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MECHANICAL STRENGTHENING TECHNOLOGY FOR CYLINDER SHAPED DETAILS IN PRINTING MACHINES

A new technology of strengthening and recovery of details based on vibration roll burnishing is offered in the present article. Experimental work and scientific conclusions are described.

Keywords: mechanical strengthening, detail, printing press, surface, cylinder, wear.

Introduction and background

Cylinder shaped parts are one of the mostly used in printing presses. Its working characteristics should prevent doubling and ghosting effects, slur, incorrect ink transfer and other problems. Inking and dampening rollers, plate, offset and printing cylinders, transfer cylinders are one of the main parts of every sheet-fed machine. Metals and hard metals are widely used for production of such details [1].

Usually one of the main factors of destruction in printing machine's details and parts during their working life is the surface. After few years of usage there are a lot of chafed places, tear and wear marks, microcracks and pulldowns appear on cylinders and rollers of printing machines, especially in offset printing. In such situation printing houses really need the system and different methods of prevention such defects and decreasing of tear and wear processes in printing equipment.

Increasing of service life of parts and assemblies of printing equipment, their usability is achieved by a variety of methods, like mechanical handling and superficial plastic deformation methods, as well as trapping decoration and strengthening technologies causing corrosion resistance and other types of coverage [2].

Mechanical, chemical, thermal and laser strengthening was analyzed before general scientific and experimental work. Analyze of all possible variants showed that the most cost-effective, efficient and short way of changing the detail's surface, especially for cylinder parts of printing presses, with online hardening and strengthening is mechanical technology [3].

In some of the works developed technological processes enhance usability detail using chromium and finishing-strengthening processing [4, 5]. Such technological features and limitations do not allow the printing houses to use the results of previous studies when restoring journals of shafts, rubber coating and

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inking shafts, current repair surfaces of offset cylinders etc. Other development dedicated impregnation aluminum, grey, zinc, silicon [6], but the question of development of the whole system is not considered.

According to the results of theoretical and practical researches, one of the most effective solutions for prevention of tear and wear processes of such details is mechanical finishing strengthening based on modified technology of vibration roll burnishing [7]. The method is not used in printing industry, but well-known in other areas of mechanical construction. It is based on strengthening of surface with a help of micro deformation of material's top layer under vibration and rotation. As a result surface got additional molecular strengthening in the areas outside of micro relief (see Fig. 1).

There are different types of single and elaborated surfaces after strengthening. Different workloads, specific working conditions and types of mechanisms require different geometry of the micro relief on surface (see Fig. 2).

Looking for specific of a printing presses, the most reliable and universal type is fully regular surface microrelief (also known as IV type of microrelief). This can be

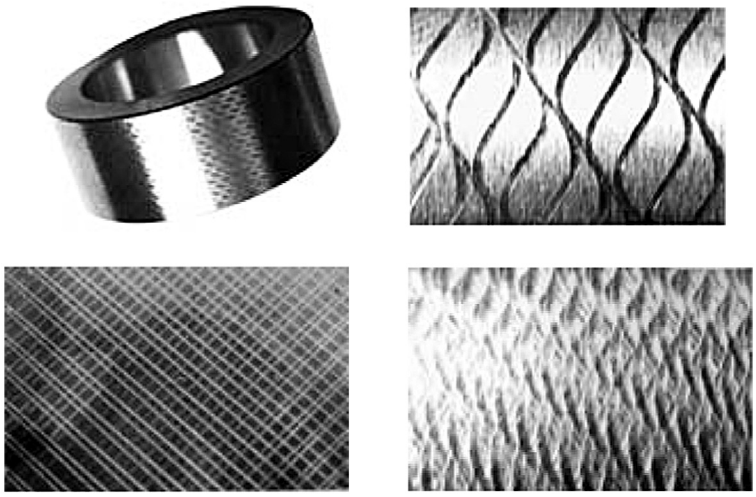

Fig. 1. Different types of surfaces after vibration roll burnishing and strengthening

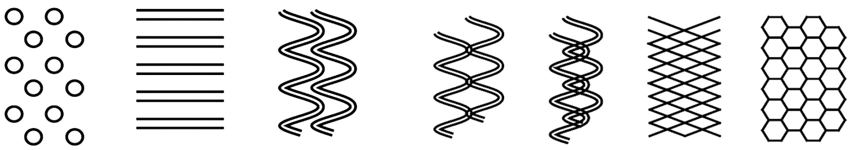

Fig. 2. Geometric types of relief after strengthening of machines parts

used for strengthening of surface of dampening and inking rollers before dressing the rubber surface [8], offset cylinders before installing underlay and offset blanket [9], ductor rollers in incing unit etc.

In the same time, some of the details like driven shafts or transfer cylinders require different geometry because of kinematic specific of paper release. For such applications semi-regular microrelief can be used [10]. Combination of this technology with complex system of equipment control brings a lot of benefits, such as increasing the working time, production efficiency etc.

Methods

Theoretical methods of research

One of the main theoretical works in CIS based on technology of strengthening was presented by Dr. Feldman, Dr. Shneider and also adopted in works of Dr. Zenkin. In different years scientists were using method of vibration roll burnishing, but never for printing presses and such details, like offset and impression cylinders, ink and dampening rollers, grippers and gripping parts.

One of the biggest benefits of method is based on changing of the surface contact area together with strengthening of details. This parameter dramatically increase adhesion between contact pairs «metal—rubber», «metal—paper», «metal—metal», increase capacity of oil lubrication, increase precision accuracy of gripper mechanism which contacts with paper [11].

For a variant of forming tetragonal structure with strengthening by fully regular microrelief the full surface has deformation. The most problematic is calculation of place where the lines are crossed (this should not be calculated twice in the formula of contact area). Surface contact area can be showed in formula (1).

$$S = 2\pi Rlk, \qquad (1)$$

where R — cylinder radius, l — cylinder length, k — increasing coefficient.

The last parameter can be showed (2):

$$k = \frac{S_p(r,d,a)}{d\sin\alpha}, \qquad (2)$$

where $S_p(r, d, a)$ is area of tetragonal rhombus.

Solving (2) can bring to the final formula:

$$k = 4\frac{r}{d}\,\mathrm{tg}\frac{\alpha}{2}\arcsin\left(\frac{d}{2r}\sin\alpha\right) - \frac{1}{2}\left(\frac{2r}{d\sin\alpha}\right)^2 * \left(1-\sqrt{1-\left(\frac{d}{2r}\sin\alpha\right)^2}\right). \qquad (3)$$

To adopt (3) for standard measurements:

$$k = 4\sin^2\frac{\alpha}{2}\left(\frac{2r}{d\sin\alpha}\right)\times \times\arcsin\left(\frac{d}{2r}\sin\alpha\right) - \frac{1}{2}\left(\frac{2r}{d\sin\alpha}\right)^2\left(1-\sqrt{1-\left(\frac{d\sin\alpha}{2r}\right)^2}\right). \qquad (4)$$

This mathematical method was developed to decrease the quantity of measurements and for making computer program for recommendations to make experimental part of work.

ISSN 2077-7264.— Технологія і техніка друкарства.— 2014.— № 2(44)

ISSN 2077-7264.— Технологія і техніка друкарства.— 2014.— № 2(44)

Experimental methods of research

When analyzing a workload, which is common for all types of offset printing machines, one of the most important factors in decreasing of detail's working condition is appears. It is the processes of tear and wear, corrosion and attenuation. There are a lot of different factors can cause such processes, but printing house's management can't avoid all of them — because of the specific of offset printing.

There are three main groups of factors which are influence on durability of the equipment — component type, workload and production. This means that changing of one will change all processes of tear and wear in mechanism parts. Production manager cannot decrease or move out some of them (f.e., humidity or paper dust), but it is possible to control them and achieve the best standards. In the same time we know, that every company is working in a competitive market, the workload must be on maximum. So, printer will change or cut this group — increasing of the runs means better progress in economic efficiency.

But looking only for a production factors, like service, preventive overhaul or maintenance rate, it is reasonable to remember about preventive factors — component type. To predict tear and wear printing house and manufacturer of equipment can:

— change material of the component;

— change working accuracy;

— improve surface coating;

— change type of the surface etc.

Some of these methods are not effective; some can bring additional benefits to the production process. During the analysis which was made in the Ukrainian printing houses some main problems were found. The main — is dependence between workload for printing machinery and tear/wear rate, control system which is working at production, preventive overhauls and quality of printing. In the same time, paper dust, aggressive chemistry, dampening solutions and other factors are lead to progressive declining of printing equipment and its components.

During the test a few main groups of factors were analyzed. The main task was to analyze the level of influence of mechanical strengthening to tear and wear processes. One of the main characteristics to be controlled was quality of printed sheets.

Special algorithm of recovery and mechanical strengthening was offered. Test was made on a different types of printing machines (Heidelberg, KBA, Adast). Duration of analyzed period was set up to 2 years.

As a main quality parameter, which shows quality of working characteristics on the machine, ink register accuracy was chosen. Other parameters to control: dot gain and reproduction contrast.

Results

Engineering part

A new apparatus for vibration roll burnishing was developed for the experimental part of research. It is based on special vibration

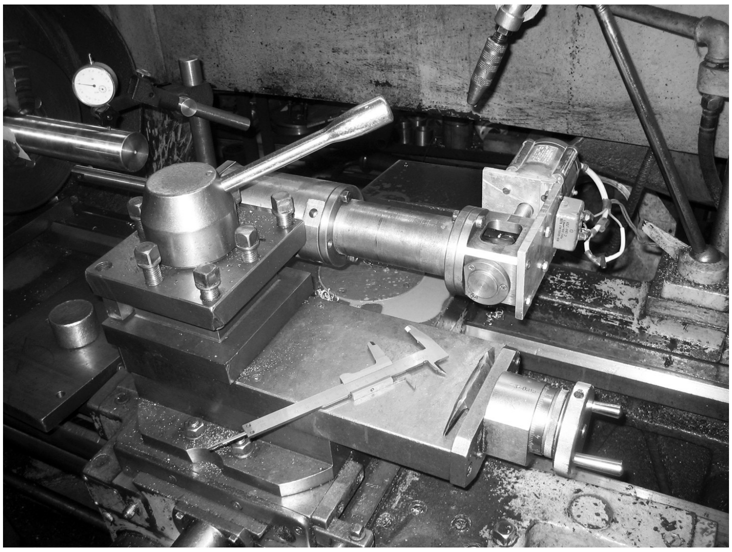

Fig. 3. Apparatus for mechanical strengthening of cylinder shaped details built on machine 16K20

impulse instrument with diamond tool which was installed on standard machine 16K20 (see Fig. 3).

Materials where chosen according to the surface characteristics of details. In general, during vibration roll burnishing the S parameter should be controlled (axial feed), P (pushing power), N (frequency) and n (amplitude) should be adopted. The variation of shapes, sizes and placement of microrelief on the surface achieved with changing of parameters: S; P; N; n_s. Dependence of the depth of the channel power (line of microrelief) handling should be found experimentally. Looking for kinematics features of the details, the parameters was chosen carefully: n_s = 40 revo, S = = 2,5 mm/turn., $n_{d.t.}$ = 1400 min.$^{-1}$, e = 1,5 mm, i = 35, P = 80 kg.

Constructional part

During the experiment the main object was the offset printing press Heidelberg Speedmaster SM 102-6 with Alcolor system. In this machine the printing group consists from 21 shafts (see Fig. 4). The group consists from: 4 ink rollers (1–4), 5 distributing ink rollers (8, 10, 13, 18), dab (20),

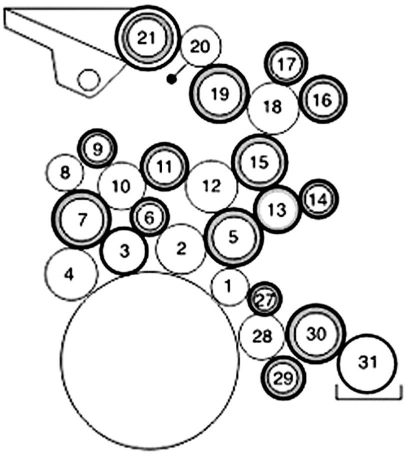

Fig. 4. The scheme of ink and dampening rollers with mounted microrelief in a printing press Heidelberg Speedmaster SM 102 with Alcolor system

ISSN 2077-7264.— Технологія і техніка друкарства.— 2014.— № 2(44)

dampening rollers (22, 23, 25, 28) etc.

In general case a process includes: the removal of group of ink rollers (1–4) from a printing press, defectation, enhanceable wear of necks, delete of old rubber coverage, rolling, on rollers (with the diameters of D1 = 42,0 mm, D2 = 52,0 mm, length L1 = = 1087,8 mm, hardness HRC 57–60) fully regular microrelief of IV type.

As known, in a process the most critical are parameters of inflicted microrelief, and modes of operations of equipment which is used for its mounting. Going out from kinematics features the amount of turns of spindle (n_s), eccentricity (e), oscillation of instrument ($n_{d.t.}$), feed of detail (S) and correlation (i) which determines the mutual location of inequalities. For this case the parameters was: n_s = 40 revo, S = = 2,5 mm/turn., $n_{d.t.}$ = 1400 min.$^{-1}$, e = 1,5 mm, i = 35, P = 80 kg.

After the mounting of the microrelief, the rubber is mounted, and then the process of vulcanization starts. After the facing process to the width 1035 mm, the roller is placed on polishing machine, making a polish, conduct the static balancing. The last step was printing test with measuring the register accuracy, dot gain and contrast. The same technological steps were made also for other details.

Printing technology part

To increase adhesion for rubber to metal body of inking roller a fully regular microrelief was applied. Increasing of contact area was reached on 10–50 % (after changing radius of instrument head) or 10–40 % (after changing of pushing power, see Fig. 5.

Increasing of adhesion between rubber and metal allowed achieving better productivity and working life of inking and dampening rollers. The tear and wear resistance during the test run with UV inks was increased on 60–90 %.

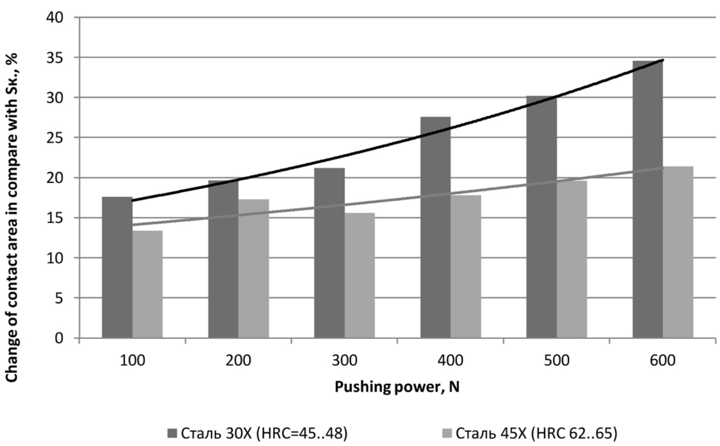

Fig. 5. Dependence of contact area from pushing power of instrument for steel 30X (HRC = 45…48) and steel 45x (HRC = 62…65)

ISSN 2077-7264.— Технологія і техніка друкарства.— 2014.— № 2(44)

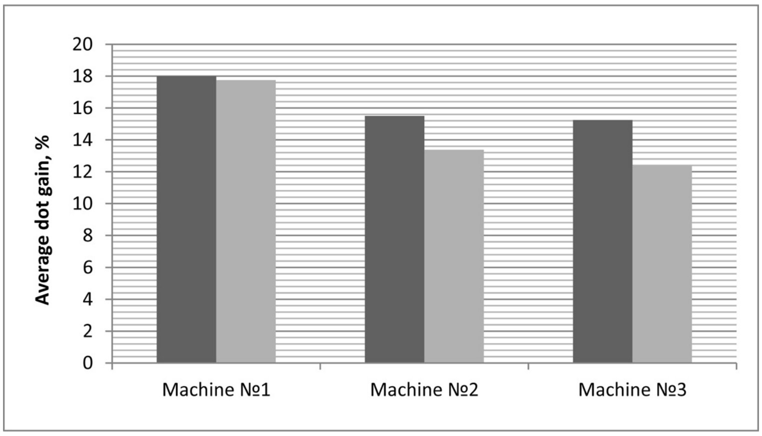

Fig. 6. Average dot gain during printing before (dark) and after (light)strengthening of the surface

Mechanical strengthening of other details, like offset, impression and transfer cylinders was made with semiregular and fully regular microrelief (II and IV type).

Tear and wear resistance was increased up to 34 %. In the same time interesting result was shown on parameters of quality. Dot gain (parameter which shows increasing of raster area after transfer on paper from offset plate through blanket) was much lower than before mechanical finishing (see Fig. 6).

The calculation for dot gain parameter is:

$$\Delta S = \frac{1-10^{-D_p}}{1-10^{-D_{пл}}} - \frac{1-10^{-\frac{D_p}{N}}}{1-10^{-\frac{D_{пл}}{N}}}, \quad (5)$$

where D_p — optical density of raster field or solid, N — coefficient of Jul-Nealsen (n-factor).

This effect takes place because of the specific of printing contact. In the process of printing ink transferring from inking rollers to aluminum offset plate and then to offset rubber blanket. This material consists from rubber surface, textile and compressible layers.

When having a workload, it squeezes, and has some microdeformations. The main loses goes from small moves which blanket has on the metal surface of the cylinder (see Fig. 7). Vibration roll burnishing increased contact area and printing blanket covers offset cylinder

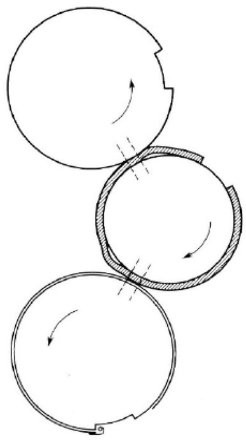

Fig. 7. Scheme of micromoves of printing blanket in the process of printing

ISSN 2077-7264.— Технологія і техніка друкарства.— 2014.— № 2(44)

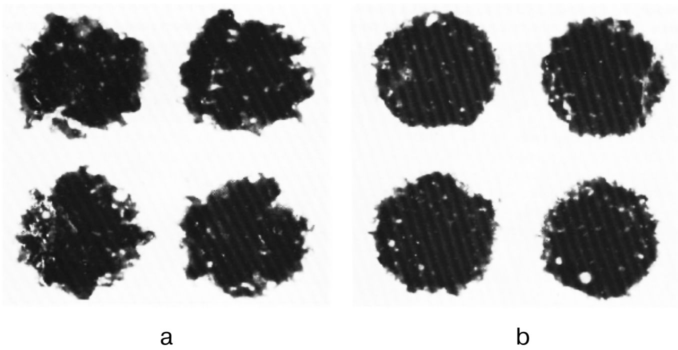

Fig. 8. Dot shape before strengthening (a) and after (b), dot gain decreased

more accurate and allows reaching of sharper dot reproduction (see Fig. 8). It brings higher contrast during printing, lighter impression and better conditions of color reproduction.

The last part of experiment was made on sheet transfer system, especially on transfer and perfecting cylinders. Vibration roll burnishing allows increasing of work stability (less double-sheets) and its accuracy (see Fig. 9).

Discussion

As the experimental part shown, the modified technology of vibration roll burnishing can bring new benefits to a printing process especially during the recovery process of cylinders, driven shafts and other cylinder shaped details. It cannot be widely used in small and middle-sized printing houses, but it shown a high efficiency in big printing houses, like Banknote Printing

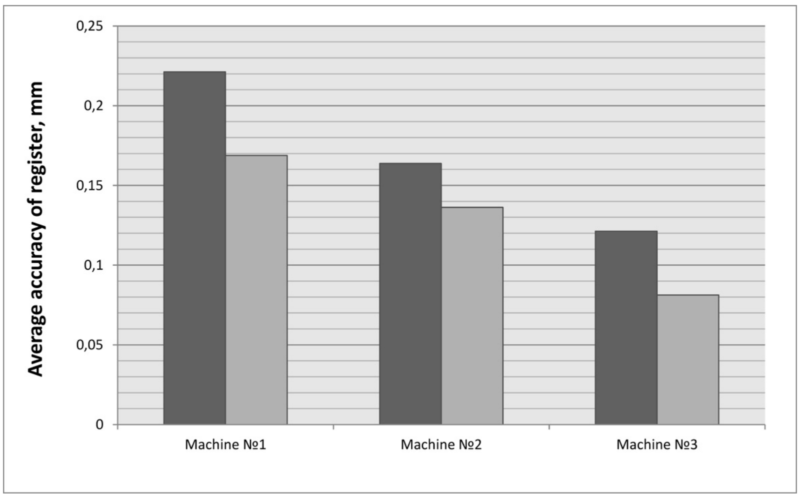

Fig. 9. Average register accuracy during printing before (dark) and after (light) strengthening of the surface

ISSN 2077-7264.— Технологія і техніка друкарства.— 2014.— № 2(44)

Factory of Ukraine and others which take part in the present research.

Technology and offered methods of its usage allows increasing the most problematic parameters of every spare part: contact area and tear resistance. This brings new possibilities of usage polymer materials in pair «metal—rubber» and guarantees a better contact filling of surface of details like inking and dampening rollers, cylinders etc. The presented results and technology are covered with patents of Ukraine and approved with more than 10 printing houses of different sizes.

One of problematic questions which were found during the presented research was connected with strengthening of cylinders. The recovery methods which are usually offered when the pull-downs appears on the surface of cylinders are expensive and don't allow increasing of their working characteristics. Offered technology can solve the problem, but increase the terms of recovery and service for 3–5 days. Other problem connected with usage of cylinder packaging after the process. The standard underlay calibrated board and polyester foils are not recommended, because it can ruin the results shown on Fig. 8. One of the possible ways is to use compressible underpacking from manufacturers of the printing blankets or use special underlay on polyurethane base.

In general, technology can bring better service results and helps to achieve better tear and wear resistance, higher connection between rubber and metal parts of printing press, more accuracy during printing and higher usage of working time because of increased service life of different details.

Conclusions

The technological process and the results of the researches allow argue about the high efficiency of system process based on vibration roll burnishing. Its usage allows to increase the adhesion of rubber to the body of the shaft, upgraded the wear resistance when printing UV inks and allowed to reduce the frequency of scheduled recovery of shafts in 1.6–1.9 times. The register accuracy was increased and dot gain was much lower. The dot reproduction became harder.

Among other advantages of strengthening with vibration roll burnishing:

1) Increasing of life cycle of spare parts and mechanisms in offset printing equipment on 30–40 %;

2) Less time usage for maintenance and service stops;

3) Decreasing of mistakes during the process of printing with conventional and UV-inks.

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Друкарська машина є важливою частиною будь-якого поліграфічного виробництва і потребує значних капіталовкладень. Механізми, які використовуються в даному обладнанні мають бути надзвичайно точними, адже це впливає на якість друкованих відбитків. Агресивне середовище, таке як фарба, концентрати зволоження, паперовий пил, зростаючі навантаження, робота в дві чи три зміни, призводять до швидкого зносу окремих деталей та вузлів друкарського обладнання. В результаті, друкарська машина частіше виходить з ладу та не дозволяє отримати відбитки відмінної якості. Існує велика кількість технічних рішень, які можуть попередити процеси передчасного зношування, проте більшість з них або неможливо застосувати до деталей циліндричної форми, або вони потребують значних капіталовкладень, що не завжди виправдано. В даній статті запропонована новітня технологія відновлення деталей та наведені результати її практичного впровадження.

Ключові слова: механічне відновлення, деталь, друкарська машина, поверхня, циліндр, знос.

Печатная машина является важной частью любого полиграфического производства и требует основательных капиталовложений. Механизмы, которые используются в оборудовании такого типа, должны быть особенно точными, так как это непосредственно влияет на качество оттисков. Агрессивная среда, такая как краски, концентраты увлажнения, бумажная пыль, повышенные нагрузки, работа в несколько смен, приводят к преждевременному износу отдельных деталей или целых узлов печатной машины. В результате преждевременного износа деталей, печатное оборудование чаще выходит из строя, а его техническое состояние не разрешает получить высококачественные оттиски. Существует большое количество технологических решений, которые позволяют решить проблему преждевременного износа, но они либо требуют огромных и не всегда оправданных капиталовложений, либо не могут

быть применены ко всем типам деталей, в частности, к цилиндрическим. В данной статье представлен новый метод восстановления деталей, а так же описаны результаты его практического внедрения.

Ключевые слова: механическое восстановление, деталь, печатная машина, поверхность, цилиндр, износ.

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