi cartoanelor pentru documente de valoare în scopul reducerii fenomenului de falsificare şi contrafacere a produselor.

Pe parcursul simpozionului au avut loc următoarele evenimente asociate:

- vizite în laboratoarele de cercetare, testare şi încercări şi instalaţiile experimentale de obţinere a sortimentelor papetare speciale din cadrul SC CEPROHART SA Brăila;
- sesiune de comunicări ştiinţifice/campanie de diseminare rezultate în cadrul proiectului POSDRU 81/3.2/S/53449, ***„Programe de sprijin organizaţional şi formare profesională pentru personalul angajat din sectorul de celuloză, hârtie şi carton în vederea adaptării la dinamica pieţei interne şi internaţionale”*** cofinanţat din Fondul Social European prin Programul Operaţional Sectorial de Dezvoltare a Resurselor Umane 2007 – 2013.
- Miniexpoziţie cu principalele rezultate ale activităţii de cercetare desfăşurată de SC Ceprohart SA (hârtii securizate, hârtii pentru ambalaj produse alimentare, compozite filtrante pentru industria alimentară, suporturi nutritive biodegradabile pentru răsaduri de legume şi flori)

De asemenea, pe durata simpozionului, au fost amenajate spaţii pentru expunerea materialelor de publicitate şi promoţionale de către firmele furnizoare de echipamente pentru industria celulozei şi hârtiei: Voith Austria, SC Aqua D&P Technologies Cluj, Metso Finlanda şi s-au purtat discuţii pe marginea acestora cu toţi factorii interesaţi.

Prin structura lucrărilor prezentate şi a participanţilor, specialişti din industrie, cercetători din institute naţionale de cercetare dezvoltare, universităţi şi firme de consultanţă, simpozionul a asigurat un mijloc eficient de transfer către industrie a rezultatelor cercetării şi prezentarea ultimelor noutăţi din domeniu, de dezvoltare a direcţiilor de cercetare existente şi de identificare a unor direcţii noi, de promovare şi consolidare a unor parteneriate durabile.

Preşedinte al Comitetului de Organizare,
Ing. Dan Buteică