Gravure Press High-Speed Folding Technology Limits and Web Width Limits

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Nowadays gravure presses reach production speeds ranging between 55,000 and 60,000 cylinder revolutions per hour. The main restriction for another speed increase is the folding device. If we consider the forces acting on the paper and the moving processes during folding, we gain an insight into this problem.

The first 3.60 m (142") gravure press has been in operation in Germany since November 1997. Is it sensible to develop presses for even larger widths or has an optimum upper limit already been reached? What effects would even wider presses have? Where do negative effects occur?

In many areas of the printing press higher speeds and larger web widths require new solutions for paper handling and press technology.

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Publication gravure printing has developed at a terrific rate in recent years. The world's first 3.60 m (142") wide gravure press has successfully been in production since November 1997 at a printing house in Hamburg, Germany, since the largest press until then, with a web width of 3.48 m (137"), set a milestone in printing press engineering.

Today's top speeds are around 55,000 - 60,000 cylinder revolutions per hour. This is equivalent to over 15 m/s (3,000 fpm).

It is often asked whether the width and speed development has now reached the upmost limit or optimum, or whether considerable increases are still to be expected in the future. In paper-making machine engineering we find a similar situation.

When considering future press widths, not only the rules of physics must be taken into account, but also to a large extent the production requirements.

Gravure presses have to cover a large range of products which can vary considerably in format size and number of pages. Personalized magazines and catalogues, for instance, require a totally different composition to that of a product with a large run and a large number of pages. For the latter, we try to produce the individual sections of the magazine in the least possible printing passes and with the largest possible web widths, or to fold and bind them in one single operation. Whereas, for printing partial runs with a low number of pages, narrower web widths are generally used, as producing with several deliveries does not usually pay.

Modern gravure presses with web widths of up to about 3.60 m (142") have probably reached their optimum width for application in magazine and catalogue printing for the time being.

One run on one of these presses can process products with 96, 2x48 or 4x24 pages with 12 pages in width and 4 pages in circumference in one cylinder revolution. With 6 pages in circumference the output is increased to 2x72 pages or 6x24 pages.

Production with 4 pages in circumference is often used for the following reasons:

- faster engraving time due to the smaller cylinder circumference
- a pagination jump of 8 in collect-run production with one ribbon
- short printing time, as the forme cylinder speed does not have to be reduced. With 6 pages in circumference its speed has to be reduced by a third at the

same web speed. The engraving time is increased accordingly due to the larger cylinder circumference.

If we were considering processing 4 pages in circumference with small format sizes, it would soon become clear that with a web width of 3.60 m (142") we would already have to expect considerable forme cylinder deflection. With a circumference of 840 mm (33"), about 1 mm (0.04") must be taken into account as the absolute limit in order to obtain a sufficiently even print across the width.

A further criterion for this type of slender forme cylinder is the surface treatment which would produce an uneven copper surface if any vibration is generated.

As the deflection of the forme cylinder is cubed when the width is increased, unpermissibly high values would be obtained with small formats. Therefore, it would have to be avoided by changing to the 6-page or 8-page layout. This would lead to 50 % or 100 % longer engraving times respectively, with, of course, an accordingly higher number of pages on the forme cylinder. Whether this can be used advantageously depends on the corresponding print job.

In the case of collect-run productions with 6 pages in circumference there is a less favourable 12-page pagination jump which makes the layout planning of the available pages more difficult.

Further press widening would affect the reel cores, which at today's speeds and web widths are already bordering the critical speed. If cores of over 150 mm (5.9") in diameter were to become necessary in the future, this would seriously affect the logistics and costs of manufacturing the paper reels. The wider the reels, the more unfavourable the reel distribution with regard to the drum width of the paper-making machine.

In today's printing presses, the over 6-ton paper reels are safely controlled by reelstands with load-relieving belts acting from below.

In order to be able to keep the mass moments of inertia of the web-guide rollers in the press low, carbon fibre is being used at present. This material reacts to deflection twice as well as steel, although its turning mass is only one fifth of that of steel. As the guide rollers are not equipped with their own drive, the web is particularly well relieved during unstationary operating conditions (acceleration, braking). This effect is of particular advantage when processing narrow webs on large presses. Register-true printing of wide paper webs is straightforward in gravure printing thanks to metered steam application after each printing unit.

From the technical point of view of web width development there is still room for play. However, it would be much more difficult for press speeds to increase to over 60,000 rph, as the loading capacity of the paper during folding is limited. The printing process itself is relatively uncritical. Web speeds of over 20 m/s have already been achieved in tests in this area.

During folding, incredibly high loads, generated by kinetic forces, acceleration and slowdown processes, act upon the paper. There must be no marks, tears or folded-over corners on the folded product. As during the folding process a number of physical parameters are squared with a linear speed increase, it is extremely hard to carry out further steps in development. To make matters worse, the printing paper loses carrying capacity as a result of material cost savings and larger proportions of recycled paper. Limper paper with less loading capacity with electrostatic ribbon tacking at the folder infeed makes the folding process more difficult.

If we consider the individual components of the press (apart from the folder from the unwinding stand to the superstructure), there would be a good chance of using design improvements to surpass the present speed limits and web widths. Only the reel cores with 150 mm (5.9") inner diameter are already bordering the critical speed at the highest web widths and speeds.

A new core dimension would have to be fixed in conjunction with the paper industry. It is also disputable whether the shorter reel change intervals would mean changing to larger reel diameters. In the past, reels with a diameter of only 1.50 m (5.9") came under discussion.

The real factor preventing today's speeds being surpassed is the folder. For a better understanding of the problem, let us go step by step through the pass of a sheet of paper to be folded by a folder with variable cut-off length. As opposed to offset rotary printing, in which work is carried out with a fixed cut-off length, in gravure printing only folders with variable cut-off lengths are used. This is also one of the great advantages of gravure printing over rotary offset, as products with different format sizes can be produced.

Before the ribbons arriving from the superstructure enter the folder, they pass through an electric field with positive and negative high-voltage acting upon both sides of the ribbons. The forces at work make the individual ribbons interlock and act more rigidly in the folder. This effect is needed to improve the crossing between the cross-cutting cylinders and the following tape section. The electrostatic forces are supposed to hold the individual sheets against each other so that any turned-over corners caused by individual sheets working loose during the folding process are avoided. The electrostatic ribbon tacking system plays a large role in achieving high speeds. In an interesting new development the charge is no longer transferred via electrode tips, but directly onto the paper ribbons via rubber-covered rollers with insulated bearings.

When cross-cutting the ribbons, the lead edge of the sheet is already in a tape system whose speed corresponds to the folding cylinder speed. The size depends on the maximum cut-off length of the folder. The larger the difference between the maximum cut-off length and the format length of the respective product, the larger the acceleration of the sheet after the cross cut of the ribbons. The speed difference increases on a linear basis with increasing press speed. If the difference becomes too great, it may result in product smearing if the ink is not dry enough. Therefore, we try to select the smallest possible sized folder, as this way the surface speed of the folding cylinder and the tapes is lower.

When the speed of the sheet increases, its kinetic energy or momentum is squared. A sheet weighing 150 g with a speed of 17 m/s in the folder, for example, receives 21.6 kgm^2/s^2 of kinetic energy. This clearly illustrates the forces acting upon the paper even at today's press speeds. If the trimmed sheet section reaches the folding cylinder assembly, the lead edge of the sheet is held tight by grippers. The sheet is pressed against the cylinders by tapes in order to intercept the centrifugal forces. However, if the sheet manages to enter the open folding gusset, these forces become free and the sheet is repelled and/or strikes against the tongue basket in the folding gusset.

The basic principle of the folding process is incredibly easy.
Before folding, the first folding knife on the collecting cylinder is driven out until its radius intersects that of the open folding jaw and the sheet is forced into the closing folding jaw as it passes. The spine then moves on with the folding jaw cylinder and the grippers release the leading edge of the sheet to that it can follow the spine. Hence, the sense of movement of the leading edge of the sheet is reversed, causing a whiplash effect at high speeds. In order to make the movement processes as smooth as possible during folding, the folding cylinders are designed with large diameters. With today's high speed equipment there are normally 7 functional elements (grippers, folding knives, folding jaws) located on the cylinder circumferences. This is known as a 7:7 folder. There also used to be 3:2, 5:4 and 5:5 versions. An improvement on the 7:7 technology does not seem practicable from today's viewpoint, as the next step would be 11:11 folders. This number is the result of the premiss that the divisor of the collecting cylinder when processing 4 and 6 pages in circumference must not be divisible by 2 and 3. In the case of an 11:11 folder this would result in a deeper and more pointed folder gusset.

During the folding process, great centrifugal forces act upon the sheet from all different directions all at the same time. When the sheet is folded, the air has to escape from between the leading and trailing sheet sections as quick as a flash.

If we were to follow the movements of the sheet during the folding process with a high-speed camera, we would think it a miracle that the folded copy could come out of this zone undamaged.

Once it has been folded, the copy is guided to the spider wheel delivery via tape systems. In the event of split delivery to two spider wheels, a splitting device with mobile tongues is needed after the folding jaw cylinder. At 60,000 cylinder revolutions, the tongues have to move up and down over 33 times a second.

Before the copy reaches the spider wheel delivery, the kinetic energy has to be reduced to avoid damage. The product must therefore be slowed down by decelerated stretches of tape.

This short explanation of the processes in the folder clearly shows that this technology is already in full force today and we are already touching the upper limit of the technically feasible. There are practically no other folding techniques in sight.

Perhaps 5 % - 10 % of today's performance is reserved for technical development in the future.

What is more crucial now is to stabilize the top speeds reached today and to make high calculatable net output obtainable.

Where are the limits for gravure rotaries?

- reelstand
- printing unit
- folder

➡ **Productivity increase by**

- higher output
- increased press width

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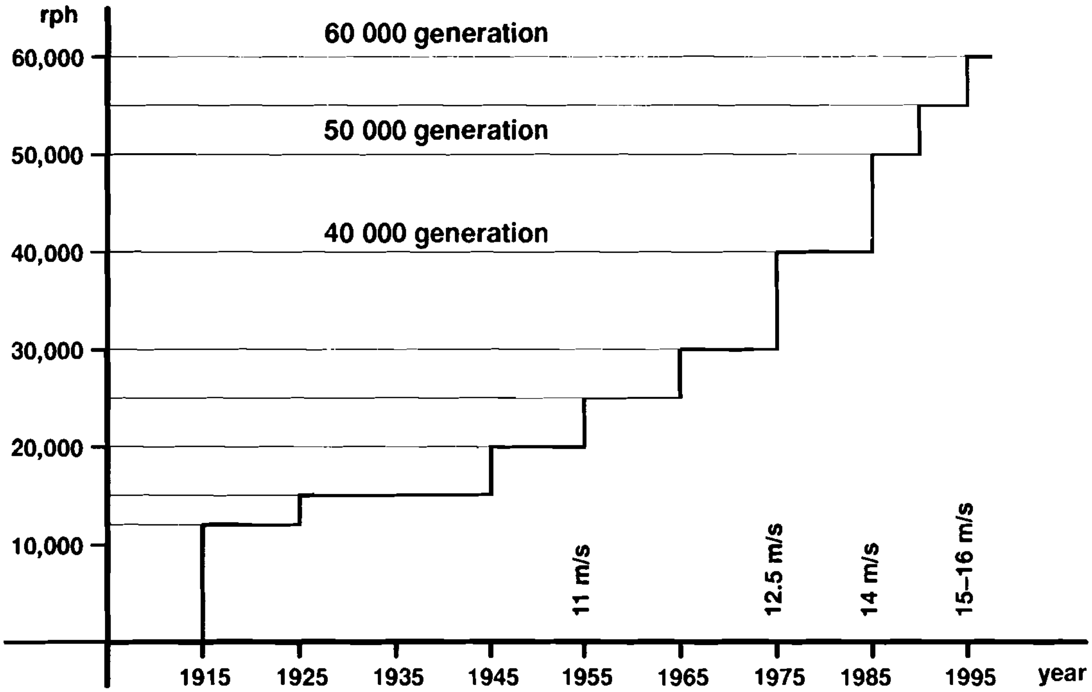
Gravure limits

391 069 76–E 3/94



Speed development of gravure rotary presses

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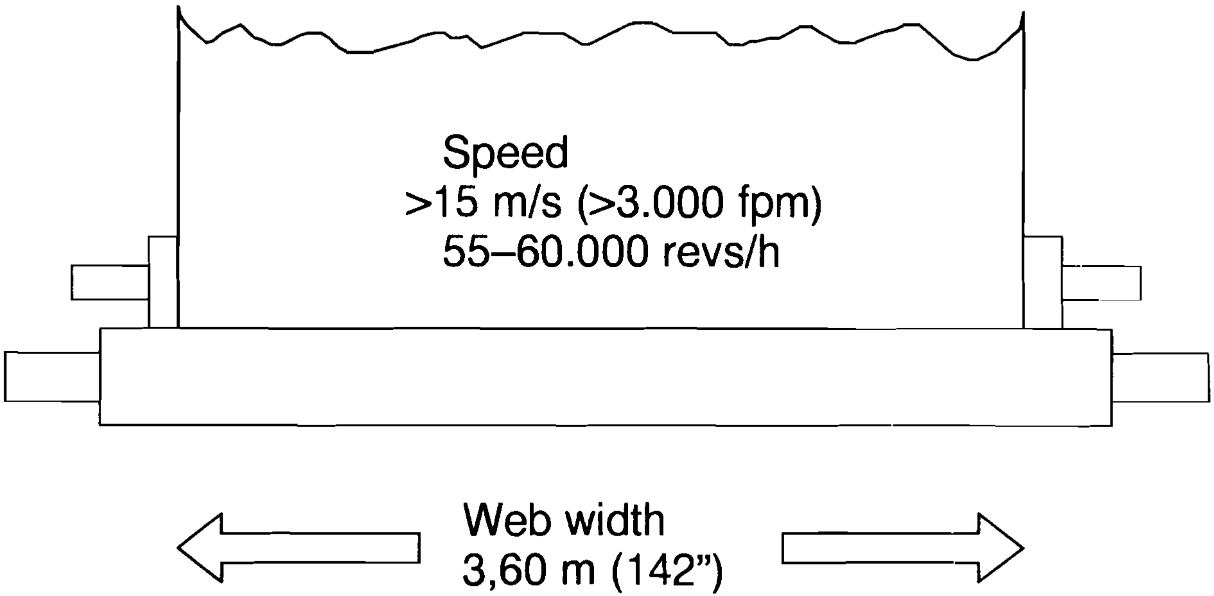
391 049 30–E 7/95



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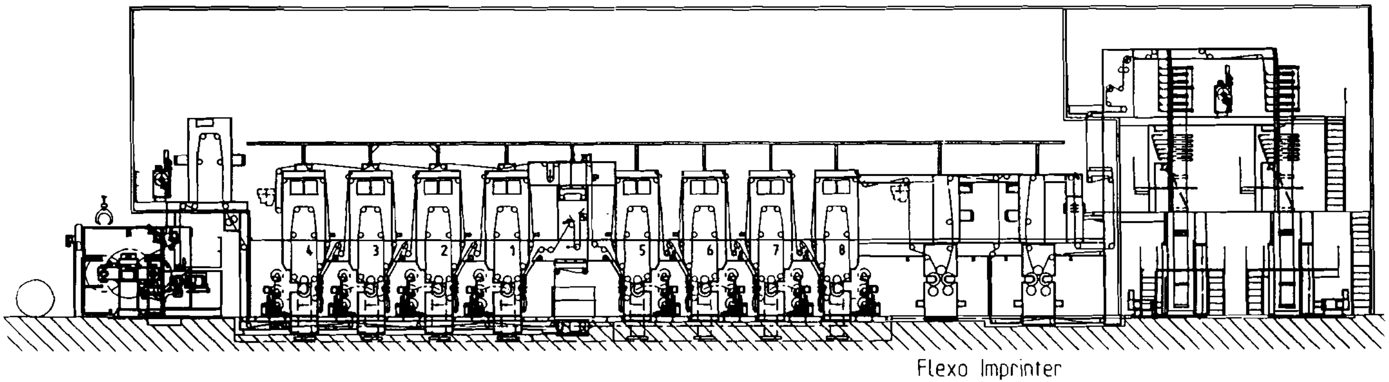
Today's Limits of Gravure Presses
Speed – Web width

391 400 09–E 3/98



138" Gravure Press for the U.S. Market

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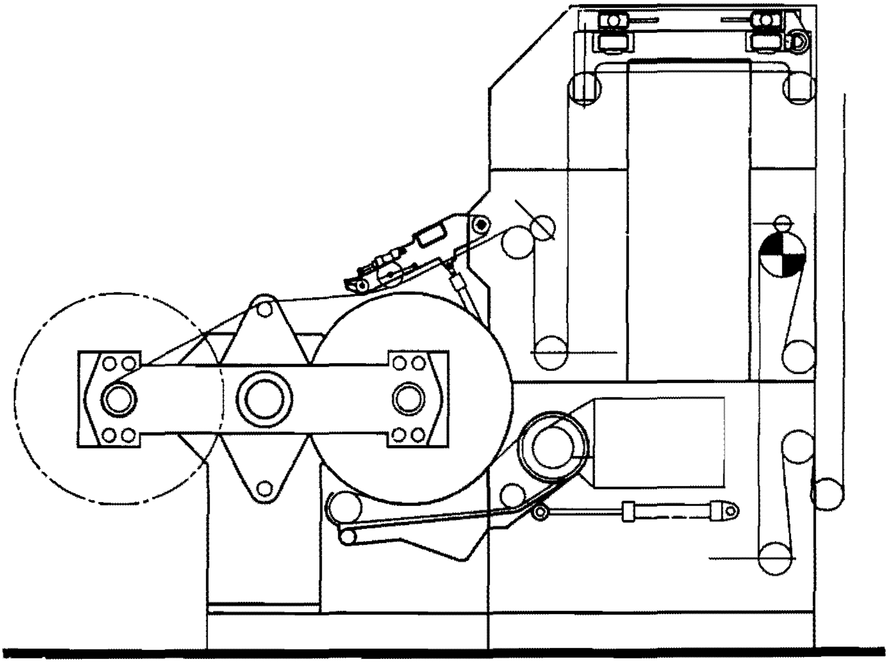
391 400 03-E 3/98



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Reelstand
with supporting belts

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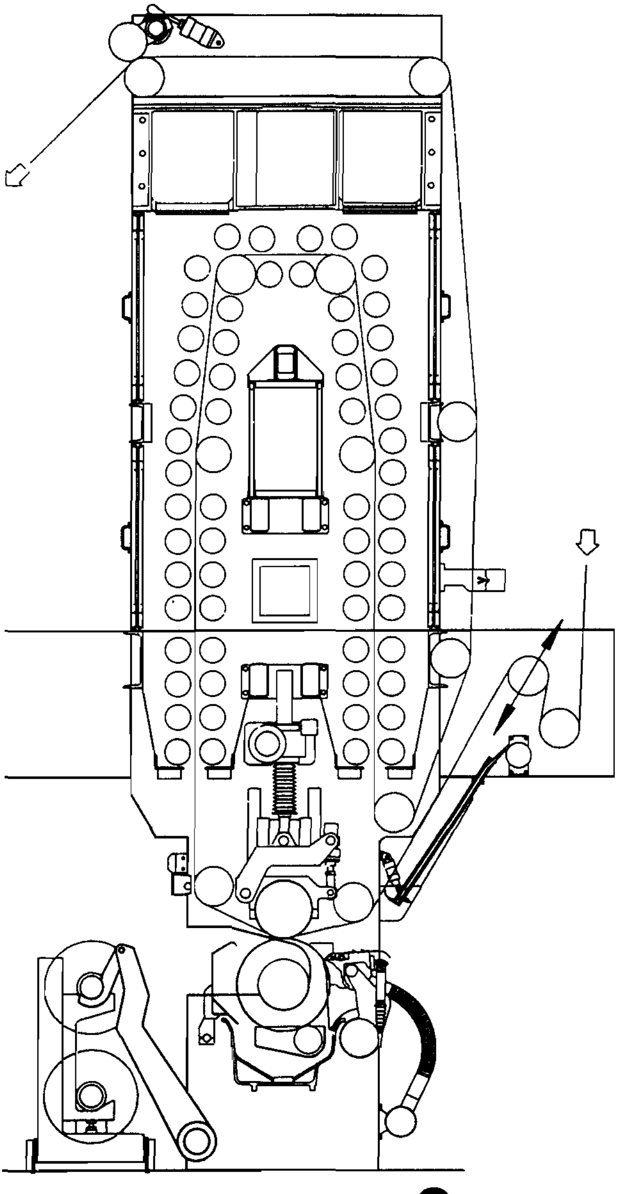
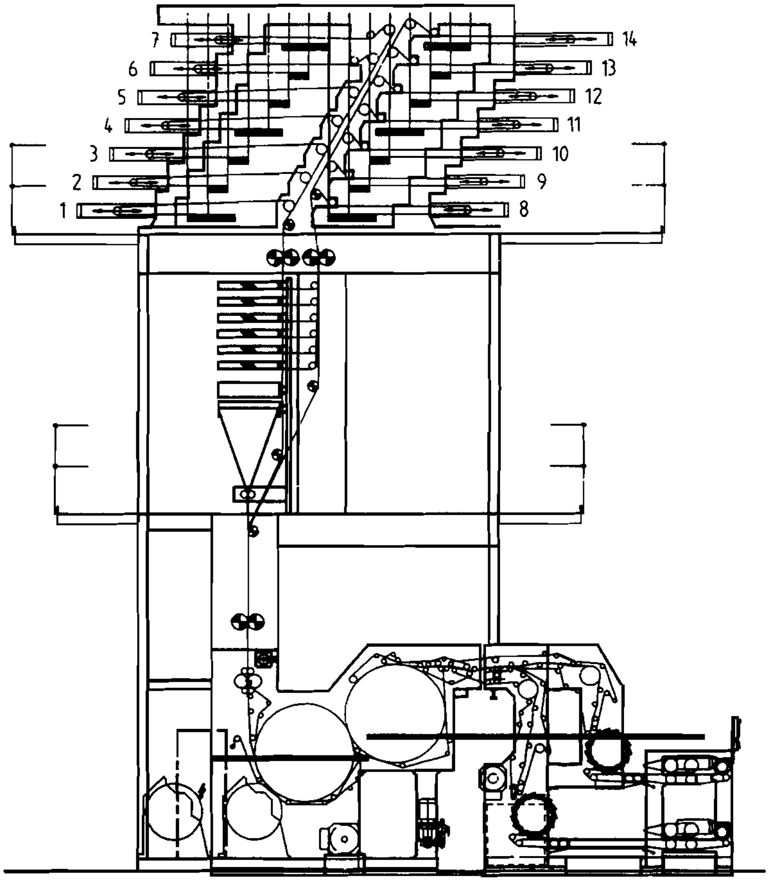
391 089 84/1 11/96



Albert-Frankenthal AG

Printing unit TR 9B/348

391 079 50/1 3/95



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Gravure Press for the U.S. Market
Superstructure and Folder

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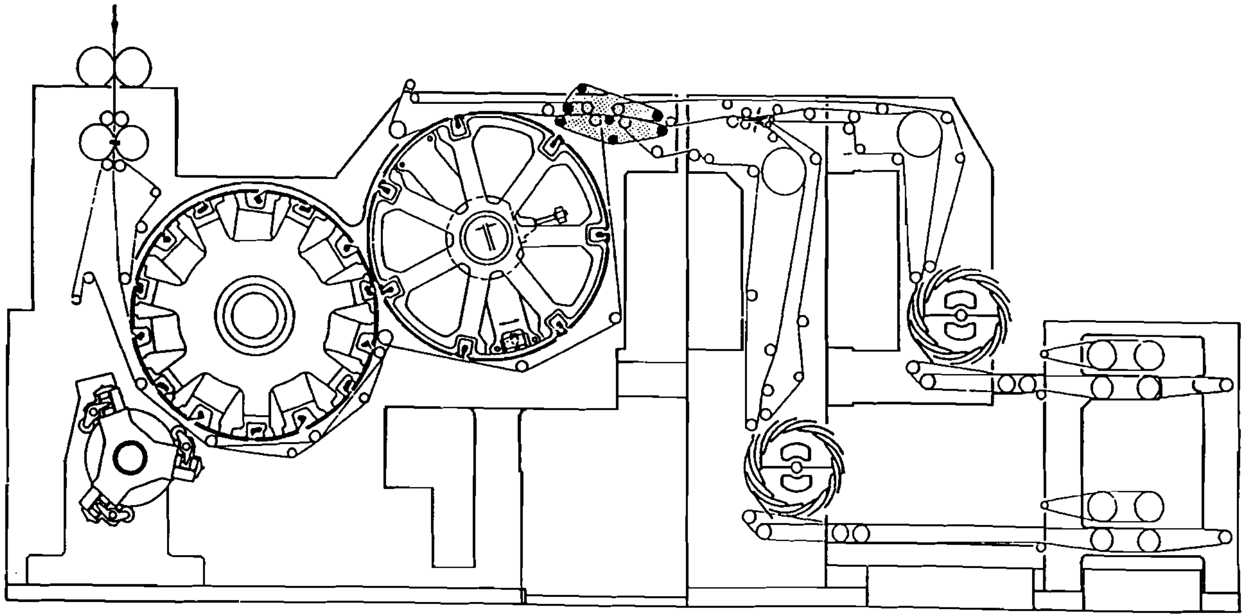

V 7/7 folder
Double slow–down delivery station

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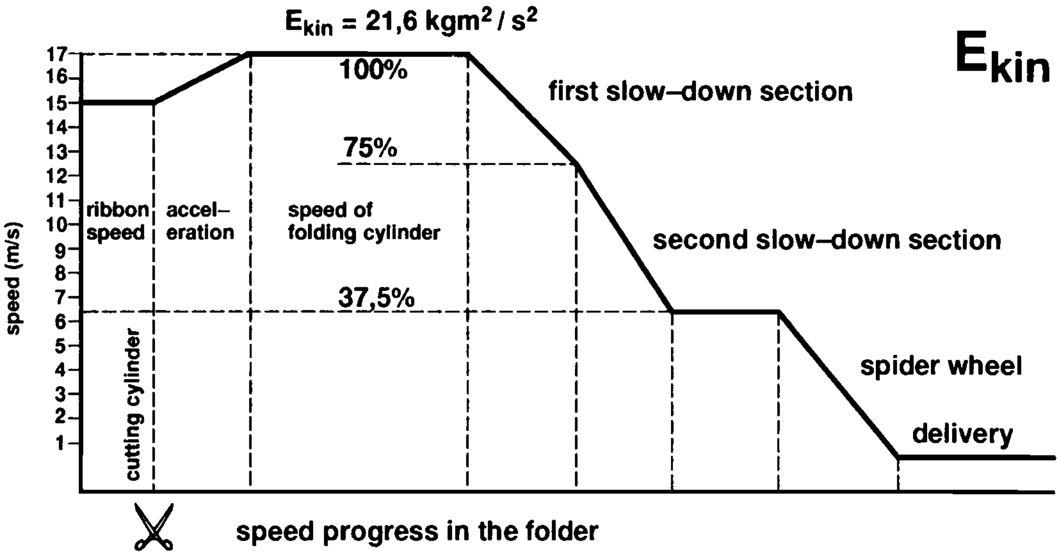
391 069 92–E 2/94

$E_{kin} = \frac{mv^2}{2}$



product weight 150g

Kinematic forces and product speed in the folder (4 around collect production)

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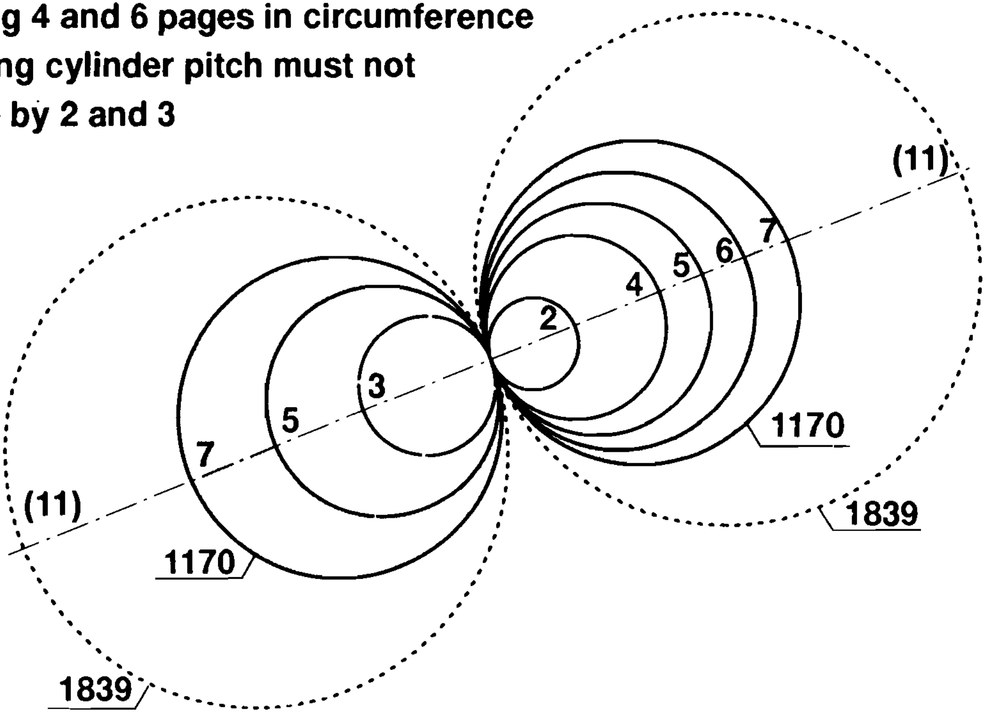
For handling 4 and 6 pages in circumference the collecting cylinder pitch must not be divisible by 2 and 3



Folding cylinder systems

(max. circumf. = 980 mm)

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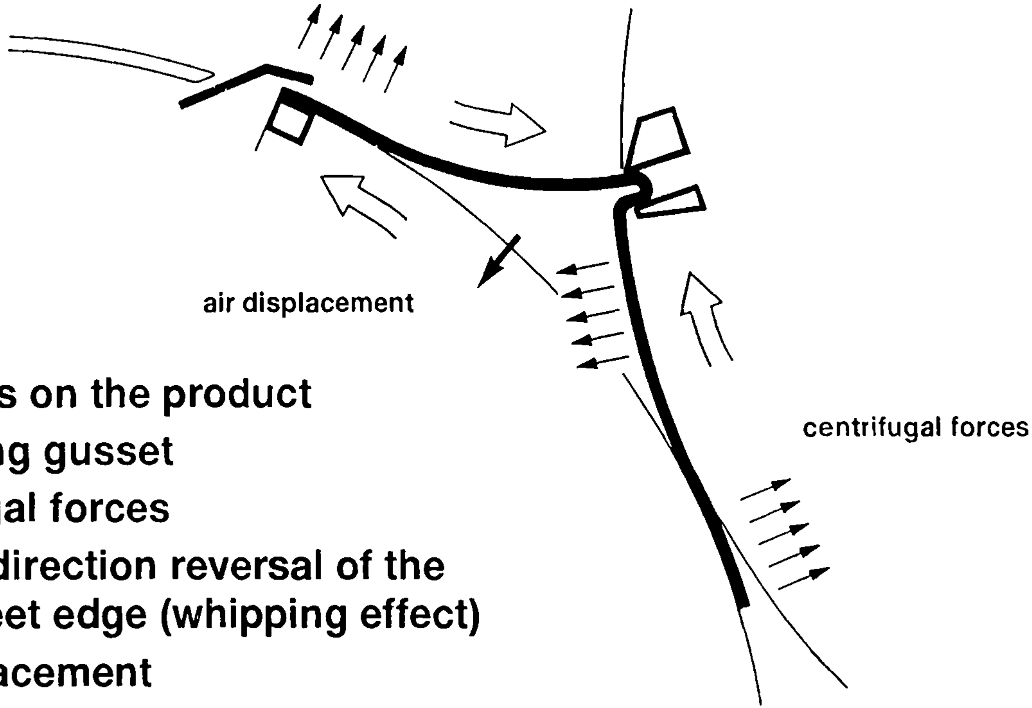

➡ **force effects on the product in the folding gusset**

- **centrifugal forces**
- **moving direction reversal of the front sheet edge (whipping effect)**
- **air displacement**

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"Bermuda triangle" in the folder

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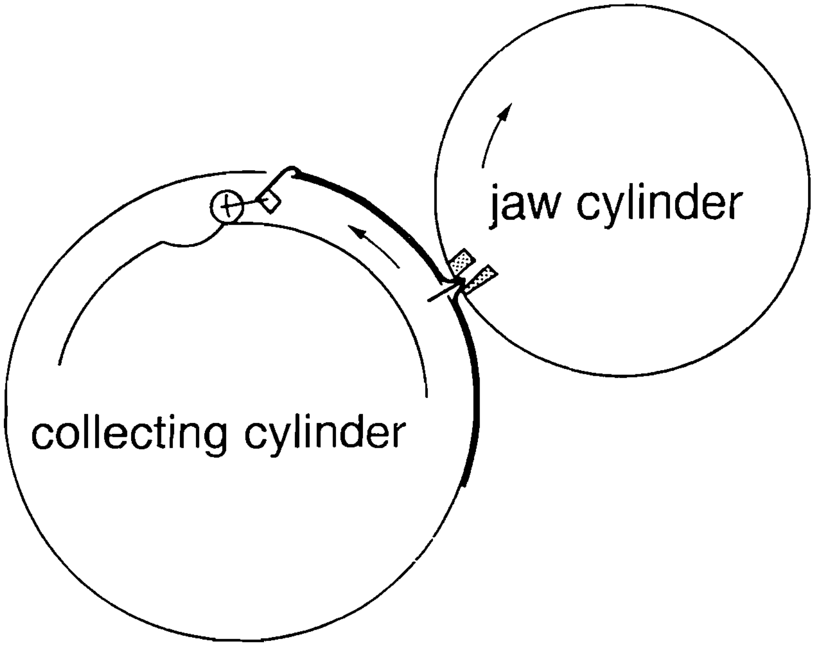

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Product passing–on of the grippers at the folding process

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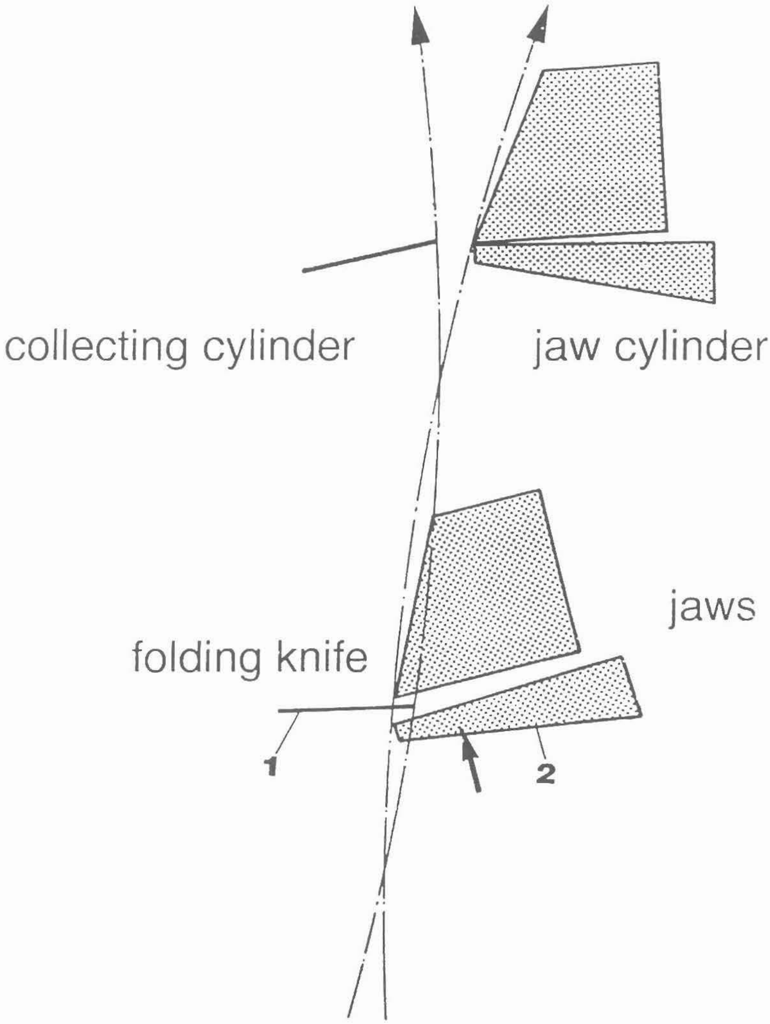

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Way of the folding knife between the jaws at the folding process

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- **New reel core dimension**

- **Deflection of the forme cylinder with 4 pages on the circum–ference and small format is too great (>1 mm/0.04")**

- **Folding process can no longer be safely controlled**

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Main criteria when today's speeds and widths are exceeded

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