MODERN APPROACHES IN THE DESIGN OF SHEET-FED OFFSET PRINTING PRESSES

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Rezumat. *Acest studiu urmărește o analiză comparativă a soluțiilor constructive ale unor elementele componente ale maşinilor de tipărit offset cu alimentare în coli şi influenţa acestor soluții asupra calității produselor tipărite, productivității, costurilor, consumurilor de materiale şi ergonomiei operării. Studiul a fost realizat pe mașini de tipărit fabricate între 1995 și 2015, deținute de CNI CORESI SA, București. Timpul necesar pentru fiecare setare a mașinii a fost înregistrat, s-au măsurat pierderile tehnologice de hârtie, consumul de cerneală și viteza de lucru pentru fiecare mașină de tipărit. S-a analizat modul în care integrarea în construcția mașinii de tipărit offset a unor elemente, care execută operații efectuate inițial off-line, poate scurta ciclul de producție și aduce valoare adăugată produselor tipărite. Rezultatele cercetării au contribuit la optimizarea fluxurilor de producție în concordanță și cu utilizarea cea mai avantajoasă a resurselor umane disponibile.*

Abstract. *This experimental research was conducted on the printing machines manufactured between 1995 and 2015, owned by CNI CORESI SA, Bucharest and it aimed at a comparative analysis of some constructive solutions of sheet-fed presses parts, the influence of these solutions over the print quality, the productivity level, costs, materials consumption and ergonomics of operation. The time needed for each machine setting was clocked, technological paper loses and ink consumption and working speed for each printing press were measured. We also analysed the way in which the integration into printing press of some operations, initially executed off-line, can shorten production cycles and bring added-value to the printed items. The results of the research have contributed to the optimisation of the production flows in line with the most advantageous use of the available human resources.*

Key words: sheet-fed offset printing presses, manufacturing parts, quality products.

1. Introduction

The quality and complexity of printed products depend, to a large extent, on the machines on which they are made. High quality expectations of printing consumers, be they books, magazines, packaging, newspapers, posters, labels or personalized prints, require more and more complex machines. Improved colour

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management, ink and dampening solution temperature control, minimized vibration during the printing process, remote control of the press functions from the control panel, the integration of auxiliary modules in offset printing presses are the advantages of modern technical solutions [1-3]. They provide not only added quality to printed products, but also increased productivity, easy control over machine components, reduced technological losses, or a reduced effort of the operator.

This study presents comparatively constructive solutions of some of the components of offset printing machines. Knowing and analysing these solutions are of great importance both for the proper technological design of the printed products and for the added productivity, quality, time, energy and labour savings, to reduce the production cycle.

2. Construction of sheet-fed offset printing presses

The kinematic scheme and main components of a sheet-fed offset printing press are shown in Fig. 1:

- feeding unit;
- sheet conveyance;
- inking unit;
- dampening unit;
- transfer cylinder, impression cylinder, plate cylinder, blanket cylinder;
- dryer;
- delivery unit.

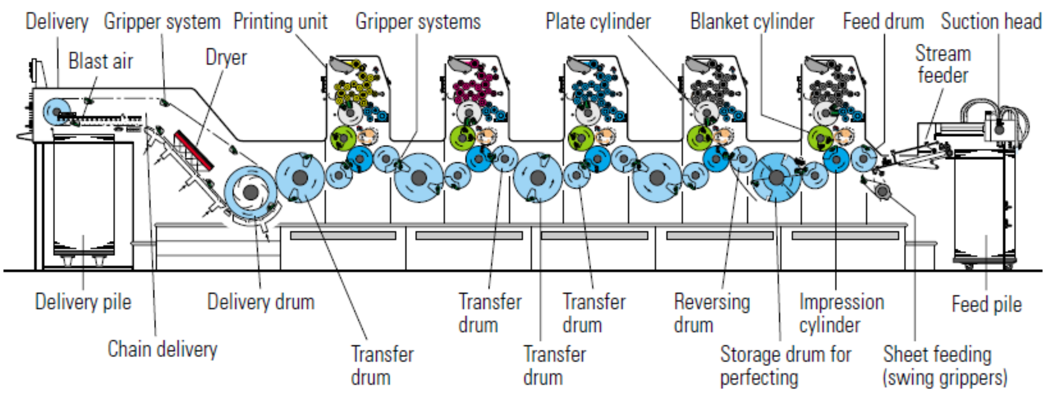


Fig. 1. Sheet conveyance in a sheet-fed offset printing press [1].

In the paper [4] were presented the solutions for the construction of: control shaft and torque transmission to each printing unit, the ink supply system, register control and print technical parameters via the main control console, printing cylinder bearing system.

Fig. 2 presents the most important construction element of a printing press: the printing unit. The relative positions of the plate cylinder, blanket cylinder and the impression cylinder have the greatest importance in achieving a high quality print. This is why the precision with which cylinders and their bearings are manufactured is very high.

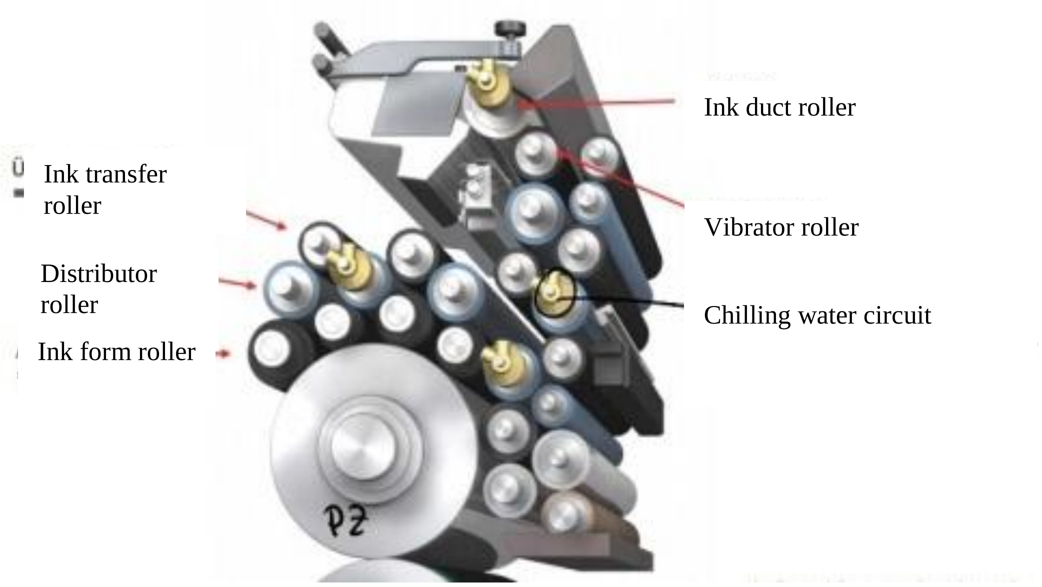


Fig. 2. Printing unit [6].

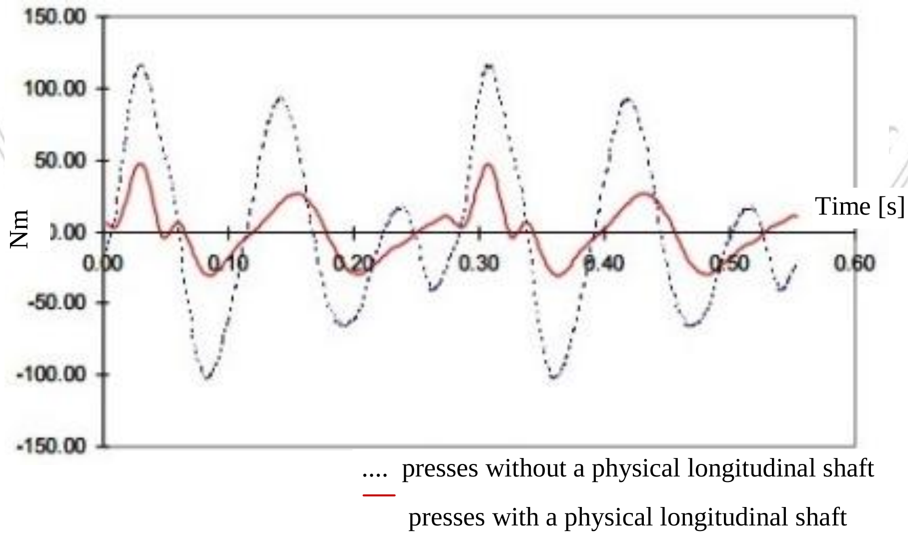


Fig. 3. Drive shaft torque variation diagram between two consecutive printing units [6].

A solution to minimize the vibrations and stresses wheel of the kinematic chains is to drive through a longitudinal mechanical shaft so that the torque is still transmitted to 1-3 additional points by means of conical gears. This solution attenuates the shocks caused by the successive inlet to and from the pressure and reduces by approx. 50% the vibration level (Fig. 3).

The adjustment of the diagonal register is carried out differently by each machine manufacturer:

- Heidelberg Druckmaschinen AG - the plate cylinder position is set using the eccentric bearing mounted on the operator's side;
- Manroland AG - the transfer cylinder position is set using the eccentric bearing mounted on the operator's side (Fig. 4).

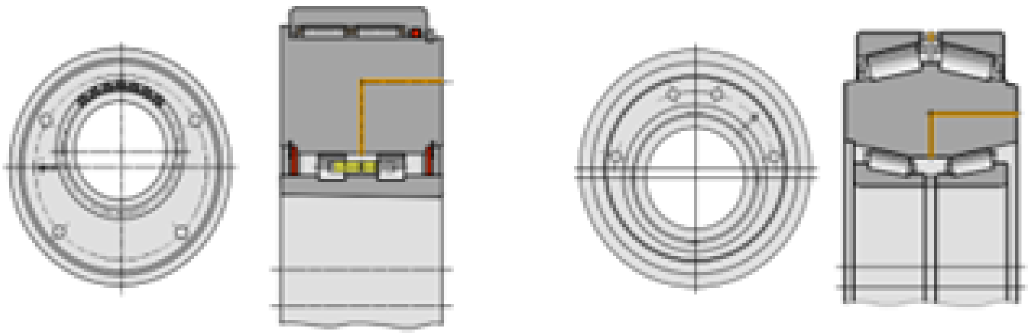


Fig. 4. Eccentric bearings [6].

Ink supply systems are built with non-segmented or segmented distribution blades. They influence the passage from hard to soft tones and vice versa, printing of solids (solid tones).

In Table 1 are highlighted the comparative values of certain technical characteristics that influence the productivity of printing. These were recorded over one month of production, regarding full colour printing jobs.

Table 1. Comparative values of some technical characteristics

The type of fountain ink	*Technological losses (paper sheet /job)*	*Inking setting time (minute/job)*
Fountain ink with steel blade (manual setting)	85	15
Fountain ink with ink slides (remote setting)	35	5

The results presented in Table 1 clearly show the advantage of the ink slides, namely electronic control, by reducing the technological losses by 29.75% and saving the ink consumption adjustment time by 10 minutes per work compared to printing presses provided with steel fountain ink blades.

3. Temperature control of inking rollers

Modern sheet-fed offset printing presses are ordered from a main console (Fig. 5). This is the way to set the optimal dampening and inking level, adjust the overlapping of the four or more colours or adjust the ink roller temperature in order to avoid excessive heating while increasing the working speed of the printing press.

Fig. 5. Main console [5].

A strict control of the ink temperature is a must in order to achieve a high quality print. While the dampening solution temperature control has been solved by the refrigeration, mixing and recirculation unit, a controlled cool water flow inside the ink transfer rollers and the ink duct will keep the inking unit at the right temperature. Without this system, ink temperature, due to mutual inking roller friction, within approx. 45 minutes of press operation, will rise to approx. 50°C. This would change ink viscosity, alter the water-ink balance, and will affect print quality (Fig. 6).

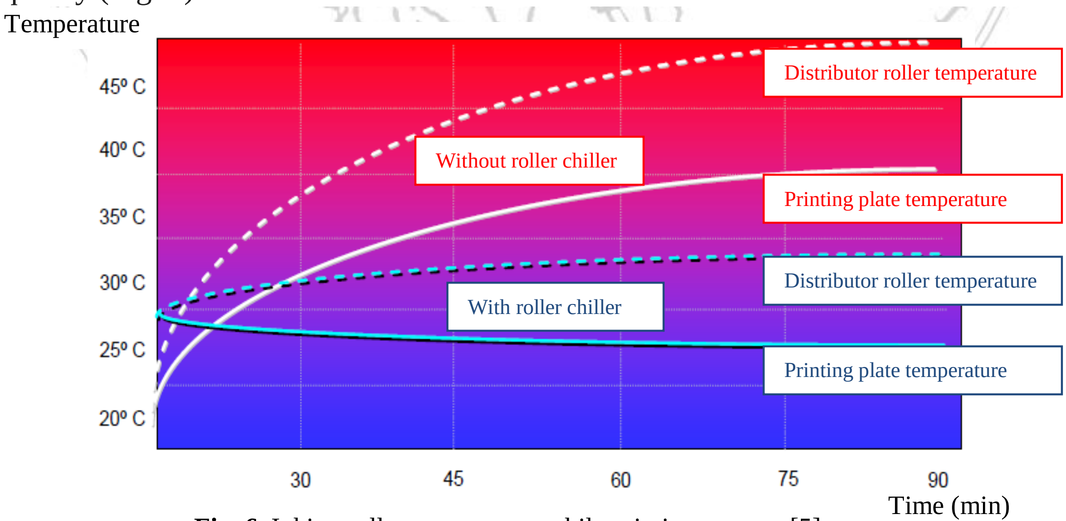


Fig. 6. Inking roller temperature while printing process [5].

4. Perfecting system

Running a printing press with perfecting facility allows printing both sides of the paper sheet at a single pass which is an important feature in terms of printing speed and profitability. The perfector is usually placed at the middle of the press (4+4) or after the first (1+4) or second printing unit (2+4) (Fig. 7).

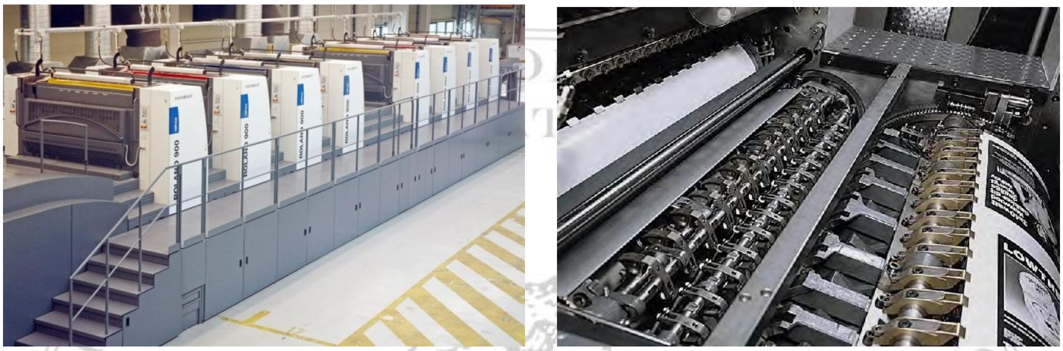


Fig. 7. MANROLAND 900 printing press, with perfector [6].

Usually there are two perfecting systems in order to print the paper sheets on both sides at a single pass: single cylinder system or three cylinders system. Fig. 8 presents a perfector with three cylinders.

Fig. 8. Perfector with three cylinders [6].

The perfector will increase the printing productivity almost two times and reduces the technological losses of paper by 30%.

5. Automatic wash-up systems

The automatic wash-up systems for impression and blanket cylinders (Fig. 9, Fig. 10) help to quickly remove a lot of quality problems for printed matter such as: hickies, printing lint, dirt on the back side of paper sheet, duplication, ink stripping, muddy halftones.

For the printing presses without automatic wash-up system, impression and blanket cylinders cleaning require up to 20% of the work shift, the use of sponges and cloths which need special recovery and neutralization.

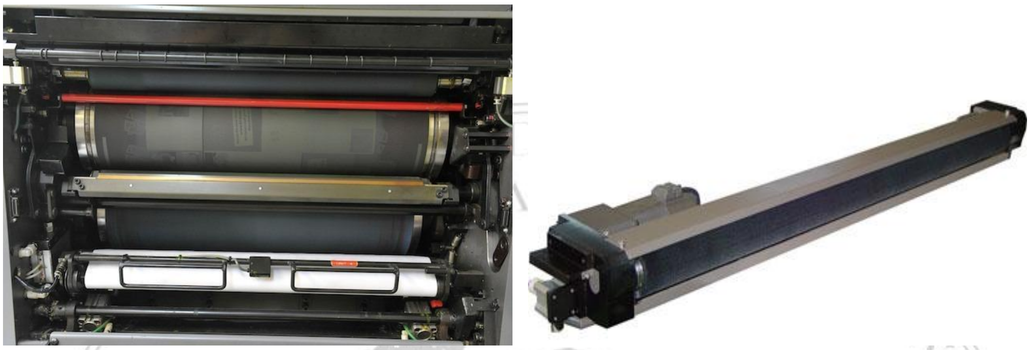
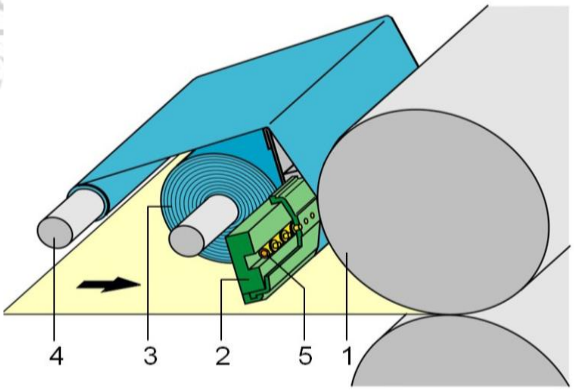


Fig. 9. Brush wash-up system [7].



1. Blanket cylinder
2. Wash-up device
3. Wash-up tissue
4. Used material rewinder
5. Washing device nozzles

Fig. 10. Absorbent tissue wash-up system [7].

Automated systems, using either absorbent tissue or brush, reduce the wash time to less than 5% of the time allocated to a work shift, reduce technological paper losses by up to 30% and the materials and fluids used on scrubbing are totally recovered and recycled (Table 2).

Table 2. Blanket & impression cylinder wash-up systems

Automatic wash-up system	*Manual wash-up*
- short cylinder washing time (5% during a shift)	- it takes 20% of the daily working time only when washing jobs
- cylinder cleaning can be enabled at any time during printing	- generates waste whose neutralization is expensive
- low consumption of washing materials (2 cm material and 50 ml solution / unit / wash)	
- reducing technological paper losses by up to 30%	

6. In-line cold foil application device

The development of the paper and cardboard packaging industry and label production required technical solutions to integrate multiple operations on a printing press in order to save time, materials, working space or energy. A way to improve the look of your labels or packaging is to print some graphic details with gold or silver foil. This process is traditionally done offline, in flatbed die cutters using a heated plate in order to transfer gold or silver foil to the printed substrate, a process that involves high energy consumption and long time heating-cooling the die cutters plate.

MANROLAND AG has developed an integrated system on the MANROLAND 700 and 900 models for cold foil in-line application. The Inline Foiler Prindor (Fig. 11) is mounted on the second and third printing unit of the printing press. In the first printing unit, a special adhesive ink (a primer) is printed on cardboard. In the second unit, the cold foil film passing through the offset cylinder and the pressure cylinder is unwound and gold or silver layer sticks to the cardboard. On the third printing unit the folio film waste is rewound in order to be removed. Further, the printing press prints the cardboard as any normal offset printing press.

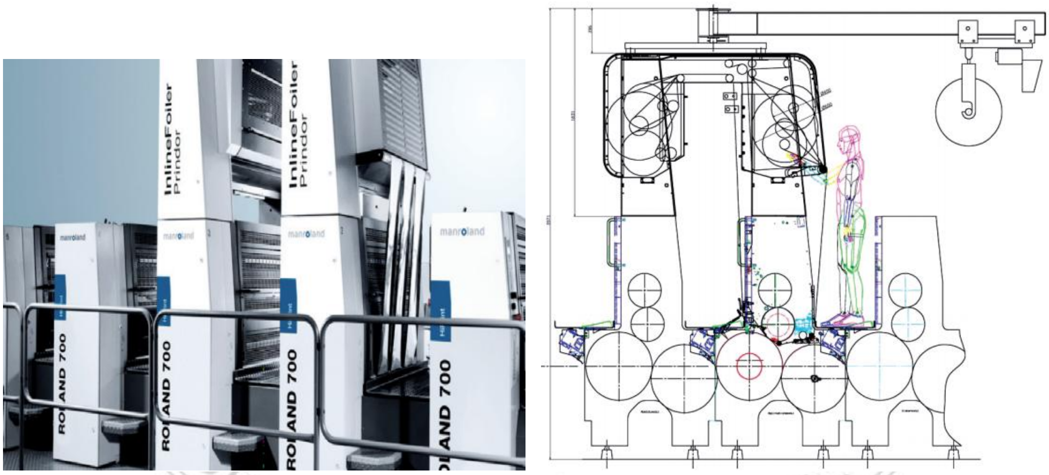


Fig. 11. Inline Foiler Prindor device by MANROLAND [8].

The major advantage is that if non-absorbent media suitable inks are used can also print over the gold or silver areas as well, thereby delivering spectacular graphics. Further advantages would be a perfect register of gold/silver and ink graphic elements and no side effects that could be generated by the carton contact with hot stamping plate.

The system is designed to be able to use 5 to 7 different rolls with different colours or shades on the print width. Apart from the remarkable appearance of the prints, this system brings about other advantages, highlighted in Table 3.

Table 3. Advantages of gold foil application systems

INLINE FOILER PRINDOR	*HOT STAMPING flatbed die cutter*
- printing and cold foil stamping at the same pass; it means 100% time and energy saving for off-line hot stamping	- high energy consumption (approx. 200 kW/h)
- no need of a heated die cutter whose energy consumption is of 150-200 kW/h	- special room needed for die cutter
- no offline sorting operation because the printing press has an automatic sorting feature between the last printing unit and delivery unit	- expensive hot foil clichee (approx. 2 euro/cm²)
- gold/silver cold foil speed 20% higher than hot stamping	- high skilled die cutter operator
- no need for expensive hot foil clichee	- long heating/cooling time
- printing over the gold or silver areas, delivering spectacular graphics	
- perfect register of gold/silver and ink graphic elements	
- no side effects that could be generated by the carton contact with hot stamping plate	

7. Web paper to sheet printing and delivery feed systems

The declining editions and shorter and shorter runs of full colour publications (brochures, magazines and catalogues) made it too expensive to print on web presses. For this new market segment, the printing presses that print from webs and deliver printed sheets are suitable.

This kind of printing presses prints light weight papers at a printing speed close to that of web presses (Fig. 12).

The machine consists of both web offset press components (web feed, paper web tension control system, overlay printing unit design, printing both paper sheet sides at a single pass) and sheet-fed presses specific components (stream feeder, sheet conveyance, delivery unit).

They are cutting-edge machines in terms of printing speed and print quality, and the most important thing is the advantage of using web paper, which is significantly cheaper.

The inline sheeter device consists of a knife and counter-knife system, placed perpendicular to the web feed direction, whose cutting frequency will determine the paper sheet length supplied to the feeder table.

The width of the sheets is the same as the width of the paper web.

Fig. 12. Inline sheeter paper feeding system [9].

The ability to cut variable lengths of sheets solves one of the critical issues in polygraphic manufacturing technology design: optimally fitting the print to the paper sheet size, so the wasted paper will be minimized.

The advantages of this feeding system are highlighted in Table 4.

Table 4. Advantages of the feed system in web-to-sheet paper

Web paper feeding – sheet-fed printing	*Standard sheet-fed printing*
- possibility of cutting variable length paper sheets	- loss of paper in printouts that are in a disadvantageous format compared to the paper size
- web paper is cheaper by up to 20%	- printing presses without perfector need double time to print sheets on both sides
- printing both sides of the paper in the same passage	
- effective print time decreases by 50%	
- energy consumption is approx. 65% compared to successive paper sides	
- the advantage of non-stop feeding	

The only disadvantage: the available range of paper thicknesses printed in these machines is limited to the web delivered papers.

Conclusions

The changes that occurred in the last decade in the printing market have compelled both print and machine manufacturers to adapt their approaches to new consumer needs and requirements.

The process of seeking ways to permanently increase the quality of printed products, diversifying and personalizing them has led to the upgrading of the machines and systems in use, the rapid increase in their automation degree, the change in the structure of the production cycle and the introduction hybrid technologies.

Progressively, much of the operations went under the control of computer assisted systems. This has increased the quality level through better colour management, rigorous control of ink temperature and dampening solution, main console register control, automatic cylinder wash-up systems.

The next step was the integration in printing presses of operations that were initially performed on dedicated equipment such as drilling, punching, gold/silver printing, IR or UV in-line varnishing.

The technical solutions analysed brought to the attention of the management of the National Printing Company CORESI SA Bucharest a variant of the technological structure which has the capacity to meet the quality requirements of their partners, the increased volume of jobs per day which will improve the working speed significantly and will eliminate the unjustified waiting time between printing and finishing.

The comparative research highlights the influence of integrated innovations in offset presses component systems over the time, materials and labour consumption and print quality, as well:

- the results in Table 1. clearly show the advantage of inking remote control, by reducing technological paper losses by 29.75% and saving 10 minutes/job (Roland 700), compared to steel blade ink fountain equipped printing presses, which require manual inking adjustment (Planeta Variant);
- it has been pointed out that printing presses that are driven with a physically longitudinal shaft induce a vibration level 50% lower than synchronous electric drive on each printing unit, resulting in a quality print, with uniform and precise details (Fig. 3);
- it is worth mentioning the perfecting system, which brings a 30% saving of the standard technological paper loss and a doubled printing productivity;

- remote inking and position register control performed from the main console reduces the setting time by 60% per job;
- the automatic blanket&impression cylinder wash-up device saves 15% of the setting time and 30% of the standard technological paper loss (Table 2.);
- the importance of ROLAND's Inline Foiler Prindor systems and the web-to-sheet paper feed from KOMORI LITHRONE was highlighted in Table 3. and Table 4.

The data presented in this study prove that the development of offset printing presses to sophisticated equipment, versatile, fast and highly computerization is underway.

R E F E R E N C E S

[1] Kipphan H., *Handbook of Print Media Technologies and Production Methods* (Ed. Springer-Verlag, Berlin Heidelberg, Deutschland, **2001**).

[2] Ritz A., *Offset Grundlagen, I-Ausdruck* (Stuttgart, Deutschland).

[3] Smithers PIRA, *Print and Production Manual* (11th Edition, UK).

[4] *Soluţii constructive ale maşinilor de tipărit offset în coli şi influenţa lor asupra calităţii imprimării*, article available at address http://www.imst.pub.ro/Upload/Studenti/SSS_2016/lucrarile_sesiunii_stud_**2016**/L01_Cazac_Viorica.pdf.

[5] Print Media Academy, *Konstruktionsmerkmale von Bogen-Offsetmaschinen* (Heidelberg, Deutschland).

[6] Dörsam E., *Konstruktionsprinzipien im Druckmaschinenbau*, (Technische Universität Darmstadt, Fachgebiet Druckmaschinen und Druckverfahren, Deutschland, **2012**).

[7] https://www.google.ro/search?q=automatic+wash-up+blanket+device&espv.

[8] http://ftp.manroland.us.com/printvalue/pdf/inline_foiler_prindor.pdf.

[9] https://www.youtube.com/watch?v=EeiIaDJOHOg.