

On-and Off-Line Soft-Calendering of Coated and Uncoated Paper Grades

KLEINWEFERS.*

For most paper and board grades, finishing is the last but necessary step in the production process to give the sheet surface the desired properties for further processing and use.

Improved quality, the tendency to produce specialties for smaller market segments and the necessity to optimize costs in the manufacturing process are a permanent challenge for the machine builder of finishing equipment.

This paper is dedicated to soft-calendering of coated and uncoated paper grades.

What does the term-soft-calendering mean ?

Soft-calendering refers to finishing with soft nips in comparison to calendering with hard nips in a machine calender.

The differences in obtainable effects between soft-nip finished and machine calendered paper can be characterized as follow :

Machine calenders are smoothing and more or less calibrating machines to smooth the topography of the sheet and to give paper webs a constant caliper as you will never find a totally even profile.

In the hard calender nip which is quite narrow due to its quasi inelasticity, the paper web is treated with a comparably high specific pressure thus resulting in an uneven densified sheet.

A varying density due to overcalendering is especially undesirable with graphic papers, as it is causing mottling effects and non-uniform ink or coat absorption or even blackening during the calendering operation.

This means-and this is not a new conclusion—that hard nips alone are very limited in their ability to impart smoothness and gloss without having disadvantages for the user of the paper.

For better finishes, therefore, soft nips are being used (Fig. 1)

The higher elasticity of soft nips creates a wider nip and reduces the specific nip pressure considerably. This bears the consequence that, during the glazing process, irregularities in the sheet formation are as evenly densified as normal paper surfaces. To some extent, the elastic rolls adapt the topography and produce a sheet with uniform density. This evenness of the sheet densification results in a uniform and improved print image. Thus, the use of elastic rolls for surface finishing has considerable technological advantages which can be grouped into the following main items :

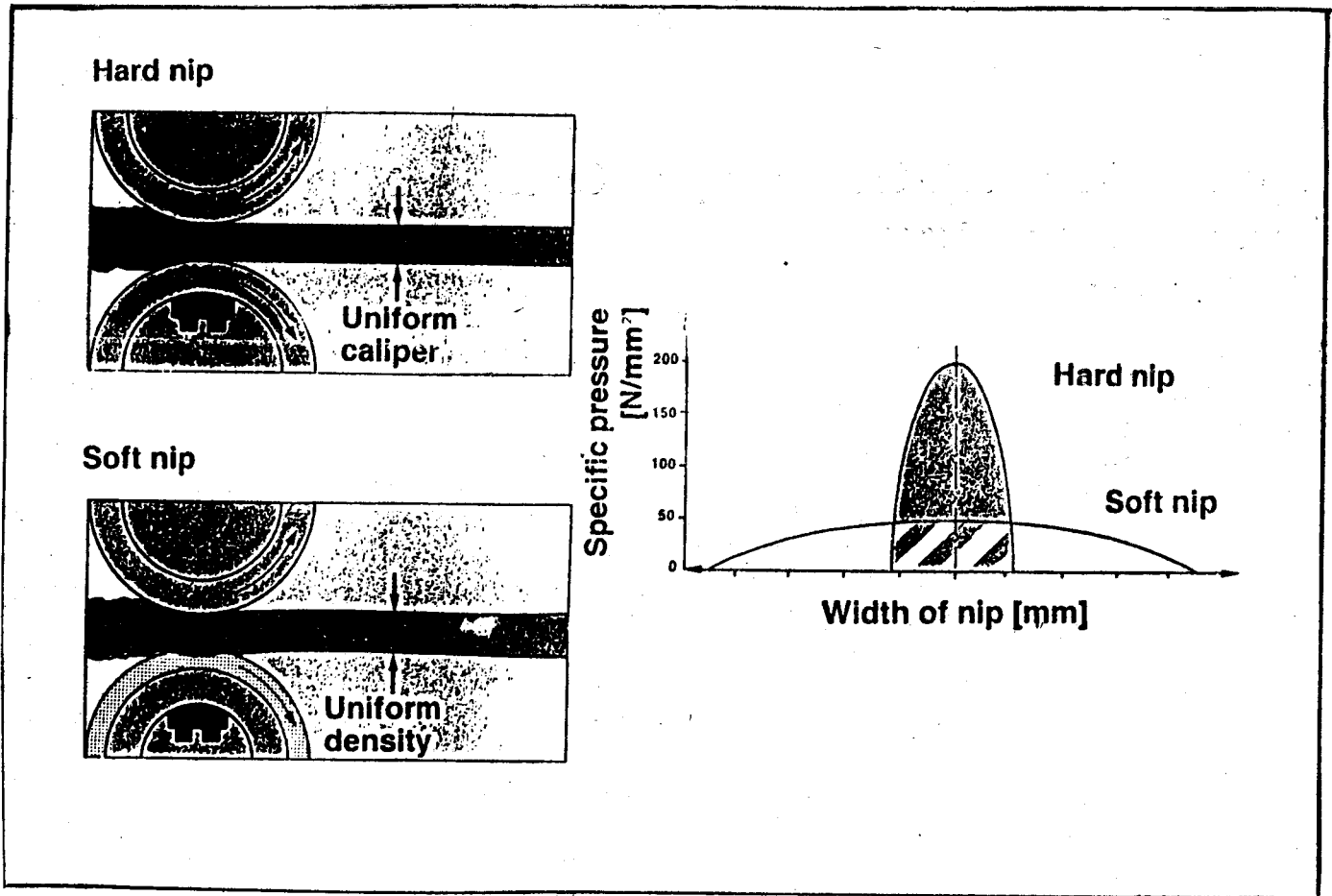
- less or no mottling
- no blackening
- uniform densification
- higher smoothness
- higher gloss
- higher strength
- higher moisture content
- better printability
- better runnability

For decades, the supercalender has been and still is the classic softnip finishing equipment with unsurpassed surface finishing results.

Supercalendering is effected by passing a web through a number of soft nips formed by a vertical arrangement of alternating hard rolls and resilient bowls (Fig. 2).

During that thermomechanical process the paper web is gradually treated under the influence of pressure, moisture and temperature, partially generated in the process itself and partially introduced by heated rolls.

*West Germany



Although the supercalender has been optimized in all aspects and is running today with speeds up to 1000 m/min, it is still "an unloved child" in the paper manufacturing process, as it is a purely "off-machine" operating equipment.

As a competent finishing machine builder KLEINE-WEFERS has taken the challenge to meet the wishes of the paper makers to design finishing equipment operating "on-machine" in paper machines and coaters at full machine speed.

The concept for that machine design has been to separate the interlined soft nips of the supercalender and to engineer and build completely new equipment with individually controllable soft nips:

THE SOFT-COMPACT CALENDER

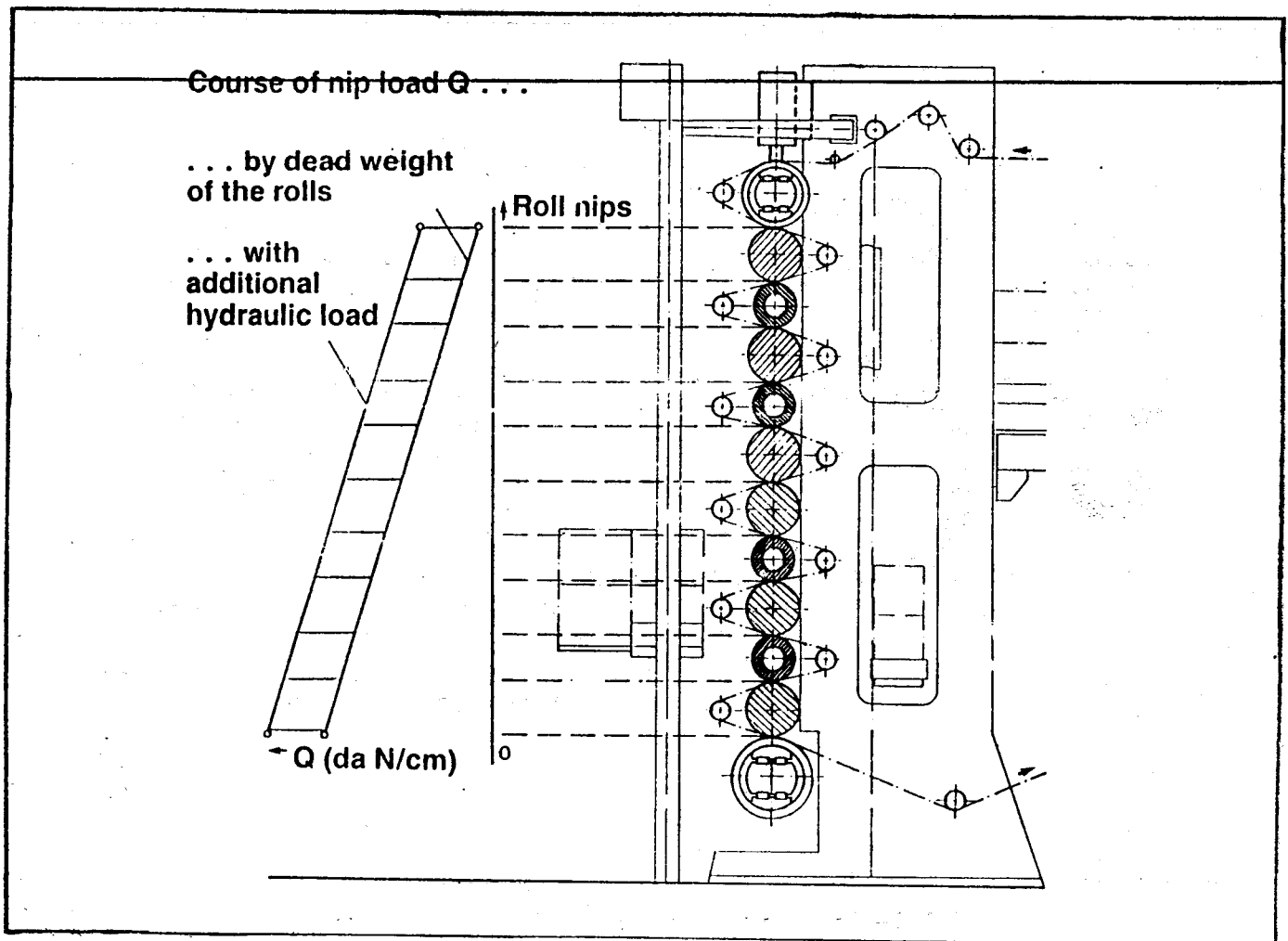
The soft-Compact Calender represents a new generation of finishing machines designed primarily for on-

machine installation, but also for off-machine operation if demanded by production or specific customer requirements.

The design of the Soft-Compact Calender is characterized by the possibility to control nip pressure (and temperature) individually in each nip over a wide range, thereby affording a flexibility in obtainable finishing effects far superior to conventional calendering technology.

This flexibility in effects, caused not only by individual nip control, but also by matching the number of nips to the specific finishing requirements, allows to use the Soft-Compact Calender for a wide range of uncoated and coated paper grades with a variety of finishes from matt and silk effects up to glossy paper grades.

Experiences with Soft-Compact Calender finished paper grades have shown that this type of equipment



can replace machine calenders in a wide range of applications, where better finishes and quality bulk are required. But it is limited in the ability to provide full CD caliper control as soft covers in turn are limited in their acceptance of specific pressure and their sensitivity to high temperatures generated in the finishing process.

On the other hand, the Soft-Compact of latest design in a commercially acceptable configuration seems not in all respects to be in a position to provide first-class supercalender finish in modern, fast-running paper machines and coaters, as it is difficult to introduce the huge amount of thermal energy into the process required for those finishes and those speeds.

Besides replacing the machine calender, the Soft-Compact Calender of today therefore is mainly an additional finishing item for those paper grades with

upgraded quality, but not necessarily requiring first-class supercalender finish.

With continued development in components and roll covers as well as in new coating formulations for coated paper grades, the Soft-Compact Calender may well become an alternative to the supercalender in the future.

Looking at the parameters strongly influencing the finish of soft-calendering operations, we realize that there are two major categories besides those of the furnish :

- the technologically relevant ones such as temperature, nip pressure, speed and surface added moisture.
- and those related to equipment design

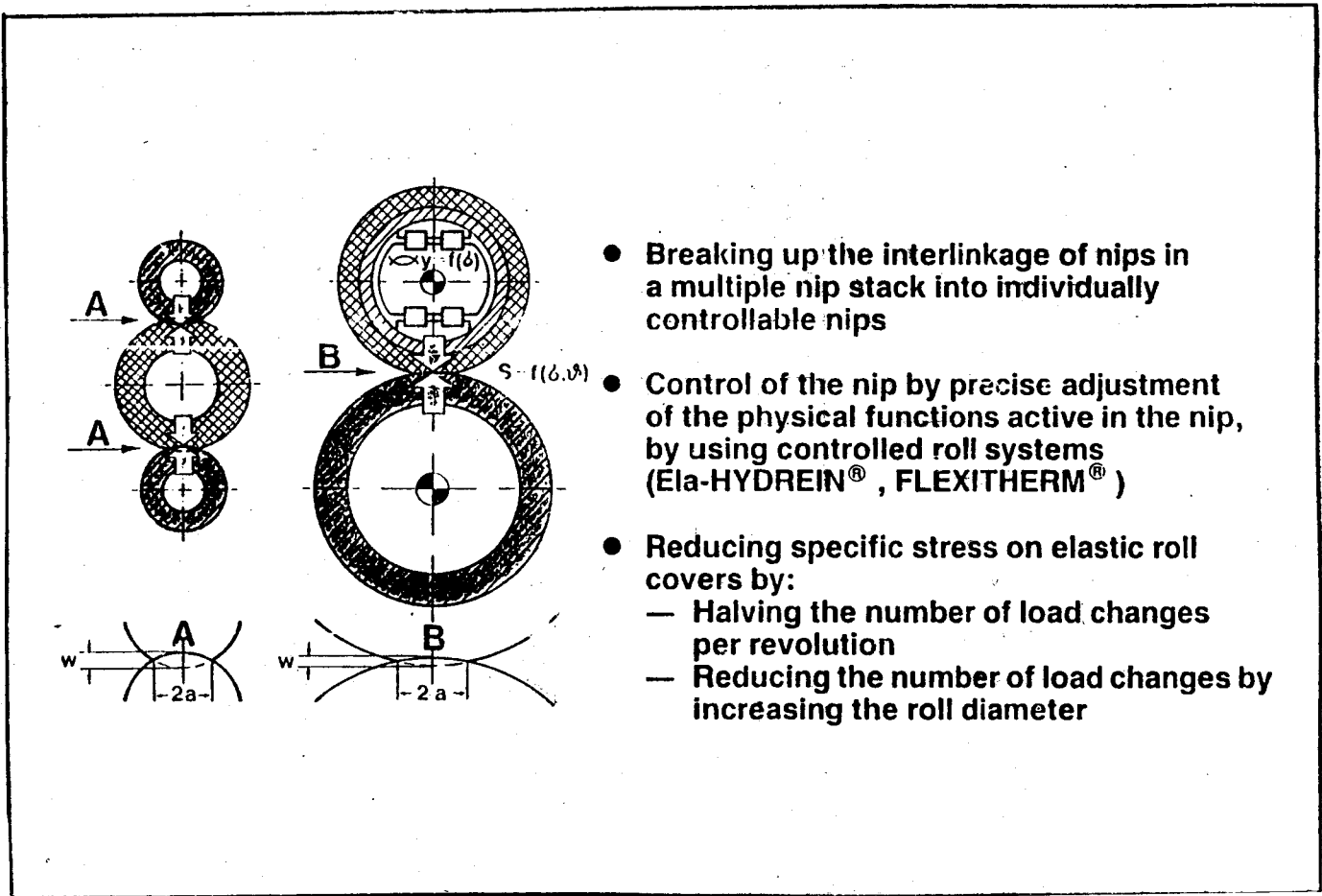


FIG. 3—Design features of the Soft-Compact Calender with individual nips

THE EQUIPMENT DESIGN

The configuration of the Soft-Compact Calender, whether it will have only one nip or two nips side or even more (Fig. 4) will be determined by the paper grade to be finished and, of course, by the required finish. In any configuration, the nip is individually controlled and nip loads can be varied independently from an absolute minimum—may be less than the dead-weight of the roll—up to the design limits.

The nips are formed by an adjustable crown-controlled roll with an elastic cover and a heated, sometimes cooled, chilled iron roll or even elastic-covered roll, too.

The most important components of a Soft-Compact Calender are the roll system carrying the elastic cover and, of course, the cover itself.

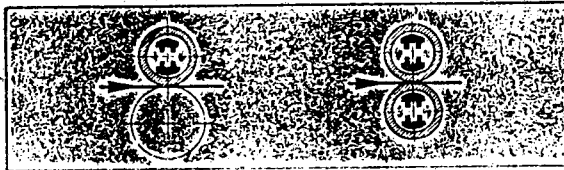
As the main application of a Soft-Compact Calender is the on-machine operation, one has to take extreme care—besides the finish—of the life and the running time of the cover which is the most sensitive element.

In addition to the cost for refitting, damaging or even destroying a cover will result in more frequent roll changes, thus in production losses due to reduced overall efficiency, and—in loss of a lot of money.

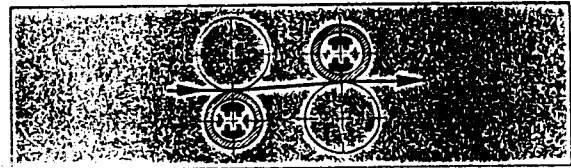
Therefore, the best roll system to create nip pressures as uniform as possible or as exactly adaptable to specific operating conditions in order to avoid undesired heat generation, probably influencing the cover performance, will be finally the cheapest one.

In our Soft-Compact Calenders, we mainly use Ela-HYDREIN crown compensating rolls with indi-

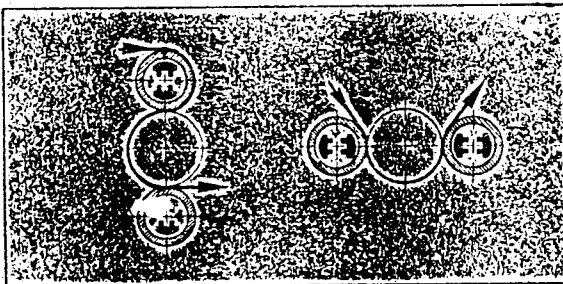
Mono single-nip, one stage



Mono single-nip, two stages



Duo single-nip, one stage



Duo single-nip, two stages

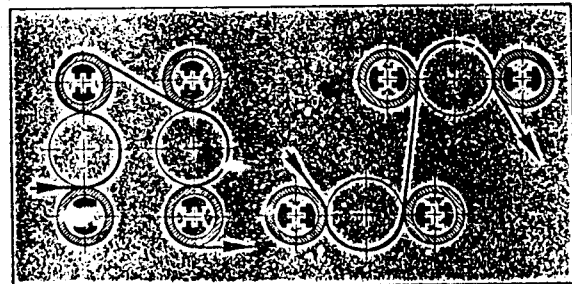


FIG. 4—Configurations of Soft-Compact-Calenders

vidual zone-controlled roll of normal design, but a specially engineered one with sophisticated edge control designed by the finite element method for the use in Soft-Compact Calenders.

All this is based on our experiences as a finishing specialist in the supercalender field.

Of course, for narrow machines and for "Tower" operating conditions with respect to nip load, machine speed and temperature level, swimming rolls or similar available roll systems can be used. But only a roll with positive zone control including the roll edges, assures the necessary adaptation of the roll to the web profile and, if desired, influences it in an admissible range without risking the elastic cover.

Additionally to that fact, an Ela-HYDREIN crown compensating roll system enables you to run in closed loop control as we are doing, for example, on smoothness measurement for heat-sensitive paper.

Of major importance for the performance of an on-machine operating soft-nip finishing system is the quality of the elastic cover.

Temperature and pressure acceptance, heat generation by hysteresis, hardness mark resistance and wear behaviour are some of the key criteria, determining the obtainable finish and the necessary grinding intervals. (Table 1)

We have four categories of resilient covers for Soft-Compact Calender operations available to serve a wide variety of finishing effects from matt to glossy grades :

- The three classes of synthetic covers are Elamatt, Elabond and Elaplast, and covers made of natural fibres which are used in super calender operation too.

Table 1—Elastic covers for
Ela-HYDREIN rolls

	Brand name	Hardness (°Shore P)	Specific pressure (N/mm ²)	Limits of application	
				Acceptable cover temp. (°C)	Load Changes (min ⁻¹)
Synthetic covers	Elamatt	85—86	25	60 (85)	265
	Elabond	86—88	35 32	80 80 (110)	265 530
	Elaplast	91—92	40 30	80 100 (120)	530 530
Fibre Covers	Fiberun (CO, VT)	87—89	45	90 (120)	600

They all differ in their properties, abilities and limitations. To meet the requirements of each specific job, they will be selected according to the necessary operating parameters to match the finishing effects desired by the customer.

With our four nip Lab-Soft-Compact Calender running up to 2,000 m/min, line pressure up to 550 N/mm and surface temperature of the heated roll up to 200 °C—meeting all parameters of today's and, may be, tomorrow's practical requirements—we can simulate and demonstrate to our customers with their papers and their coatings what is obtainable and what they can realistically expect later on in a mill operation.

Besides the major components, such as the crown compensating roll system and resilient covers, there are some additional ones, instrumental for a successful operation of Soft Compact Calenders (Fig. 5).

In our philosophy IR scanners for each covered roll are necessary to monitor the actual soft-nip finishing process. Being aware of the real cover

temperature of the resilient rolls at all times and, therefore, able to take countermeasures when the surface temperature level or profile readings are running out of normalcy, are necessities for on-machine finishing.

In addition to the possibility to take countermeasures at the right time, temperature scanning can initiate emergency warning signals and finally automatic nip opening to protect roll covers when an unacceptable temperature level is reached.

One of the most important parameters in the finishing field is the temperature.

To introduce continuously huge amounts of thermal energy with a uniformity of temperature at high levels within a few degrees C over a large web width into a fast running finishing process with a limited number of nips is a task to be resolved.

Temperature controlled FLEXITHERM-VL rolls of new displacerless design are the tool to achieve this. Computer based thermodynamic calculations secure the proper layout for each job and for the highest

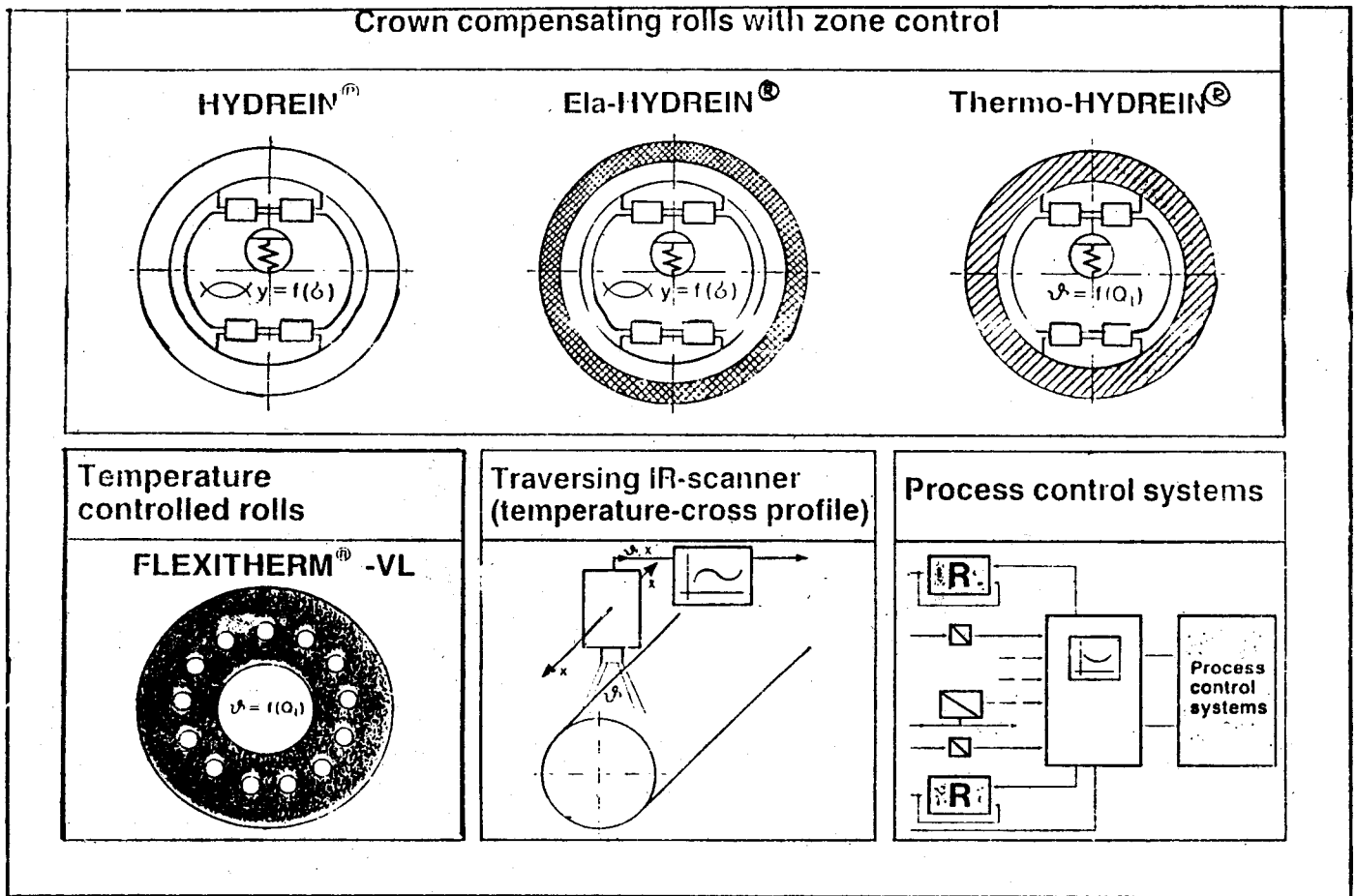


FIG. 5—Major components of the Soft-Compact Calender

requirements. But not only thermodynamic aspects are involved. Besides this monobloc ELEXITHERM-VL rolls are extremely stiff, in order to from a straight nip, operate in an uncritical vibration range at all machine speeds and—they are maintenance-free.

Futhermore, there are a number of necessary components such as

- web threading system
- devices to control open nip threading
- web break detectors
- fast roll separation units

and others which ensure a troublefree operation without affecting the overall efficiency of the production line and securing the cost advantages of on-machine finishing.

In order to maintain a high overall efficiency the procedure for changing the main wear part of the Soft-Compact Calender—the elastic covered roll—is of

major importance. Therefore two alternatives in Soft-Compact calender design including different roll changing devices are presented.

The first one is a two stage Mono Single-Nip configuration of open design in back to back arrangement. While the top rolls can be changed easily with the house crane, bottom rolls have to be lowered on a separate roll trolley, in machine direction and laterally moved on floor level (Fig. 6).

The second one is a two-stage Mono Single-Nip configuration too, but of "Closed" frame design. It offers minimum space requirements in machine direction but need some space laterally as bottom rolls have to be removed laterally out of the stack on the track-bound trolley (Fig. 7).

Also the top rolls are to be lifted upwards with the house crane.

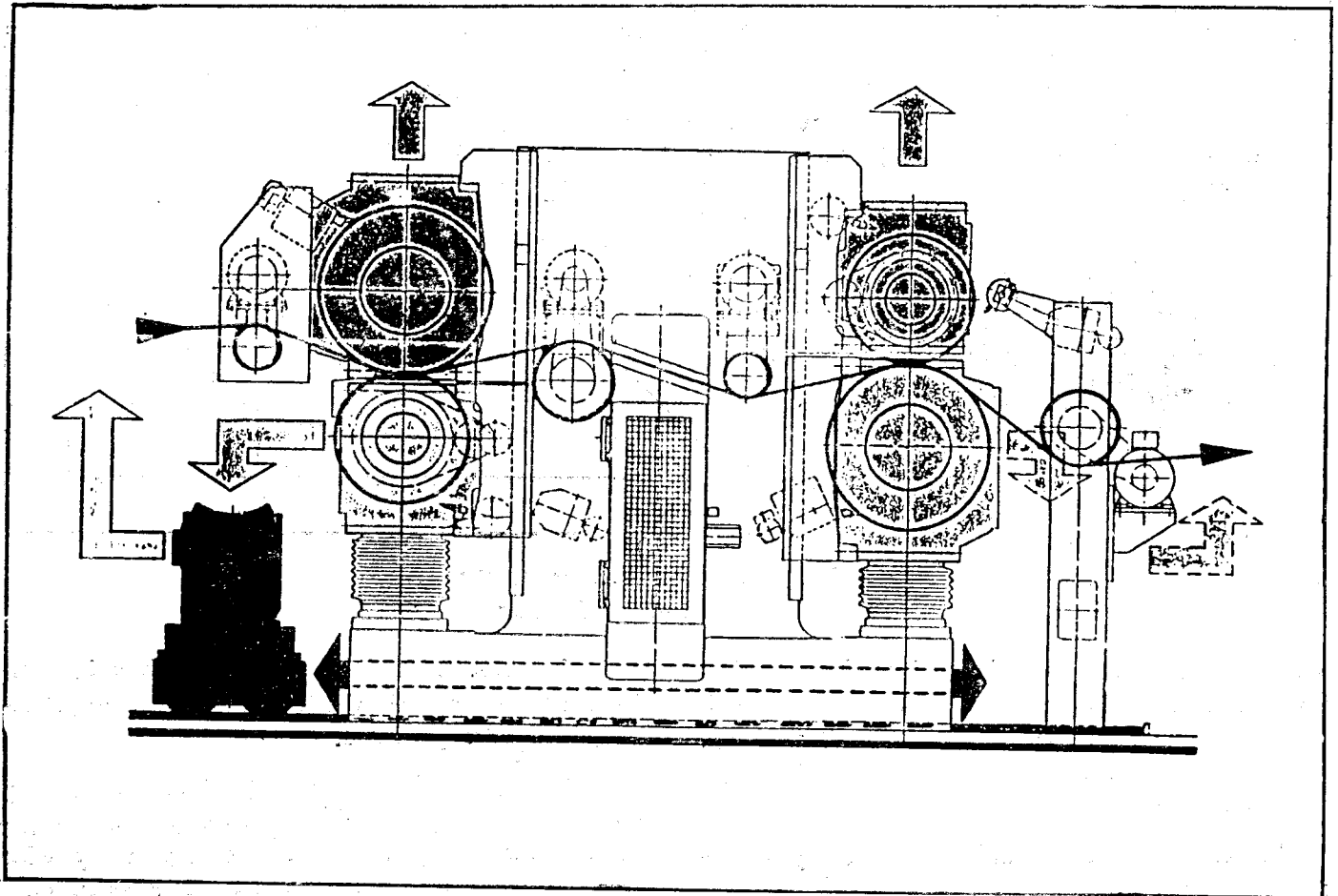


FIG. 6—Soft-Compact Calender
roll change procedure

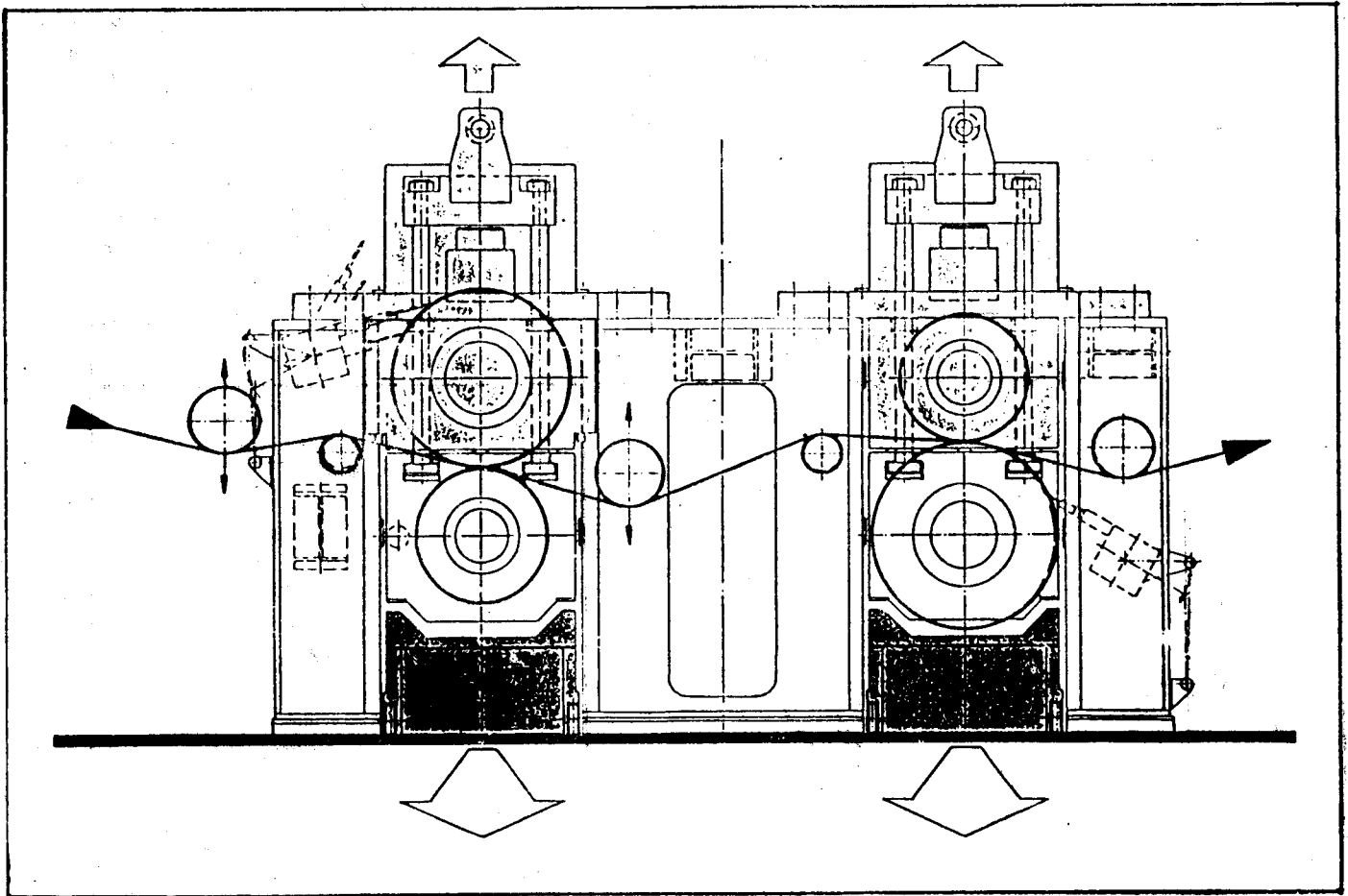


FIG. 7—Soft-Compact Calender
roll change procedure

In a Mono Single-Nip configuration in closed design, all the hydraulic pipes for the Ela-HYDREIN zone controlled roll in the bottom position can be disconnected quickly and easily from their flexible hoses by a quick release coupling with automatic oil shut-off during a roll change.

In the following I would like to discuss typical Soft-Compact Calender configurations with regard to their obtainable finishing results of different paper grades. If available, the effects are compared with those finished in a "conventional" manner on a hard nip machine calender and on an off-line supercalender, respectively.

Typical grades for the one nip Soft-Compact Calender are carbonless paper CF and CB, label papers with lower smoothness requirements, wall papers etc.

In case there are elastic covered rolls installed in both, top and bottom position, matt papers—uncoated and coated both sides—can be finished to an excellent quality.

If a superior finish is required only on one side as with high quality label papers the one stage Duo Single-Nip is suitable.

The Mono Single-Nip SCC with two stages is primarily used to finish both sides of the sheet. According to the layout with respect to the maximum nip pressure, the temperature of the heated roll, the operating speed and the quality of the elastic cover finishing effects from matt to gloss grades can be obtained.

In order to compare the finishing and printing results of a hard-nip versus a soft-nip operation evaluations have been made on a 49 g/m² newsprint paper with a content of some 40 to 50% de-inked fibres (Fig 8)

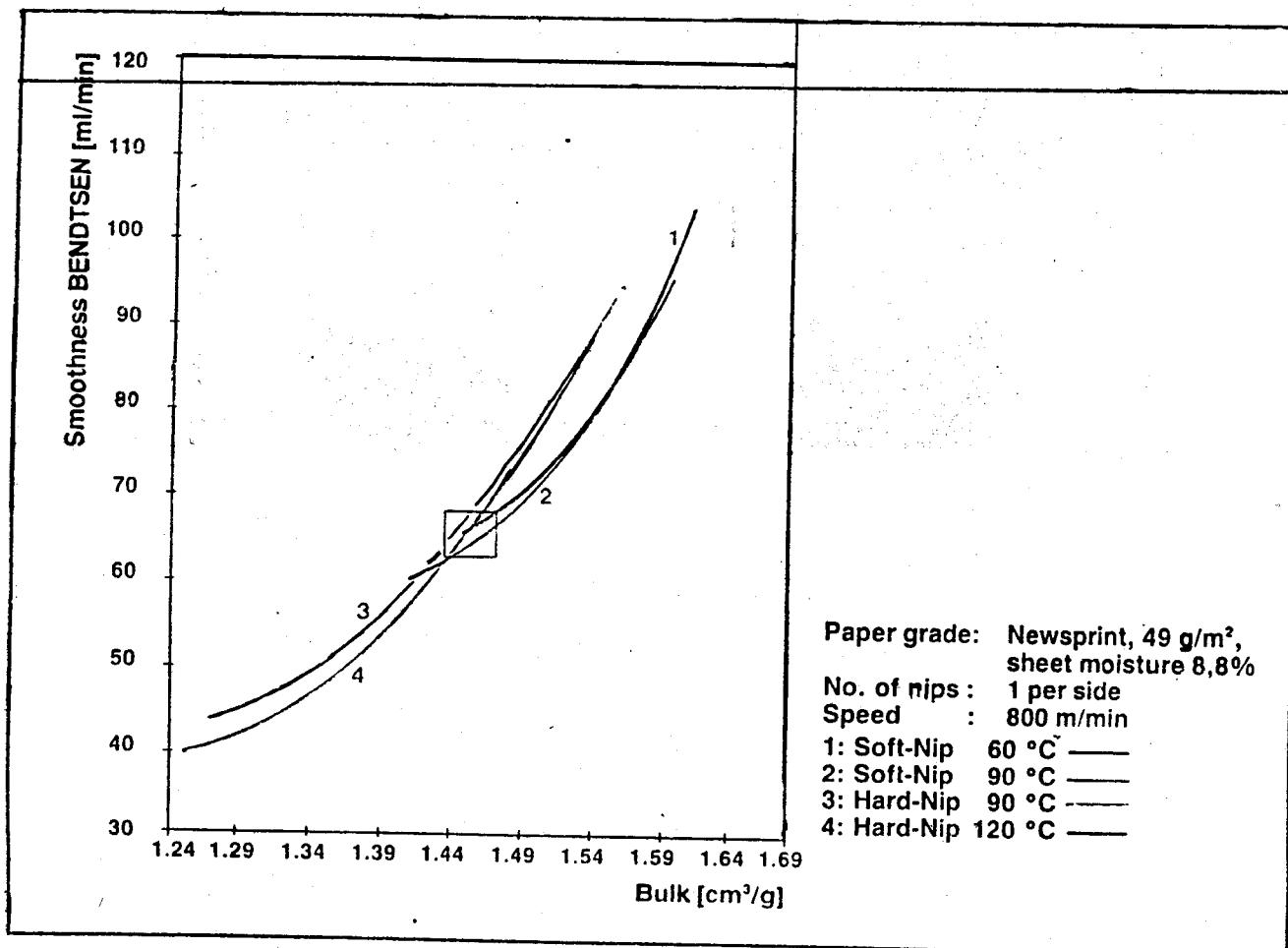


FIG. 8—Comparison hard/soft-nip smoothness over bulk

Pictures with an enlargement of 50 taken from the sheets with very similar results concerning measured smoothness and bulk (Marked area)—indicating that paper sheets have been exposed to the same amount of “forming work” in the hard as well as in the soft nip—have shown significant differences in their topography.

As the soft-nip finished sheet surface has been more closed and “smoother” topography-wise there has been no surprise of the better printing results although the measured relevant physical sheet properties did not show significant differences.

Another application of this configuration of Soft-Compact Calender should be mentioned :
the pigmentized mechanical printing paper.

“Make a new paper product in a continuous process” for “finding a niche between LWC and SC”.

Print tests have shown the results :

heat-set printable, brilliant colours, brightness and runnability undoubtedly LWC-class, laser usable.

This second generation of wood containing coated printing grades will be finished cost-effective on-machine, not needing the final gloss points of an off-machine supercalender-finished LWC-grade.

The respective Soft-Compact Calender will be started up in a Finnish mill in the near future.

The flexibility of web run and finishing effects has been shown on a two-stage Duo Single-Nip SCC (Fig. 9).

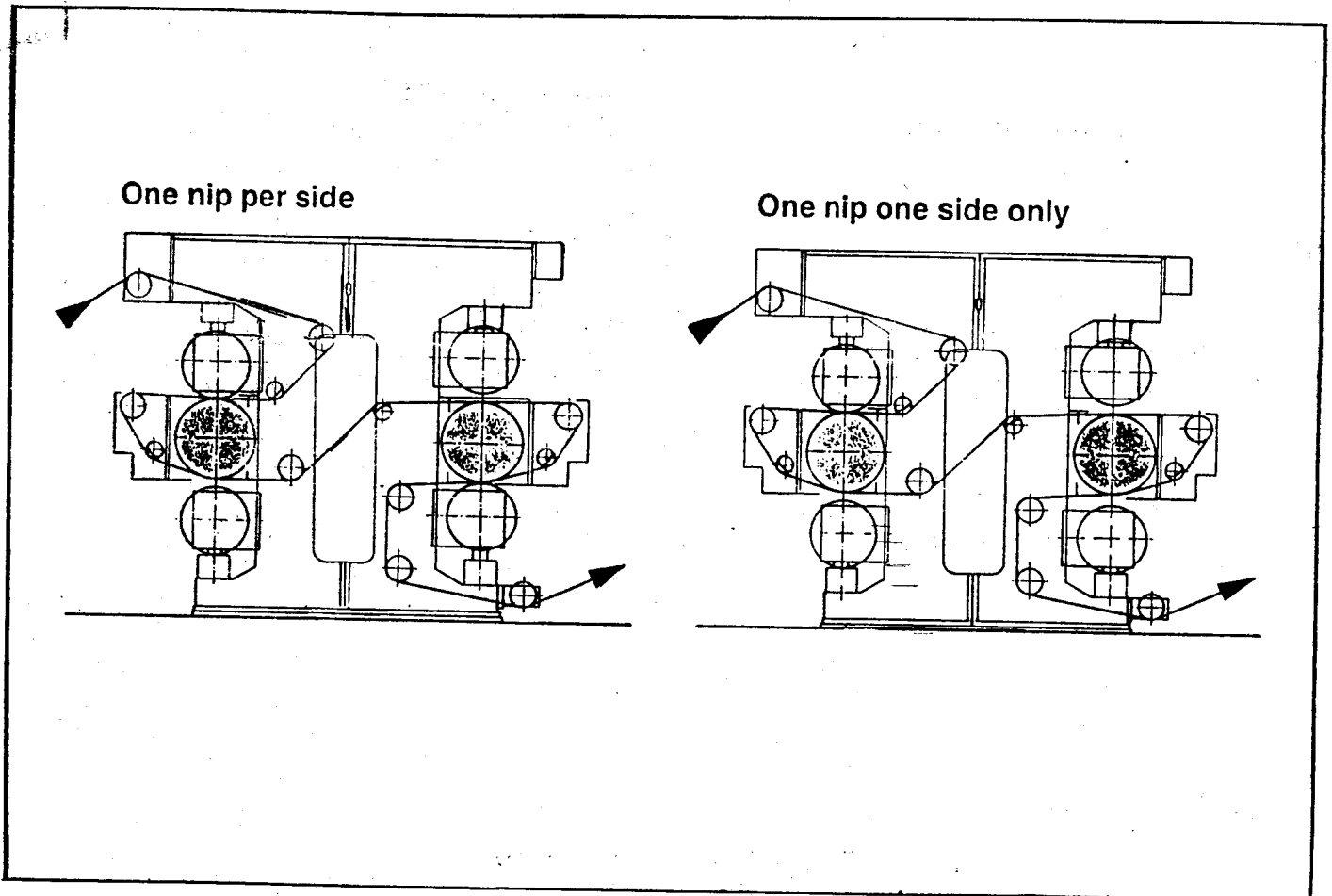


FIG. 9—Soft-Compact Calender
Flexibility of web run

Whether you are looking for a one or up to four nips one-side only finish or if you are requiring a two nips per side finish, this configuration gives the possibility for the whole range of effects, (Fig. 10)

Not only by the web run but also by the possibility to apply different nip pressure to each nip, avoiding any kind of two-sidedness, too.

The influence on the finish is demonstrated on 0.80 g/m² both-side coated woodfree paper grade comparing one and two nips per side. (Fig. 11, 12) and from that it is evident that smoothness and gloss

of a two nips per side finish are better than that of only one nip per side (Fig. 13).

But to obtain from this most sophisticated configuration first-class supercalender finish like art paper in more than a good piece of equipment.

By the way, from this Soft-Compact Calender configuration the widest ones in the world with a face width of 8.75 m have been built for a Dutch newsprint mill, which shall be the first such tried off machine (Fig. 14).

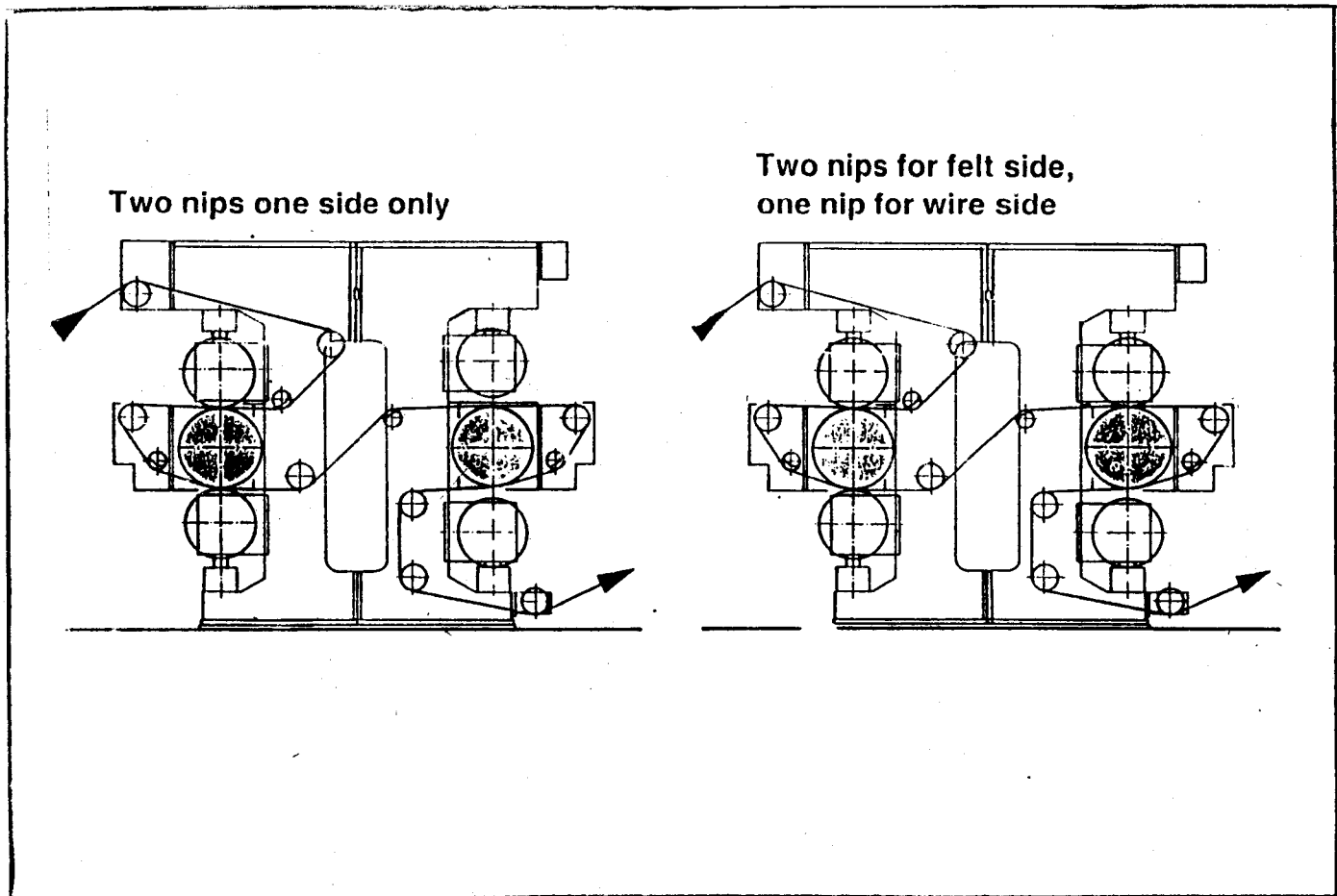


FIG. 10—Soft-Compact Calender
Flexibility of web run

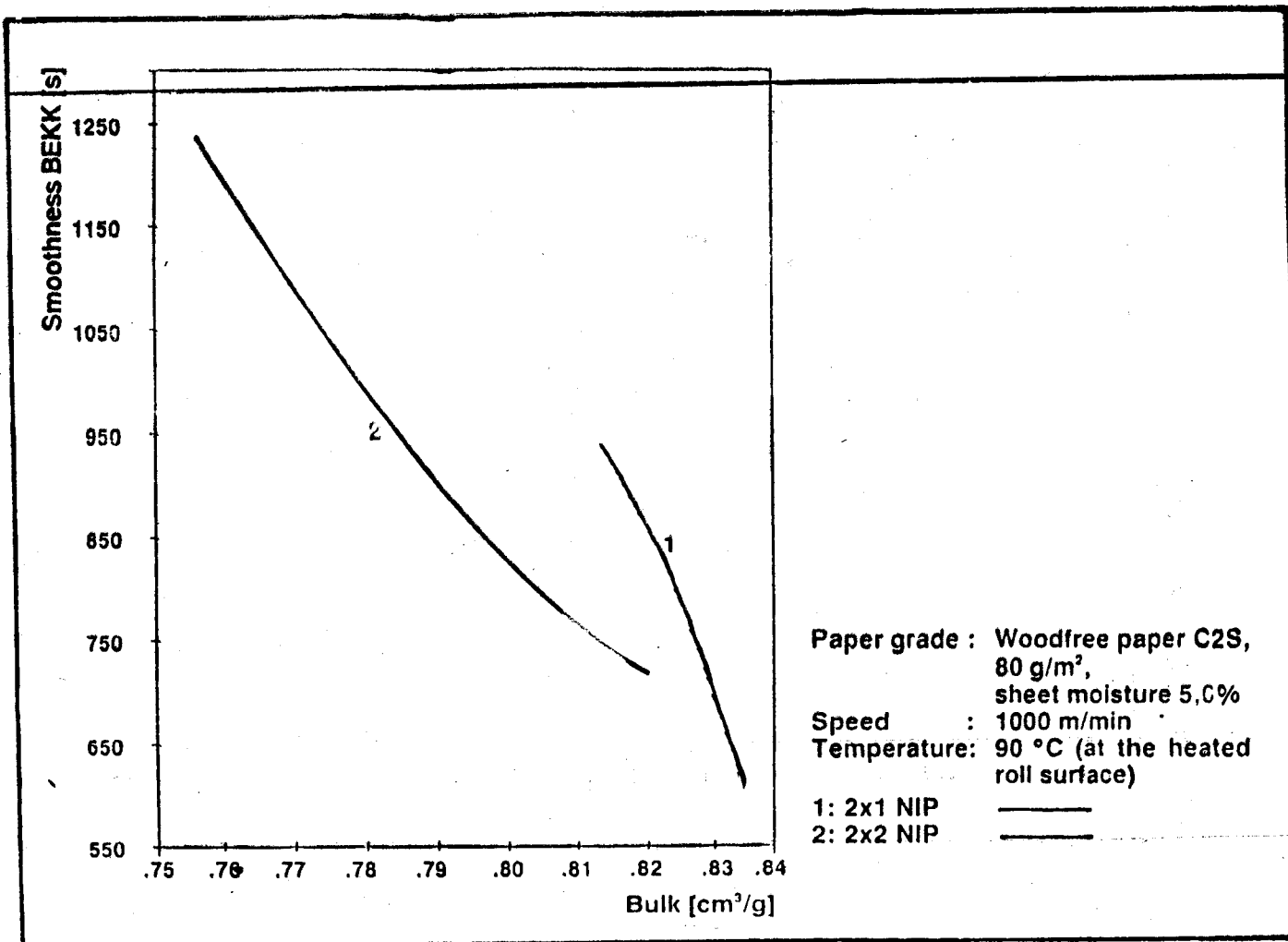


FIG. 11—Comparison one nip/two nips per side smoothness over bulk

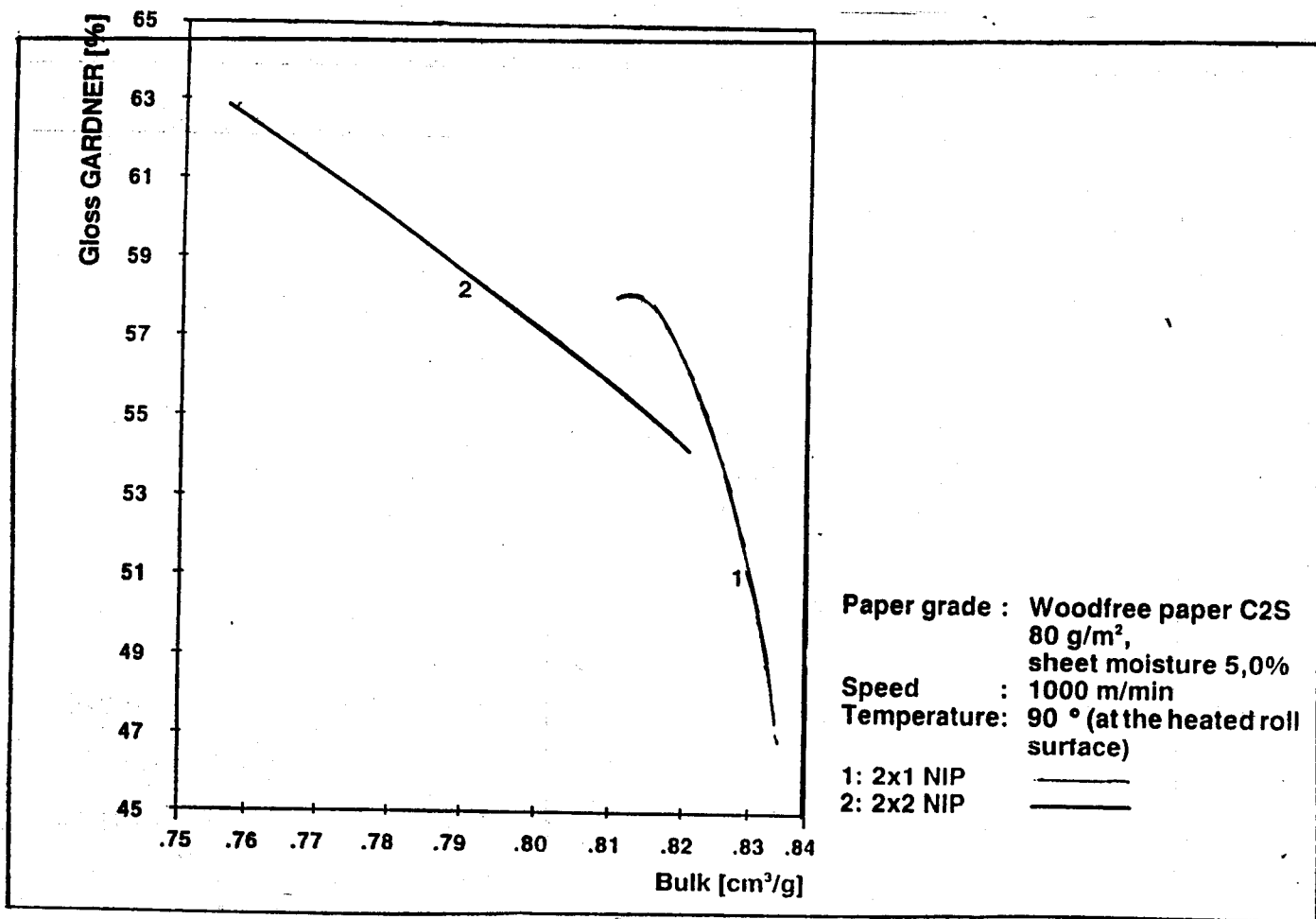


FIG. 12—Comparison one nip/two nips per side gloss over bulk

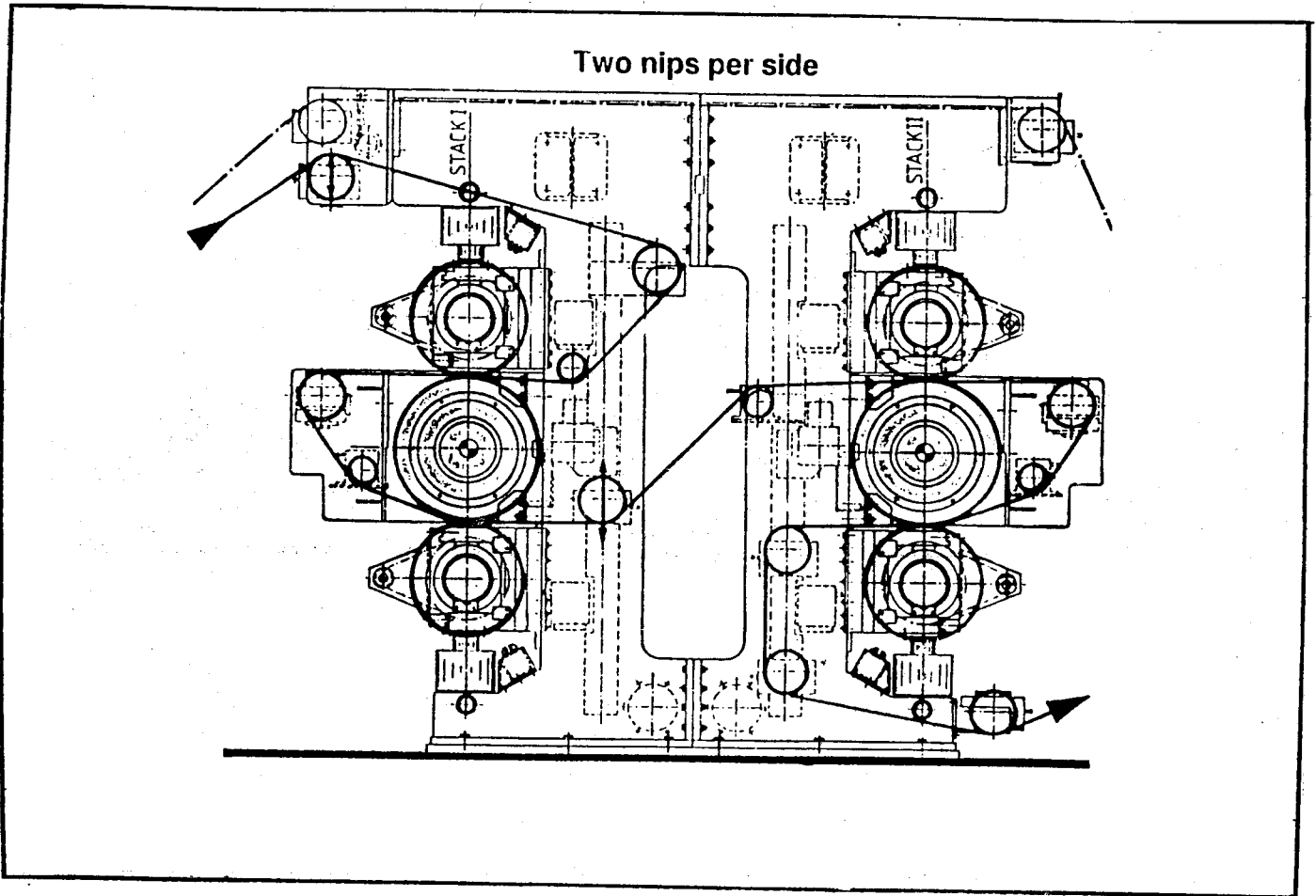
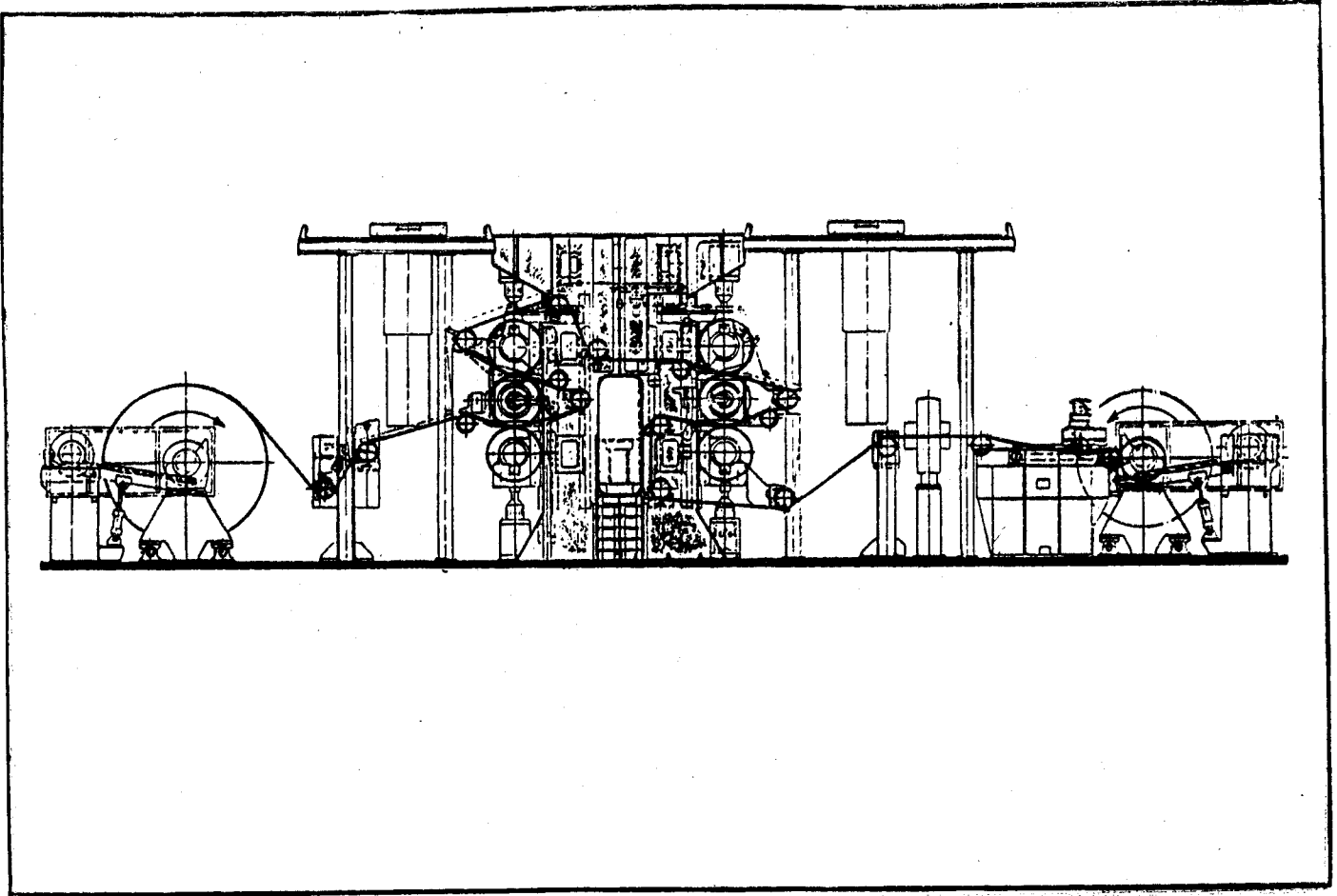


FIG. 13—Soft-Compact Calender
Flexibility of web run



**FIG. 14—Soft-Compact Calender
for off-machine operation**