Design and Application of Refiners In Stock Preparation

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Stock refining is one of the most important processes in paper making. For writing papers, the stock must be well beaten to produce hard, 'rattly' paper. For printing papers, the fibres should be well fibrillated, and with most pulps, they should also be shortened to secure a smooth, close formation. In the case of paper boards where maximum folding qualities are desired, it is sometimes necessary to reduce the amount of refining and sacrifice some printing qualities in order to maintain long, flexible fibres. The rate of refining is an important consideration on such grades as glassine, tracing and grease proof papers, where pulp is usually beaten to nearly its maximum. The variety of refining tasks to be performed during the production of such paper grades is reflected in a spectrum of refiner types. They differ considerably from one to another both with regard to their operating conditions and design.

Conical, Steep Angle andDisc Refiners represent still the most important machine types used in the field of refining. Varying from small to big capacity paper plants, many of the Indian mills are using one of the above types of refiners of VOITH design in their stock preparation and machine refining stages. Some mills have refiners of Voith design (manufactured and supplied by M/s Utkal Machinery Ltd.) with refining tackles of differing bar width, (straight or oblique) bar configuration, intersecting angles, operating speed and power input. Also, having introduced Steep (Wide) Angle and Double Disc Refiners in Indian paper mills, it is aimed in this article, to give, briefly, a clear picture of the design, constructional features, development and application of these three types of (Voith) Refiners and also the effect of the above mentioned variables on refining.

CONICAL REFINERS

a) Shallow Angle Refiner

Conical Refiner, type R (1R and 2R) falls in this category as it has a shallow cone angle of only 16°. These refiners were earlier designed for tackles having individual metal bars with wooden fillings in between. In this design, the slot width, formed in the rotor plug, determined the bar width to be used. Careful soaking of wooden fillings were essential during prolonged equipment shuts to avoid shrinkage and accidental damage to other bars. In order to have the flexibility of stock treatment, tackles of different configuration and combination, in cast execution, are now offered with the following cutting (intersecting) angles:

Rotor bar angle	Stator bar angle	Cutting (intersecting) angle
0°	6°	6°
0°	30°	30°
20°	30°	50°

These tackles can be changed in a short time as compared to the other design. For meeting the requirement of higher operating speeds and power inputs (around 200-250 kw depending on grade of pulp), necessary improvements in the design are effected. On request, refiners can be equipped with indirectly cooled stuffing boxes and with additional cooling for the stator tackle. The plug is adjusted by handwheel or remote control. To prevent 'dry' running of the refiner, rapid rotor back-off can be incorporated by means of a two speed reversing motor.

The use of conical refiner is appropriate in plants of small and medium capacity producing wide varieties of grades, requiring flexible refining systems from the point of view of technology.

b) Steep Angle Refiners

The cone angle in this type is 60°. With the sizes of ORS, 1RS, 2RS and 3RS, the range covers the power input of 200 to 600 kw. The bar heights are 20 to 25 mm depending on machine size. The grove depths are reduced to between 10 and 12.5 mm with a plastic filler. This plastic (three-component) filler can be removed when the tackles are worn half way down.

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Remote operation and rapid plug shifting can be also incorporated. These refiners offer special advantages in the field of drastic fibre shortening of long fibre stock, characterised by a higher specific bar edge load. It meets the requirement of medium and high capacity paper plants.

DOUBLE DISC REFINERS

The double disc refiner programme incorporates four sizes covering a power range of 200 to 1250 kw. These are in specific sizes OSDM, 1SDM, 2SDM and 3SDM which have disc diameters of 500 or 610, 750, 865 and 1050 mm respectively.

The refiner has a rotor fitted with disc plates on both sides, which is mounted to side axially between two opposing stator discs. One of the stator discs is connected firmly to the machine housing. The other is fastened to a refining disc carrier which can move axially in the housing cover. The adjusting gear consists of a two stage worm gear unit with a reversing motor and a threaded spindle which engages with the refining disc carrier through a nut. The clearance between the two stator discs can be altered with the adjusting gear.

When the stock is fed to the refiner and the gap width is reduced, the axially movable rotor assumes a central position between the stators, because of the power centering effect of the closed power flow between rotor and stator discs.

The salient features of the Double Disc Refiner are :

1) Refiner is simple, rugged in construction and reliable in operation.
2) The refiner has a non-floating shaft which eliminates (a) axial thrust on the bearings, thus prolonging their life, and (b) need for telescopic coupling.
3) The main drive shaft bearings are grease lubricated which ensures safe and dependable operation under conditions prevalent in the paper industry.
4) Provision of cylindrical roller bearings on tender side permits quick removal/assembly of complete shaft assembly including drive coupling and drive side bearing. This results in lesser down time and ease of maintenance.
5) The shaft protective sleeve can be changed from the tender side without disturbing the shaft assembly.
6) The swivellable housing cover and provision of simple mounting fixture provide access to all the four disc surfaces simultaneously for quick and easy disc changing
7) Provision of pole changing motor with remote operation for (a) rapid withdrawl during stock flow failure and (b) loading at crawl speed.
8) Provision of electric control stand for manual or automatic supervision and control of refiner.
9) Provision of graduated scale to indicate segment wear.
10) Occupies less space and offers power economy.
11) Flow types (a) Parallel flow with two inlets, (b) parallel flow with one inlet, and (c) series flow.

SAFETY DEVICES

The following safety devices are provided and the refiner is supplied completely wired and tubed for operation :

1) **Safeguard against dry running and low inlet pressure**

   Audio signal with automatic rapid withdrawl of the disc in case of stock flow failure.

2) **Excessive outlet pressure**
   Audio/visual indication for necessary corrective action.

3) **Low sealing water pressure**

   Audio/visual indication for taking necessary corrective action.

4) Also provided is a safeguard against mechanical damage due to excessive backing through limit switches.

All the above devices are provided with both manual as well as automatic electric control stands.

The Refiner plates are available in cast or welded designs. In comparison with the cast design with welded bars, it is possible to obtain closer bar spacings and greater bar height. This produces a greater bar edge length per second, higher throughput, higher power input with the same bar edge load and longer tackle life. The welded tackles have twice the groove depth as that of cast design.

Double Disc Refiners are in successful operation in big capacity paper plants like Sree Rayalaseema Paper Mills and Bhadrachalam Paperboards Limited.

INFLUENCE OF MACHINE VARIABLES ON REFINING

It should be noted that within certain limits when a refiner is properly applied, there is not a great difference between conical and disc refiners

regarding their ability to develop fibres. In other words, a fibre cannot read the label on the refiner and does not know if it is in disc or conical refiner. It is aware of only two things—how many times it is hit and how hard it is hit each time.

Since the refining action takes place on the leading edge of the tackle bar/segment, the specific contact length in km/sec. (also called inch contacts per minute) is calculated considering the number of bars in rotor and stator, effective contact length of the bars and the speed of refining unit.

It then follows that with a refiner tackle of high number of specific contact length in km/sec (or inch contacts per minute), the net power in watt secs per km becomes very low resulting in minimum cutting and maximum bruising. Therefore the amount of fibrillation can be increased by increasing the number of bars and speed.

Other factors that affect refining intensity are consistency and cutting (intersecting) angle of the refiner bars. When the consistency is increased, the fibres are close to each other and this produces more fibre to fibre action over the leading edges of the tackles which produce more fibrillation. With the decrease in cutting (intersecting) angle (closer the bars come to being parallel), the more severe the refining action and thus more cutting. Increasing the intersecting angle produces higher long fibre content.

Speed of the refiner is another factor influencing refining. Higher the mean peripheral speed, higher the fibrillation and long fibre content, however, with an increase in no load power.

The effect of change in peripheral speed, intersecting angle, stock consistency, machine loading on paper properties are shown graphically in the enclosed sheets.

It is also to be noted that for maintaining a reasonable amount of long fibre content and in turn strength properties, the loading of each refiner should have drooping nature with the increase in freeness in °SR, otherwise 50% of the permissible loading that the fibre can withstand can be maintained in all the refiners, increasing the number of refiners in operation.

As extensive articles are already available on the selection of refining systems and the effect of raw material and other pulping conditions on refining, the same is not touched upon.

All the above mentioned types of refiners can be incorporated with a suitable power input controller.

BATCH REFINING

In the enclosed sheet, system showing continuous refining as also batch refining with cycling system and recyling tank is shown. For refining of low tonnage stock and high freeness requirement in the range of 90°SR, particularly for speciality papers, it is essential to achieve an exacting end result for which such batch systems with extensive instrumentation controls are also suggested.

MACHINE REFINERS

Particularly for the machine refining stage (after machine chest), the following should be kept in mind.

- —the functions of machine refiner are not for strength development, but rather for the formation and drainage control on the wire with minimum response time and minimum wetting action. The unit is sometimes called 'Tickling' refiner.
- —the unit power consumption should be moderate, limiting to 2.5-4 kWh/100 Kg.
- —the intensity factor should be high, i.e. with low net power over a smaller area of refining.
- —any slowing of stock as a result of hydration is undesirable and prevents the addition of water on the wire. Slow speed refining unit is therefore desirable, however, the same is inter-related with the hydraulic capacity of the unit in handling furnish volume.
- —due to lower pH of stock lower stock consistency of 3-3.5% as compared to stock preparation refining of 4-5%, fine sand and other foreign matters carried through the broke, and also higher amount of mineral material of talcum/china clay (particularly for writing and printing grades), the wear of tackle for the machine refiner is higher in comparison with the life when operated in stock preparation.

VARIABLES INFLUENCING REFINING RESULTS

Raw Material	Refining Equipment	Process Variables
Wood (type, species)	Type	Refining arrangement
Green/dry wood in percentage	Machine loading	Separate/mixed refining
Pulping method	Tackle material	Stock consistency
Bleaching method	No. of bars	pH—value
Brightness	Bar width and form	Chemical additives
Moisture content (if dried)	Knife cutting angle	Temperature
Type of pulp drying	Groove depth & width	Throughput
	Tackle configuration	Soaking of stock
	Peripheral speed	
	Refining pressure/intensity	

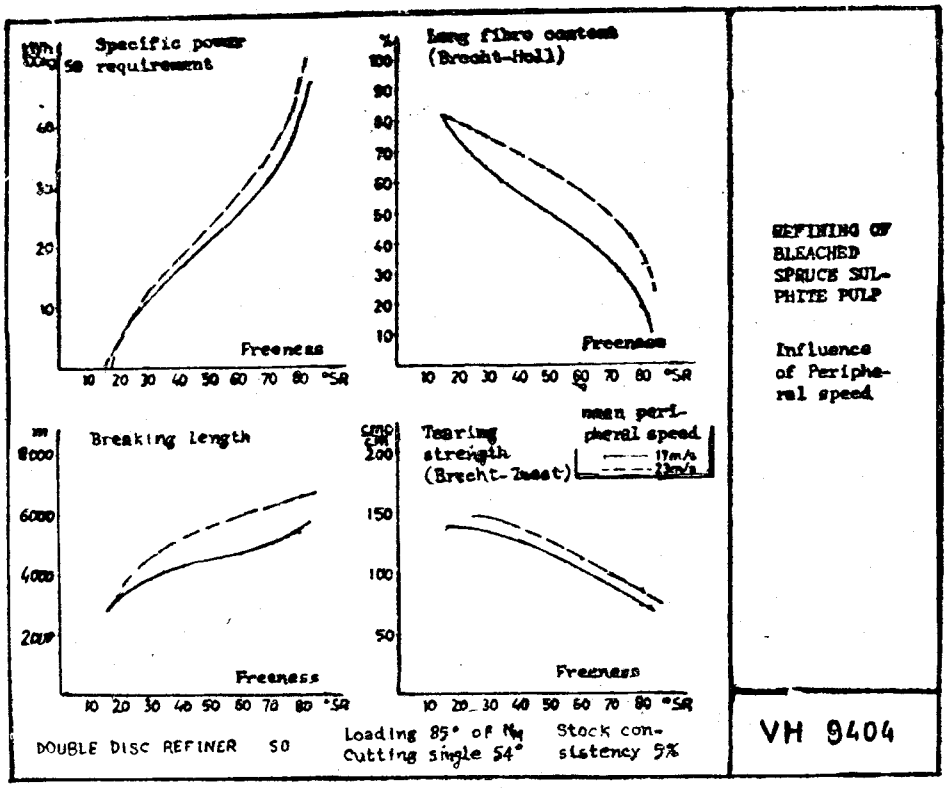

Specific power
SR requirement
Freeness
Long fibre content
(Brecht-Holl)
Freeness
Breaking length
Freeness
Tearing strength
(Brecht-Imeat)
mean peripheral speed
Freeness
DOUBLE DISC REFINER SO
Loading 85° of Mg
Cutting single 54°
Stock consistency 5%
REFINING OF BLEACHED SPRUCE SULPHITE PULP
Influence of Peripheral speed
VH 9404

Fig.—1

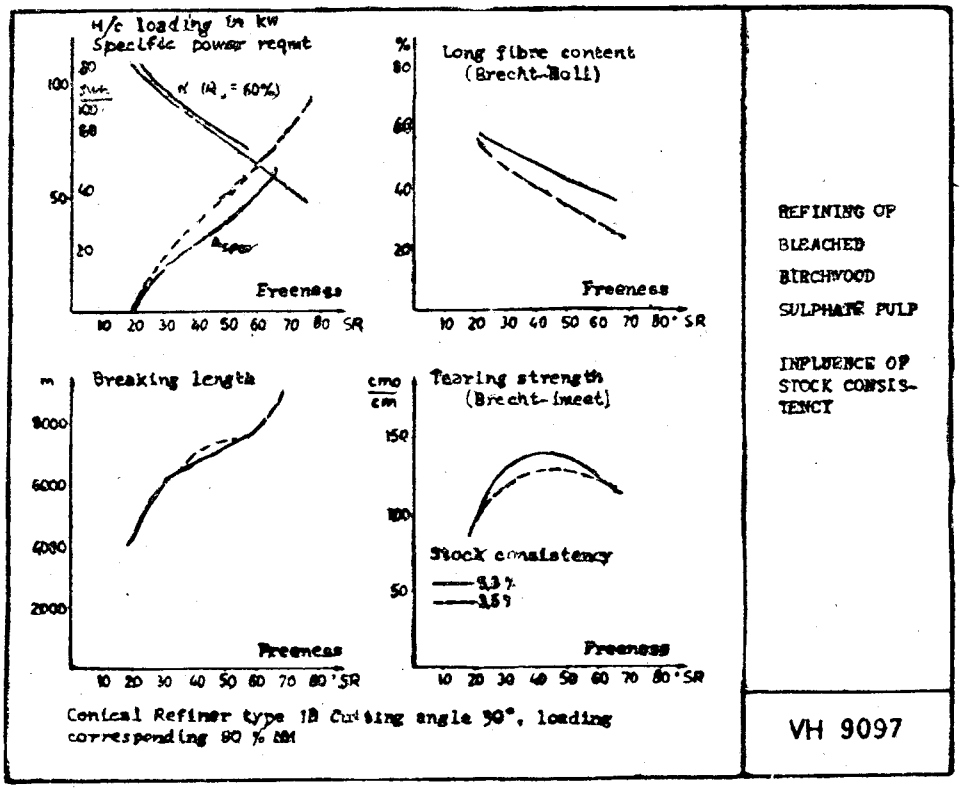

H/c loading in kW
Specific power reqmt
Freeness
Long fibre content
(Brecht-Holl)
Freeness
Breaking length
Freeness
Tearing strength
(Brecht-Imeat)
Stock consistency
Freeness
Conical Refiner type 1B Cutting angle 30°, loading corresponding 80 % SR
REFINING OF BLEACHED BIRCHWOOD SULPHATE PULP
INFLUENCE OF STOCK CONSISTENCY
VH 9097

Fig.—2

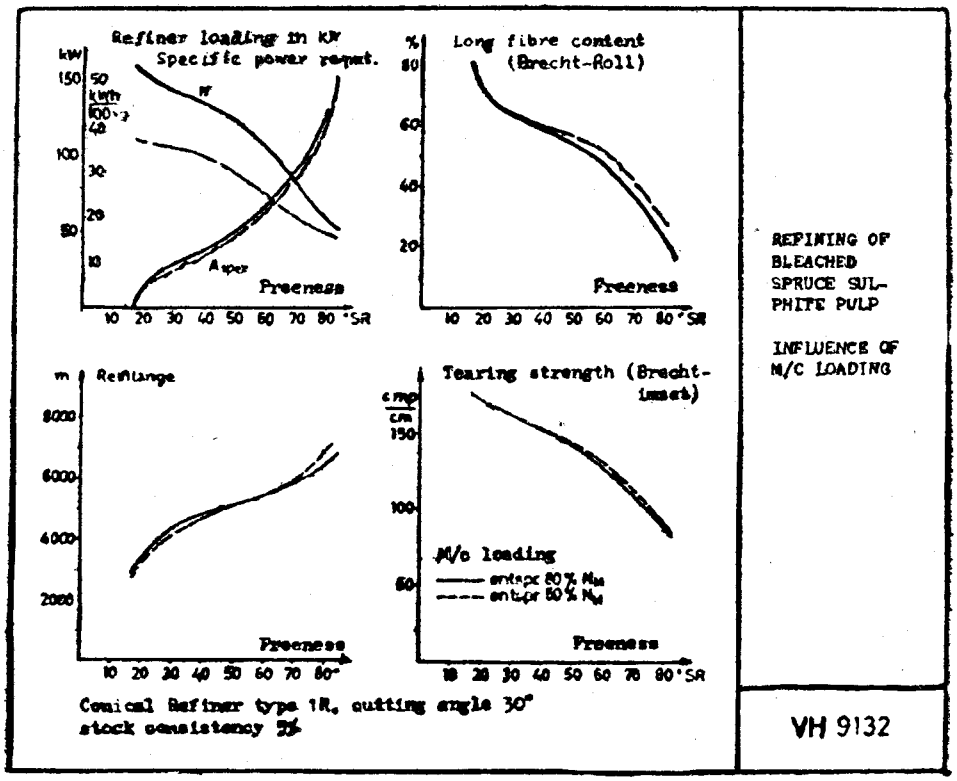

Refiner loading in kW
Specific power requt.
kW
kWh/100 kg
W
Aspr
Freeness
10 20 30 40 50 60 70 80 °SR
Long fibre content
(Brecht-Roll)
%
Freeness
Reflunge
m
Freeness
Tearing strength (Brecht-Imset)
Freeness
M/c loading
Conical Refiner type 1R, cutting angle 30°
stock consistency 2%
REFINING OF BLEACHED SPRUCE SULPHITE PULP
INFLUENCE OF M/C LOADING
VH 9132

Fig.—3

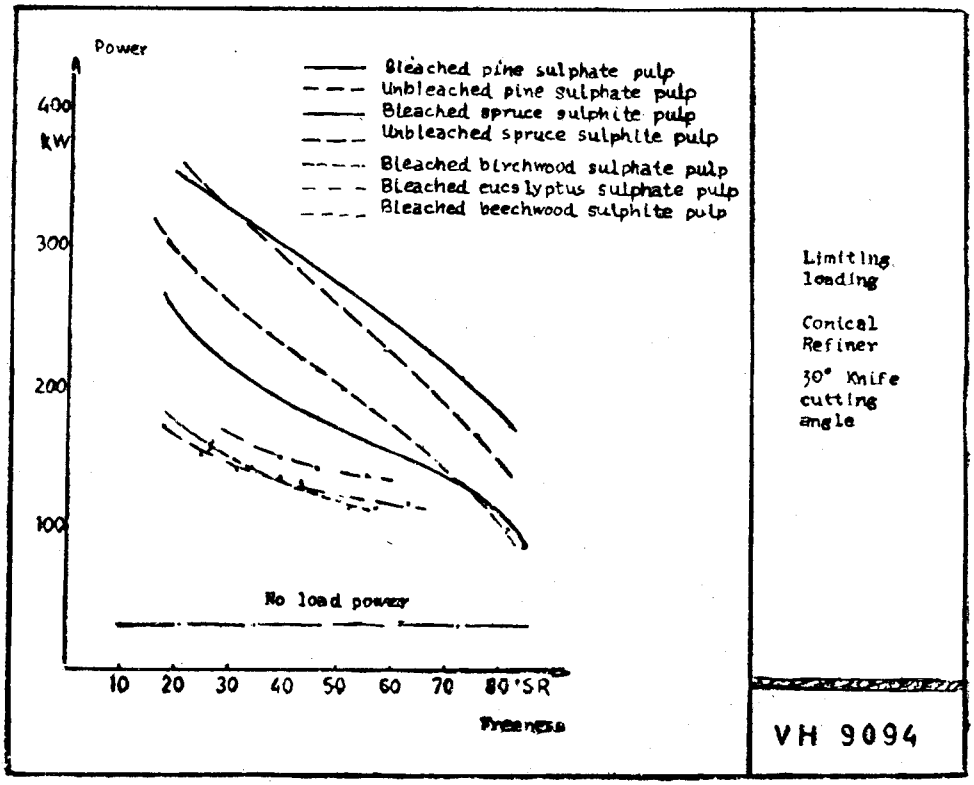

Power
kW
Bleached pine sulphate pulp
Unbleached pine sulphate pulp
Bleached spruce sulphite pulp
Unbleached spruce sulphite pulp
Bleached birchwood sulphate pulp
Bleached eucalyptus sulphate pulp
Bleached beechwood sulphite pulp
No load power
10 20 30 40 50 60 70 80°SR
Freeness
Limiting loading
Conical Refiner
30° Knife cutting angle
VH 9094

Fig.—4

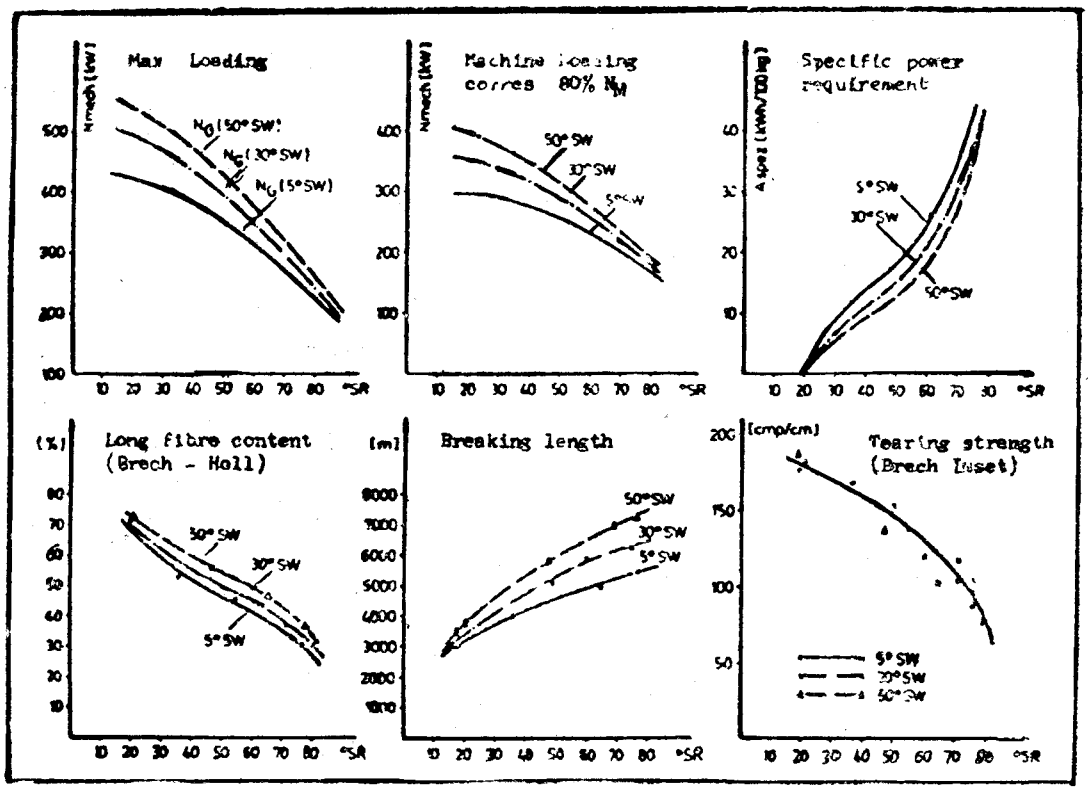


Fig.—5 Influence of cutting angle—Refining of spruce sulphite pulp in 2R Refiner with higher speed—loading corres to 80%Nm. Speed 1000 rpm. Stock consistency 5%

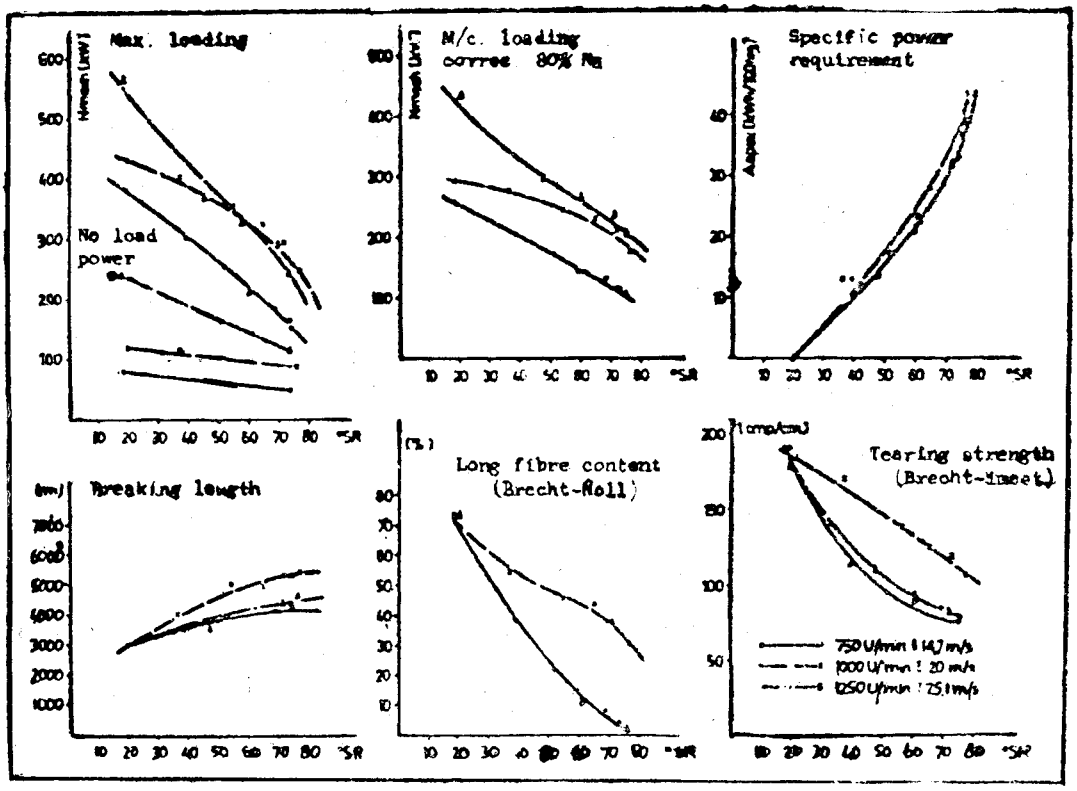


Fig.—6 Influencing of peripheral speed of refining of bleached spruce sulphite in 2R Refiner 6 mm—5° SW Loading corres to 80% Nm. stock consistency 5%

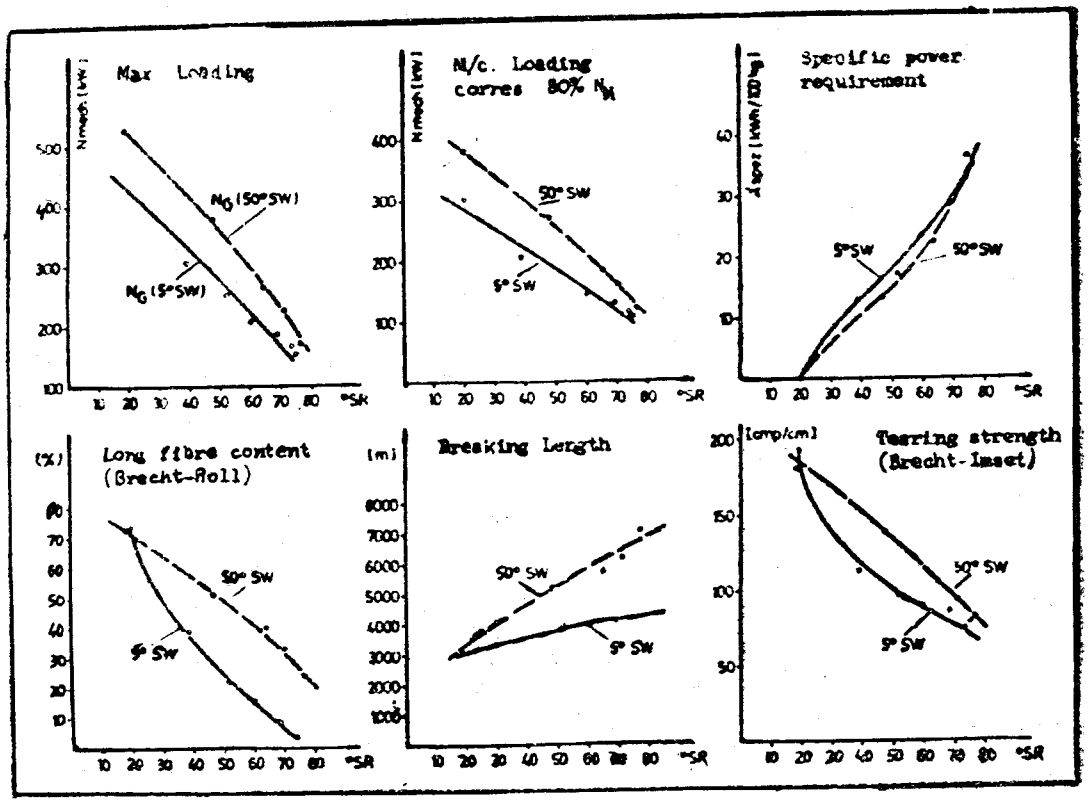


Fig.—7 Influence of cutting angle—Refining of bleached spruce sulphite pulp in 2 R Refiner Loading corresponding to 80% Nm. Speed 150 rpm Stock consistency 5%.

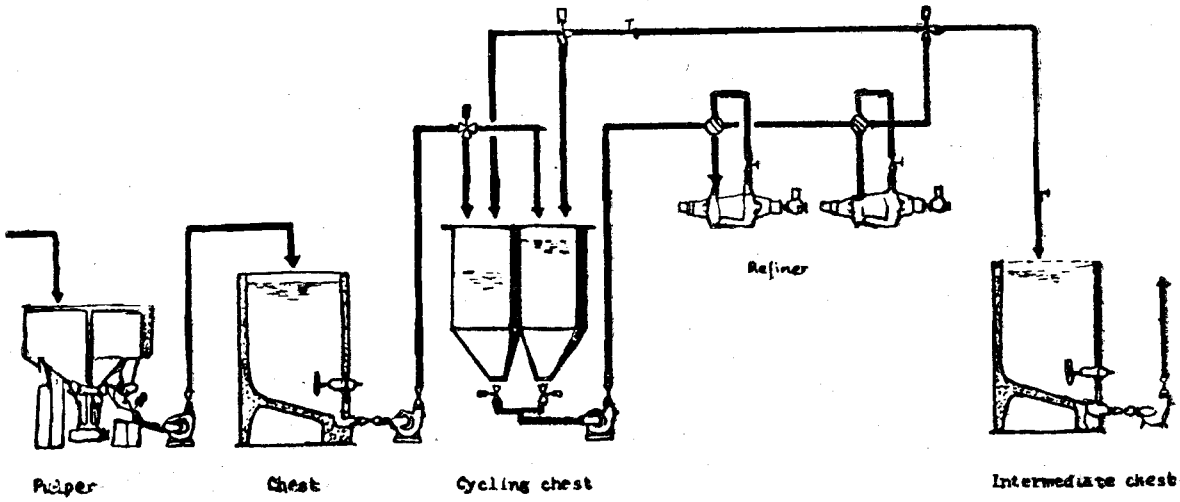


Fig.—8

BILD 3
Cycling chest—
circulating system
batch type

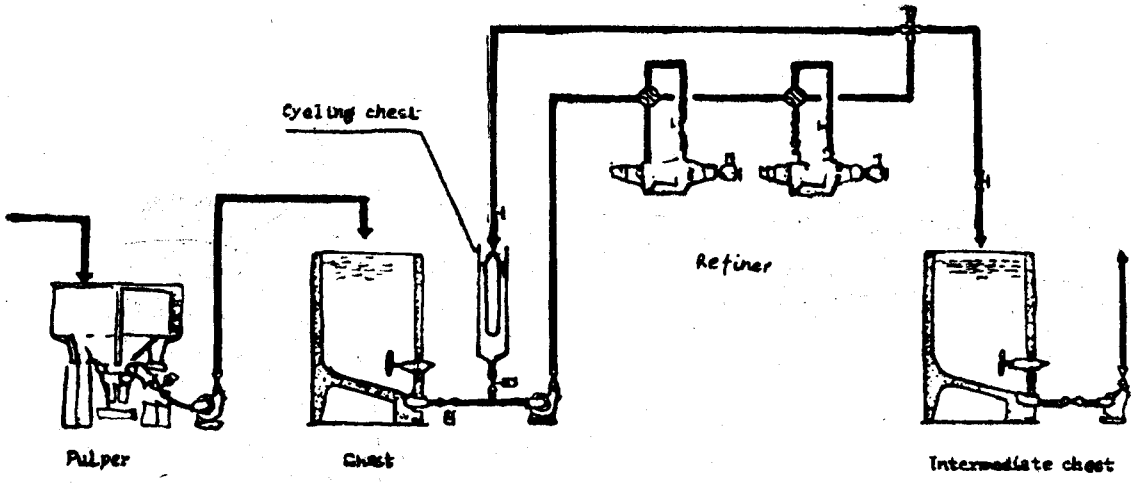
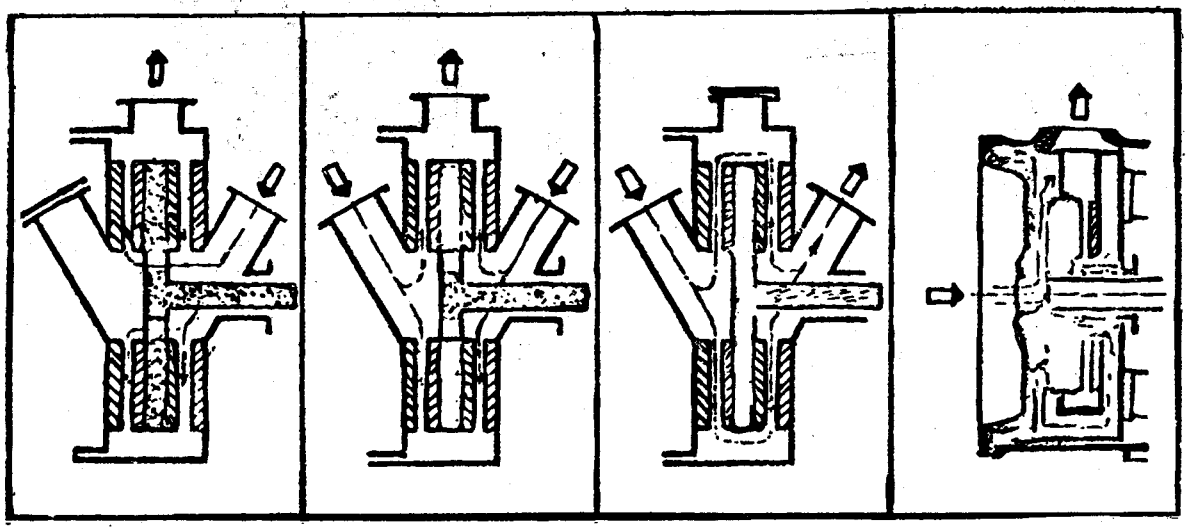


BILD 3
Recirculation refining system

Fig.—9

Double Disk Refiner—Flow Arrangement



Parallel Flow with one inlet (Duoflow)	Parallel Flow with two inlets (Duoflow)	Series Flow (Monoflow) entry to centre, outlet also from cetre	Alternative Flow entry to centre, outlet radial

Fig.—10

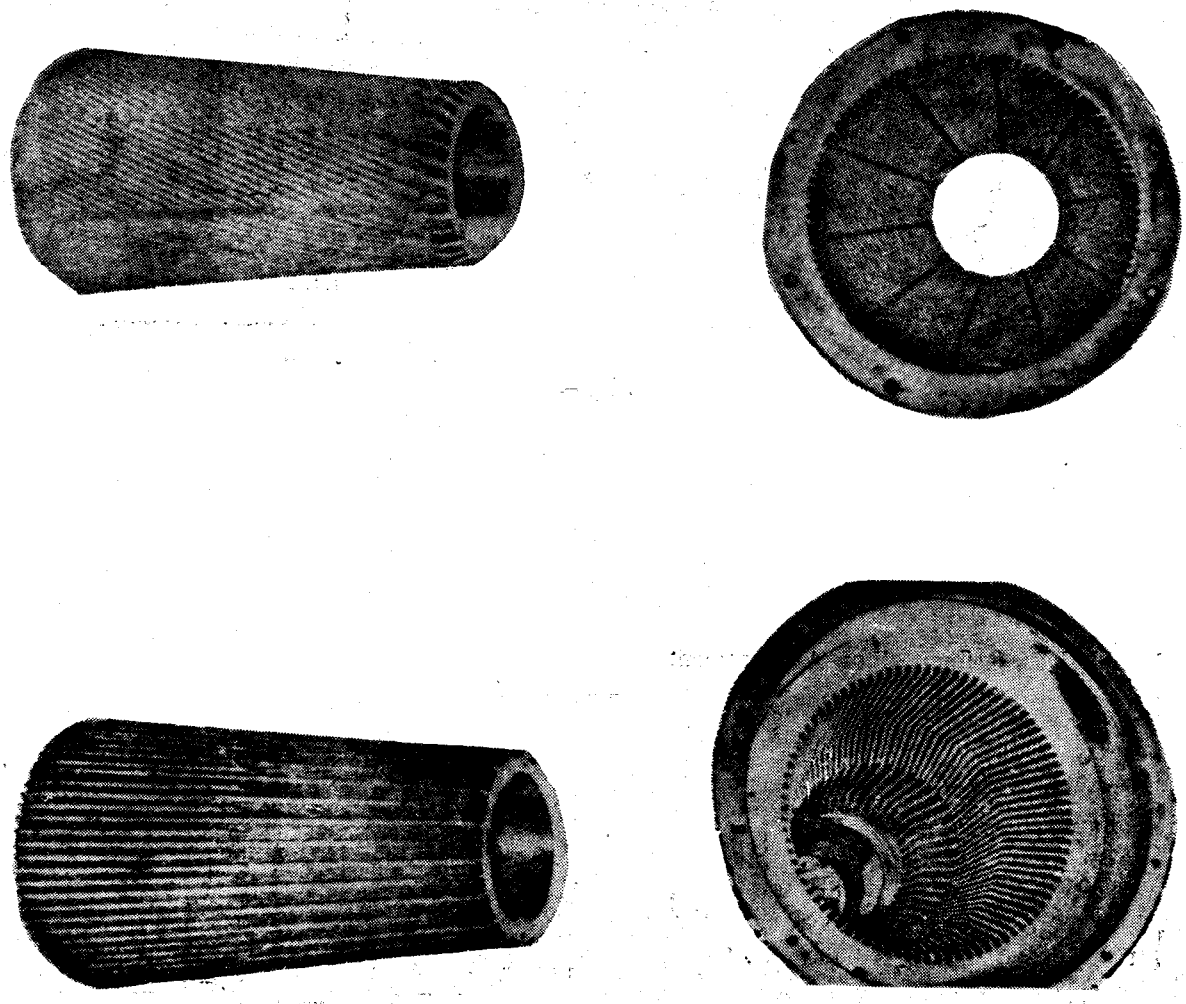


Fig.—11