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EUROPEAN ROTOGRAVURE ASSOCIATION

APPLICATION OF HIGH-SPEED CINEMATOGRAPHY IN ROTOGRAVURE

Paper presented to the ERA Meeting
in Amsterdam

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HSC is increasingly used in science and industry, as has become evident also at the 6th HSC Congress in The Hague. High-speed cameras with their illumination equipment permit high-speed operations to be time-extended and analysed from both the quality and quantity point of view.

If possible, the motions to be studied should be photographed in such a way that the motional direction crosses the optical axis of the camera diagonally. Besides it has to be considered that the motions taking place in three-dimensional space are reduced to one level. Consequently, special photographic techniques (such as stereoscopic photography and projection) are required for the exact analysis of complex three-dimensional motions.

By means of HSC, which permits any time transformations to be applied, it is possible to make motion analyses which practically are not limited by the time factor of the operations. The time introduces a third dimension to the two-dimensional screen image. With this method of analysis being used, the objects to be investigated are hardly affected.

Today HSC is applied by the entire machine-building industry, for the study of processes, by military technics, by stratosphere technics, and last but not least by medicine and biology for the investigation of mechanical, chemical, electrical and physiological operations. For engineering purposes commercial cameras of different design and size of image and with frame frequencies of 400 - 20,000/s, under certain circumstances even of up to 100,000/s, are most frequently used. For super-rapid and continuous photography cameras equipped for frequencies of more than 4 million B/s and used with cerr cells exist. Naturally colour films can also be used.

<u>Total Information of a Cinematographic Series of Frames</u>:

Space Resolution x Time Resolution

$$\boxed{I = F \cdot n^2 \cdot \ln k \cdot f_w \cdot g^{2/3}}$$

a) <u>The Space Resolution</u> can be expressed as the number of seperately distinguishable points contained in one image.

$$\boxed{I_R = F \cdot n^2 \cdot \ln k}$$

(F = denotes the area of the image
n = the resolution in lines per millimeter
k = represents the number of test steps, values of tone and colour)

b) <u>The Time Resolution</u> is given by

$$\boxed{I_T = f_w \cdot g^{2/3}}$$

(where f_w is the frame frequency and g is the quality coefficient, which equnals t_w/t_p, where t_w is the time between successive frames and t_p is the exposure time of a film point)

H. Schardin (5. and 6. Int. Congress on High-Speed Photography 1960/62)

<u>FIGURE 1</u>

indicates the relations which Professor Schardin established with regard to the information content of screened HSC pictures (lenticular screen).

For the evaluation of HSC shots it will in most cases be sufficient to watch the time-expanded operation by projecting the time-marked films onto a screen.

The gravure printing technique also comprises a great variety of working phases - starting from the preparation of the printing formes and ending with the delivery of the finished products - which give rise to a number of questions regarding kind, place, cause and time of origin of important operations.

HSC makes it possible to carefully study such super-rapid procedures and to evaluate them. By this means sources of error in the working process and shortcomings in the mechanical construction can soon be discovered and eliminated and optimum working techniques be established. The photographic analysis of rapid motion phenomena is justified not only from the economic point of view but also with regard to fundamental research.

The first graphic arts institute in Germany to deal with HSC was, as far as I know, the Darmstadt Institut für Druckmaschinen und Druckverfahren (IDD).

Before demonstrating by phase pictures a few examples taken from the Institute's sphere of activity I may outline various fields of application, which seem to me to be of particular importance with regard to the photographic analysis of high-speed motional actions:

- Observation of the function especially of machine units which are susceptible to breakdowns such as gears, doctor blade drives, autopasters, folders, stitchers;
- Investigation into the entire paper run in rotary presses;
- Investigation into the behaviour of the paper at the moment immediately after passing through the printing nip, under special consideration of the forces acting from the ink;
- Investigation into the ink splitting process and the problems involved;
- Investigation into the ink transfer onto the paper;
- Investigation into the sliding friction in the contact area between two cylinders.

The IDD has made a number of motion analyses in these fields. They will be mentioned in the following. For these analyses a Fastax camera and/or a self-built drum camera were used along with high-frequency flash lights (e.g. Strobokin). Occasionally micro-cinematographic equipment was employed.

The investigations were made partly in production run presses and partly in test machines. In most cases it was difficult to photograph procedures in the press because of the limited accessibility and the unfavourable illumination possibilities of the units concerned.

The following phenomena were investigated:-

- Folders, in particular with regard to the formation of so-called "dog's ears";
- Function of the folding elements;
- Mechanism of sheet separation from the feed pile and obstruction in the sheet delivery of sheet-fed presses;
- Side front deformations of inking rollers;
- Behaviour of the paper immediately after leaving the printing nip and picking process;
- Ink splitting, investigation into the rheological properties as a function of their geometric ambiency;
- Staple formation during high-speed stitching (the major causes of defects were found to be heavy and irregular bouncing of staples and sliding-off of guide rolls from eccenters).

Recently, HSC investigations into gravure ink transfer have been commenced. Perhaps more detailed information can be supplied at the next Meeting of ERA.

As most HSC pictures are of a confidential nature and as, moreover, the time for this lecture is limited, only a few phase slides shall be shown here:-

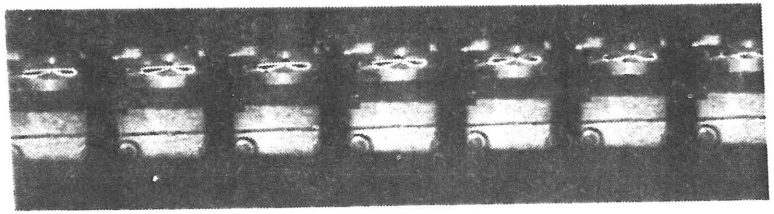


FIGURE 2

Figure 2 shows the staple mechanism, i.e. the stitching tool and the two slot holes for the stapling wire. The photo indicates six phases without paper feed. You will see that the staple is nicely balanced in the so-called "apple pip", which is the depression in the stitching cylinder. It also becomes evident that the wire has been bent symmetrically. A phase slide does not show much, a film divulges many more details.

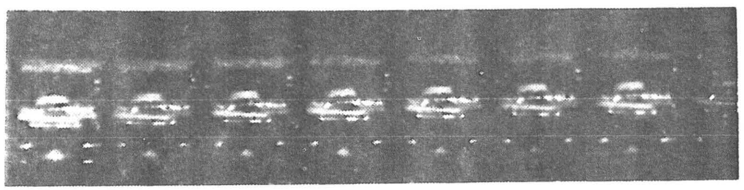


FIGURE 3

Figure 3 shows the same system, however, with paper feed. You see the paper and the staple, which has not yet been closed. In this case the staple formation turned out to be unsymmetrical because the folder did not work properly. After 11,000 stitching operations the formation of the individual staple was no longer satisfactory. The reason for such poor staple formation will be explained by the following slides.

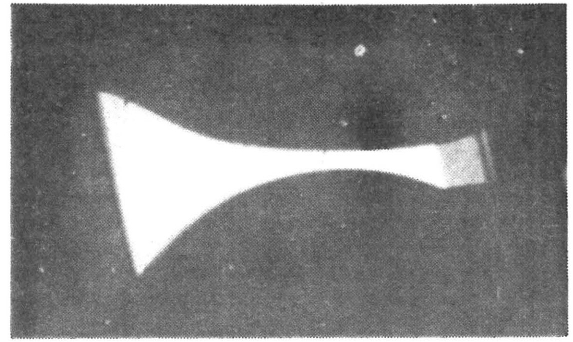


FIGURE 4

Until up to approx. 8,000 cylinder revolutions per second the guide roll for the stapling tool still rested on the eccenter.

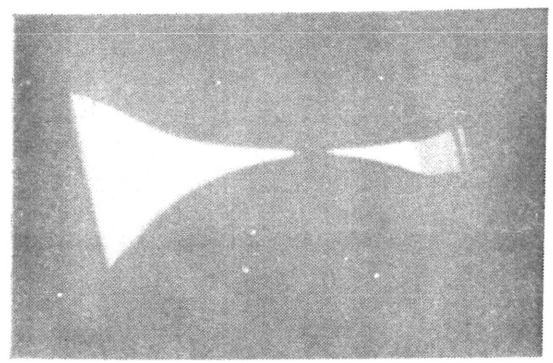


FIGURE 5

At slightly higher speeds, perhaps at 12,000 revs/sec. the guide roll slides of the eccenter by some tenth millimeters, which proves that th spring has not been calculated correctly This is a positively connected guide.

In such case the pri ter cannot do anythi The stapling system simply is not equipped for such high speeds, it has bee incorrectly designed. Incidentally, in the present case the stapling system had not been mounted properly. The machine manufacturers are to blame for such defects.

FIGURE 6

shows how between two folding cylinders the edges of the paper get unsteady and tend to form turnovers.

FIGURE 7

Figure 7 indicates this phenomenon more distinctly. Here we see the formation of turnovers between two folding cylinders. This drawback can frequently be remedied by installing or correcting a guide roller.

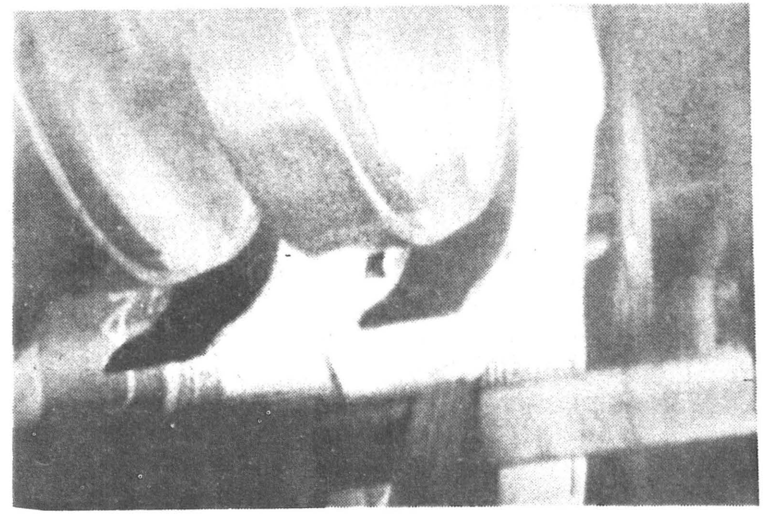


FIGURE 8

Here the formation of turnovers is shown and also the formation of so-called dog's ears at the drum delivery.

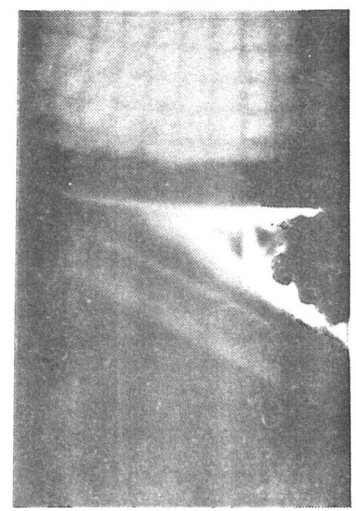


FIGURE 9

Here no longer mechanical processes of a machine-technical character are shown. This slide illustrates the ink splitting process on a type of offset cylinder. The picking phenomenon is shown quite clearly. Picking of course depends on the type of paper which is used, on ink viscosity, speed and many other factors. At any rate high-speed cinematography permits us to trace the individual phases very precisely. In the present case naturally, a microscopic system was used.

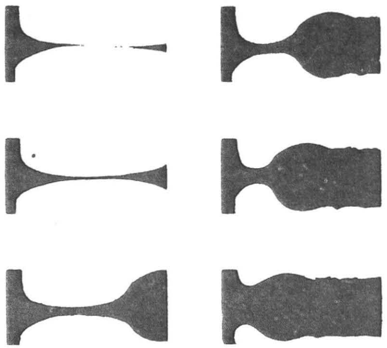


FIGURE 10

Figure 10 shows phase phenomena arising from the ink splitting process of the platen printing technique. Here no more than six phases are illustrated. Of course, they do not appear in such a close sequence, the present picture is only for demonstration purposes. Here the type of threading and the length of the thread becomes evident, also the distribution on paper and printing forme is shown.

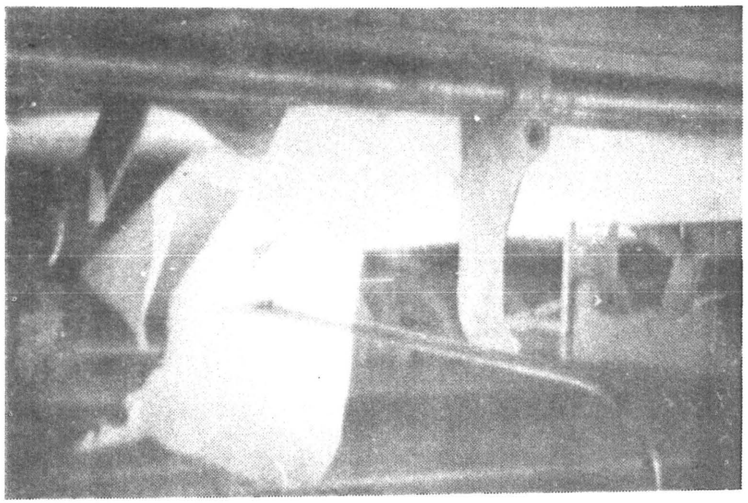


FIGURE 11

Figure 11 illustrates the delivery of fairly thin paper sheets. I do not want to quote the paper make, but it has turned out that in this case the delivery did not work satisfactorily. At minor increases in press speed the sheets leaving the delivery always showed such paper damage.

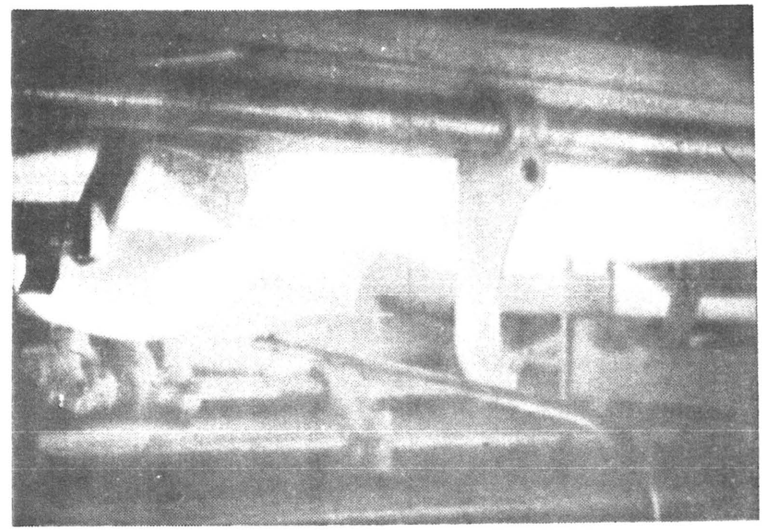
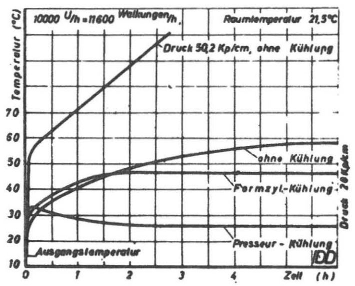


FIGURE 12

The paper was so badly damaged that it bulked up and got stuck in the link holder. The manufacturer has studied this picture and improved the design of the delivery, even with thin printing paper, in a satisfactory manner by correcting the holding system and introducing vacuum and blown air.



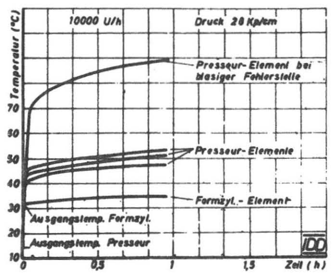


FIGURE 13

U/h	=	revolutions per hour
Walkungen	=	fullings, beatings
Raumtemperatur	=	room temperature
Druck	=	pressure
ohne Kühlung	=	without cooling
Formzyl.-Kühlung	=	cooling of forme cylinder
Presseurkühlung	=	cooling of rubber roller
Zeit	=	time
Ausgangstemperatur	=	initial temperature
blasige Fehlerstelle	=	blistery defect

WARMING-UP OF RUBBER ROLLERS

Figure 13 indirectly deals with run of paper problems. The Darmstadt Institute has made a number of tests to investigate the warming-up of rubber rollers. We have found that without cooling the temperature will after four to five hours have increased to approx. 60° C. If the forme cylinder is cooled the warming-up temperature will amount to 48°. This proves that it is of no great value to cool the forme cylinder.

If, on the other hand, the rubber roller is cooled the warming-up temperature can be reduced to 27°. If no cooling is used and the impression pressure increased to 50 kp/cm e.g., the rubber roller warms up intensively, to more than 100°. The warming-up of the rubber roller involves an increase in the impression pressure. Here for instance the originally set impression pressure

has increased by more than 60° due to the warming-up of the rubber roller.

The diameter of the rubber roller increases, which of course affects the run of the paper. In that much Mr. Monroy's report has to be corrected. Practical experience turned out results which are different from those of the laboratory tests.

We have above all to bear in mind when studying run of paper problems that on wide gravure presses the entire deflection in the centre is surprisingly great. It can range from 100 /u to 1,000 /u. This deflection means negative application of the impression pressure. So here the position is reverse compared with Mr. Monroy's statement that he sets the roller 0.25 mm closer to the forme cylinder. Due to deflection the distance between the cylinder axes increases by 250 /u, in certain circumstances even more.

We have investigated this phenomenon by tests and experiments and plotted the results in a graph. We have also established a table from which deflection figures can be read for any diameter, impression pressure and press width of up to 2,000 mm and for the various degrees of cylinder jacket thickness of a cylinder-rubber roller system where the rubber roller is only supported by one cylinder.

Take for instance the case which we have studied more closely and where the width of the cylinder is 1,570 mm, the length of the journals 260 mm and where the moment of equatorial inertia amounts to 5,600 cm^4. In that case the table indicates a deflection of 265 /u. In other words, in the period of run the distance between the cylinder axes increases by 265 /u, which corresponds to a negative pressure application. As a result, paper run is uneven.

This subject also concerns high-speed photography. You can find cylinder gap vibrations and uneven run of the web in rotary presses as well.

Take for instance letterpress and let us assume a given impression pressure and other forces which act on the run of the paper as for instance inking rollers, specific weight of cylinder, and tooth pressure depending on involute and you will obtain a certain resultant. At each gap in the blanket cylinder and between the stereo plates impression pressure cannot be applied. Consequently the resultant will vary, which means that the force P changes continuously. The theoretical state of quiescence as it was found with the laboratory test machine does not exist in practice.

The above figures prove the great versatility of investigations that can be made in the printing field by means of HSC equipment. For the purposes of quality improvement and higher speed and safety of the production process, also with regard to the economic advantages involved, a wider application of high-speed cinematography in the gravure printing technique certainly seems desirable.

Large printing plants as well as machine manufacturers, if faced with problems they want to solve quickly can make use of the services of institutes which are properly equipped for HSC application. Such problems mainly arise from flaws in the production process.