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Printability and Run ability of Papers in Web Offset Printing Technologies

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Abstract*— Paper, ink system and ink setting are most important factors defined the print quality. Towards advertisings, inserts, newspapers, magazines, supplements, catalogues, leaflets paper allows these printing products to have improved printing quality and therefore to have a real chance at the global media market. Today the market demands high quality full-colored newspapers and luxurious magazines that make all these products stand out from the competition. CSWO (cold-set web offset) and HSWO (heat-set web offset) printing technologies are proactive to improve continuously printing quality using high quality publications papers, permanently decreasing production wastes and costs. The success of these printing processes also is a result of using important types of so called mechanical papers. This article is a trial to present these different types of papers in web offset printing, both CSWO and HSWO printing technologies.

***Index Terms*—paper, quality, web offset printing.**

I. INTRODUCTION

Paper affects productivity, quality and profitability, since paper makes up to 50-70% of printing costs.[1] Permanent cost reductions of newspapers, magazines, inserts, catalogues etc. are enabled these printed products to have their position as an attractive and efficient communication medium for advertisers, publishers and industry in general. In general, due to tendency towards shorter runs and faster turnaround times, both web offset technologies with their competing printing process, achieve due market share. Designed for the highest printing speed (more than 11 - 15 m/s) and proven printing processes these technologies help printing companies all over the world to obtain the best efficiency – function optimized, standardized and cost optimized. [2] In addition, changes of graphic art industry allow combine different printing methods in one and popularize so called semi-commercial hybrid technology (CSWO + HSWO). Thus it is possible to achieve high quality level of newspapers and overcome problems as poor setting of inks on standard publication papers. Variety in printing papers quality has spelt the end for many brands, but has also given new print media papers. Paper-makers were forced to bring many tailored specialties to the market-place, particularly in the upper newsprint and magazine field. They launched new standards for NP (newsprint): INP (improved newsprint), recycled NP, colored NP, bulky NP and also new mechanical coated papers like LWC (light weight coated), MWC (medium weight coated), MFC (machine finished coated) or SC (super calandered). All this enables us to choose the best possible base paper which forms a solid foundation for every printing product, involved in the range of web offset technologies.

II. PROBLEM DEFINITION

For the purpose of this paper had been used so called mechanical types of papers. This means they have in their composition variety of wood fibers instead of pure cellulose, like: thermo-mechanical, chemical-thermo-mechanical and recycled fibers as well. Such types of paper base are qualified by light or medium weight of coatings or by treating in super calander rollers. As for newsprint (NP) have been used three different types: virgin NP fully recycled NP and improved INP. NP timely has been used in HSWO technologies, but in our case it was NP of 100% recycled fibers. In CSWO NP of virgin and of recycled fibers is a typical paper for producing newspapers. That is why; in general, CSWO as a printing method is associated with newspapers production. In additional, drying process of inks in these technologies is completely different – in CSWO setting is predominantly due to penetration in paper's pores, it is cold set process. But in the HSWO this process is mainly due to evaporation in the area of gas dryer. All this is a reason to have different inks systems in these two printing processes. From one side we have relative low viscosity inks for CSWO with definite amount of mineral oils, and on the other hand we have more tack and viscous inks with a great proportion of high boiled mineral oils (20-40%), with long molecular structure, which provoke their evaporation inside the dryer integrated in the HSWO printing machine. [3] Low boiling point mineral oils cannot be used here, because they can cause drying on the inking rollers. The former experience showed that inks setting on SC and NP in the HSWO causes drawbacks because they are both uncoated papers.[4] So, in this case are Used modified inks, consisted a small amount of low viscosity mineral oils to provoke their absorption in such types of papers. Hot air drying process in HSWO is realized by adapted gas dryer, named "suspension" dryer: the web is conveyed at high speed through the dryer without contacting any elements surface. Sufficient curing is achieved if the paper web remains within 0,8-1 s in the drying area. [5] For this, if the paper web is conducted at an average speed of 8 m/s, then the dryer is to be at least 8 m long. Passing through gas-dryer (~200°C) the solvents are forced to evaporate. The temperature of the dryer should be set according to the paper grade – the higher the paper grade, the higher the temperature in the dryer. Due to the eventual dehydration the paper web can become fragile and wavy, starting shrinking and causing difficulties in finishing processes. That is why moisturizing is recommended which is executed by water rollers and silicone section, after the dryer. For most cases, drying is controlled by

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visual and manual inspection carried out by the operator. There have been no satisfactory solutions found yet for practical online measurement of the drying. [5] This paper summarize our experience in two web printing technologies using different types of publication papers, known as mechanical papers, as we mentioned above. All results are enough reliable and are of practical importance.

III. PROBLEM SOLUTION

Papers quality in the printing has been evaluated comparatively according to their run ability and printability. This means an inspection and control on papers' behavior and interaction of paper/ink/damping solution in general. In above mentioned technologies have been carried out numerous prints on such kind of mechanical papers, as follow:

- NP – with virgin and 100% recycled fibers, both of 45 gsm (gram per square meter);
- INP – 52 gsm;
- SC – 57 gsm;
- LWC – 57 gsm;
- MWC – 70 gsm.

Our observations of print performance of the variable papers in these two completely different web offset printing processes are differentiated as follow:

- In CSWO we apply NP of virgin fibers, NP of fully recycled fibers, INP and SC;
- In HSWO – LWC, MWC, SC and NP of fully recycled fibers.

First we had inspected physical characteristics of above mentioned different printing papers (Table I). Newsprint is very cautious about the influence of composition, which resulted in the printing process and respective printed quality.

Table I. Physical characteristics of used types of papers

Properties	NP	NP recycl	INP	SC	LWC	MWC
Grade, [gsm]	45	45	52	56	57	70
Bulk, ISO 534, [cm^3/g]	1,48	1,33	1,40	0,9	0,91	0,89
Density, [g/m^3]	0,67	0,75	0,71	1,11	1,1	1,21
Brightness D65, ISO 2470, [%]	61	59	65	72	75	80
Opacity, ISO 2471, [%]	95	93	95	93	93	93
Roughness ISO8791-4 [µm]	-	-	-	1,5	0,9	0,9
Smoothness Bekk [s]	55	>60	65	-	-	-
Gloss ISO 8254-1 [%]	-	-	-	46	58	62
Humidity [%]	8	8	8	6	6	4 – 6

The difference between virgin and fully recycled NP is shown in Table II, where can be seen relative important differentiation between physical properties for both type of newsprint.

Table II. Comparison of NP of virgin and recycled content

Characteristics	Newsprint	SACHSEN
Samples	(virgin)	(100% recycled)
Grade, [g/m²], ISO 536	45,0	45,0
Humidity, [%]	8,0	8,0
Thickness, [µm]	70	62,5
Density, [g/cm3]	0,643	0,720
Bulk, [cm3/g] ISO 534	1,56	1,39
Roughness, [ml/min] Bendtsen	169	163
Air permeability, [ml/min]	215	212
Elongation, [%]	1,5	1,4
Breaking length, [m]	3500	5200
Tear strength, [mN]	206	310
Brightness [%], ISO (D65)	60	58,9
Opacity, [%]	95	93,5
Ash, [%]	~ 3,0	5,6

The methodology of the study included to show optimal inking through measuring of SID (solid ink densities) in selected solid areas of flat tones in order to evaluate quality of inking process on each type of papers. (Table III) Ink's control was carried out according to ISO 12647-2, 3 [6]. Then paper's quality evaluation in printing has been assessed with regard to their behavior patterns according to such criteria as *breaking events and wastages (makulatures).* These criteria have shown their runnability during the printing process and are of great importance for both web offset technologies. Particularly they are significant for newspapers in CSWO and for magazines in HSWO. They define productivity because of utmost importance is that paper runs well. These most relevant criteria, affecting on the running and total quality, are shown in Table IV. In our experience have been used two web printing presses as follow: for CSWO is used web offset *GEOMAN* press and for HSWO is used web offset *POLYMAN press.*GEOMAN is a typical CSWO printing press dedicated for newspapers. Our GEOMAN was configured by four towers each of them of 8-couple printing units. These units involve two H-type printing sections arranged on top of each other. It is set of the horizontal blanket-to-blanket cylinder groups with vertical web lead, permitting for multi-web production, favored for large number of pages involved in newspapers. This is the simplest and most compact configuration for producing 4/4 colors jobs with one single tower. Each printing unit has its own drive, allowing work independently. All inking units operate with pre-dampening. Dampening system is a non-contact, turbo-dampening unit with a kind of oscillator roller, resulted of no reverse transfer of soiling dampening solution to the water fountain. This machine runs a range of different papers

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from 40 to 60 gsm that do not require any additional drying on press. [7] POLYMAN is a 16-pages heat-set web offset printing press, horizontal configuration of 4 printing units, blanket-to-blanket system, equipped by gas-dryer (long 8 m) and multifunctional folder. The jobs were carried out under normal operating conditions (t° ~ 24°C, RH ~ 50%) according to CSWO and HSWO processes, as follow:

• **CSWO**:
- Euro scale cold set inks;
- Colors' sequence: cyan-magenta-yellow-black;
- Standard offset printing plates;
- alcohol free damping solution with 3,5% additive, pH -5,2, t°- 12°C, conductivity- 1500 µS/cm;
- Blanket's thickness 1,95 mm, underline 0,16 mm;
- Average printing speed – 28 - 30 thousands rph.

• **HSWO:**
- Euro scale heat set inks;
- Colors' sequence: black-cyan-magenta-yellow;

Table III. Values of SID on different papers types

Solid Inks Densities on papers, used in HSWO					
Process Inks	NP recycle. 45 gsm	INP 52 gsm	SC 56 gsm	LWC 57 gsm	MWC 70 gsm
Cyan	1,05	1,08	1,15	1,36	1,52
Magenta	0,95	0,98	1,05	1,26	1,44
Yellow	0,85	0,90	1,00	1,17	1,32
Black	1,22	1,24	1,27	1,47	1,67
Solid Inks Densities on papers, used in CSWO					
Process Inks	NP virgin, 45gsm	NP recycl. 45gsm	INP 52 gsm	SC 57 gsm	
Cyan	0,79	0,78	1,15	1,10	
Magenta	0,85	0,85	1,10	1,00	
Yellow	0,76	0,79	0,95	0,90	
Black	0,96	0,95	1,20	1,17	

- Standard offset conventional printing plates;
- damping solution with 6% of IPA (isopropyl alcohol) + 4% additive - pH- 4,8, t°-10°C;
- Blankets (Vulcan Alto ND2), thickness 1,96 mm, underline 0,14 mm;
- Speed of printing press – 36-40 thousands rph.

All results are shown in four tables.

IV. RESULTS AND DISCUSSION

Practically the comparison of papers was carried out on the base of their printability and run ability. The printability refers to the properties which the substrate must have to reproduce the text and illustrations in optimal quality.[5] Such parameters as absorption and inks, drying time, picking resistance, two-sidedness (wire mark), longitudinal and cross profiles under the influence of moisture, thickness and grade, dusting, color density and mottling (uneven solid density) are essential. Physical properties, primarily compressibility, elasticity, humidity, absorption capacity and bulk also have an influence on the runnability. Natural NP is more bulky than recycled NP. INP is characterized by higher brightness, better opacity and high bulk, all these important for achieving max color quality in CSWO. This means better ink's coverage and reduced dot gain. INP with matt surface and better brightness is unique and versatile. All this is suited for many products, like weekend newspapers, comics, inserts. INP provides a bright clear image for newspapers or separate different supplements, flyers, multicolored catalogues etc.

Table IV. Criteria for papers behavior in the printing process

№	Types of Papers	Papers Wastes, [%]]	Breaks [%]
CSWO			
1.	NP (virgin)	2,5-3,5	7,7
2.	NP (fully recycled)	1,57-2,0	4,4
3.	INP	2,5-4,0	7,5
4.	SC	4,5	3,2
HSWO			
1.	NP (recycled)	8,5-9,5	3,5-8,0
2.	SC	6,5-8,0	4,0-6,9
3.	LWC	3,5-4,5	4,5-7,0
4.	MWC	3,5-4,6	3,5-6,5

The business trends of INP are similar to those of virgin NP. Towards SC, due to its surface treatment it is possible to keep their form even, when the weight is light (in our case 56 gsm). SC papers have the highest possible density because of super calandering treatment. That is why very often SC has been selected for high volume catalogues and newspapers publications with excellent runnability and satisfactory of full-color printability. For commercial printing where dominate half-tone four-color images, optical density is the ideal regulation basis which is extremely proper parameter for measuring and regulating the inking accordingly. [8] In our study SID have been measured on control strips printed alongside the images. Different papers have different levels of value of SID, because of the different surface quality and fibers composition as well. The composition also is the reason to have different ink's consumption. In principal ink's consumption can be minimized essentially through optimization of prepress. For instance, to achieve the same value of optical density on NP as on LWC, it is necessary almost twice amount of ink. The common rule is that the ink must be matched to the type of paper – paper physical characteristics define the optimal amount of ink. (Table III) Average results for black on NP are accepted as a normal with ink consumption of about 1gsm.[5] But visual effect of density is logarithmic, which means there is a rapidly diminishing increase of density compared to the increase of ink weight on paper. However visual effect of density and the adverse properties of ink weight on paper tend to be linear. [1] In HSWO the results have shown that SID on LWC and MWC

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are higher than these on SC and NP in the same printing process. (Table III) Three types of papers have almost identical results – INP for both CSWO and HSWO, NP for HSWO and SC for CSWO and HSWO printing. All these optical densities are closed which related to lack of coating and similarity of fibers composition. SC papers despite of their high surface quality like density, gloss, smoothness, have optical solid densities closed to NP which confirmed that coating and brightness are definitely more essential for this parameter and that coating is a important for improving papers reproducible quality. Ink coverage was evaluated by optimal SID values for comparison of papers quality in CSWO. Visual effect of density, inks properties and the purity of the single color tend to have direct correlation. Our papers have different levels of SID and sometimes differences within a single paper grade vary over 15%. This is valid particularly for NP. Used types of papers have significant difference in their surface properties – smoothness, roughness, optical characteristics as brightness, opacity and gloss.(Table I) Printability is influenced by all optical properties and thus they have reflected on the values of inks densities (SID). For NP are achieved the lowest values of SID in CSWO and in HSWO, compared to other type of papers. Comparison shows that the most suitable for high quality commercial HSWO products are LWC (57 gsm) and MWC (70 gsm). As for SC and recycled NP, they are also proper for HSWO printing process, but optical densities on such surfaces are lower, because of inks absorption (partly open surface) and lower papers brightness as well. However, NP (both kinds - virgin and recycled) is dedicated for CSWO and printing process normally is not carried out on another type of paper, which is an important restriction. Quality achieved with this classical print process is known as a newspaper's quality, means CSWO+NP. Comparison between NP of virgin fibers and those of 100% recycled fibers in CSWO shows that densities are almost the same, but setting on recycled newsprint is too poor, causing smearing, set off and marking, so the total print quality was not satisfied. The influence of recycled fibers on the physical papers properties depends on the constituent part in the paper. (Table II) Permanent grow of recycled content involved up to 100% is an alternative for the paper and print productions. But fully recycled NP (in our case Sachsen) is not competitive with virgin NP, particularly towards setting time. Recycled NP has a specific surface - more flat topography, with closed porosity and better smoothness, which makes oils absorption difficult. These difficulties can be eliminated when recycled NP is applied in HSWO process, where operates gas dryer. But on the other hand the big advantage of recycled NP in CSWO is low breaking events. (Table IV) This means better pressroom runnability, without frequent breaks, machine stops and paper wastages respectively. In our case 100% recycled NP had first-class runnability in CSWO together with overall cost efficiency. For HSWO process for all types of coated papers (LWC, MWC) the absorption is not important and the whole amount of ink is forced to rest on the paper's surface due to solvents evaporation inside the dryer. This is one of the reasons for higher values of SID, even with the lower ink consumption, compared to other types of papers which are uncoated. (Table III) Towards ink setting on SC paper in HSWO, except evaporation also here is available a small amount of penetration, due to lack of coating on this paper. For SC and for recycled NP as well, ink setting is accomplished mainly by evaporation and partly by absorption, which is the reason to apply modified inks. To ensure smooth production process papers have to meet the definite requirements related mainly to strength, an important factor especially in web offset printing, where the printing speed is predominately higher. It is influenced by the type of fibers and their alignment in the microstructure of the paper. Thermo-chemical pulp naturally has greater strength than pure mechanical pulp. Also some treatment like super calandering improves mechanical strength. Papers behavior in the real printing process is described by their average breaking events (breaks as a function of type of paper) and by wastages. (Table IV) Web breaks usually occur when the tension is not proper and when there are local area weaknesses in the web or uneven web winding, web wander, web touching in the dryer or adhesion to the blanket. Web break frequency varies between different types of papers and we have found it is in the relative large limits – from 3 up to 8 % for all types of used papers. The web breaks are evaluated per 100 rolls. In HSWO typical web break range valid for LWC and MWC papers is 4 - 6%. As for SC can be said that in some cases this paper had better performance with 4-5 % of breaks which is due to its special surface treatment. As for NP breaks and wastes are better only for CSWO particularly for recycled NP. But when this kind of paper is in HSWO its performance becomes unstable. Therefore NP has to be used rarely in HSWO, only when are necessary to produce low cost high volume products where high print quality is not obligatory. Evidently all this makes necessary the target remains to achieve at least two percents reduction to improve papers runnability.

V. CONCLUSION

In web offset printing processes there are many possibilities to apply especially different types of mechanical papers which can be used for different products. Flexibility of used papers has direct relation to the perceived products quality. Coated papers as LWC and MWC are most important paper's resource for commercial web offset printing (HSWO). But when must be reached low cost paper products it is essential to apply uncoated mechanical type of papers like SC and recycled NP which offer sufficient surface quality and good process performance. For CSWO are suitable uncoated papers like NP, INP and SC as well. Along with NP of natural fibers is favorable a range of recycled grades, even up to 100% recycled fibers. They are distinctive and designed for many uses, with a special touch. Good runnability recognition of fully recycled newsprint has come from the smooth surface

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and high resistance, resulting in good process performance. When necessary to produce special full colored newspapers, on brighter and bulky surface, have to print on INP. HSWO and CSWO are altogether the web fed printing technologies which are the only in amongst of graphic arts industry where there is an endless combination of papers types. The higher the number of papers types the higher the variety of product possibilities and therefore the higher the printing efficiency.

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Rossitza Sardjeva (PhD) is working for Technical University Sofia, br. Plovdiv, as an Associated Professor of Graphic Arts Printing Specialty, where she teaches students for bachelor and master educational degrees. Also she is a lecturer for many years in Book Publishing Department of Journalism Faculty in Sofia "St. Kl. Ohridski" University. Her scientific interests are in the field of printing technologies, including digital printings, printing materials for both papers and inks, where she has a long experience.