Modification of the conventional multistage bleaching sequence for the recycling of the effluents by UF/RO technology

SAPKAL, V. S. AND BASU, S.*

SUMMARY

It is suggested to modify the conventional bleaching sequence from CEHH to CHHH, whereby colour load, corrosive, precipitating characteristics of the combined chlorination (C) and first stage Hypo effluents could be reduced considerably.

An attempt has been made in this Work on evaluating the applicability of UF/RO technology in recycling the C and HI stage effluents for reutilization in the bleaching plant. Results indicate, that, under optimal conditions of feed pressure, and flow rate, colour and chloride loads in the effluents could be reduced to the extent of 85 to 95% with permeate flux of recyclable character.

Pulp and Paper industry is highly water intensive, and consequently generates high level of pollution load in the form of industrial effluents. The most single deficiency in conventional waste treatment systems, based on bio-chemical conversions, is the inability of these systems to reclaim water for reutilization, since inorganic total dissolved solid load in the influent, and out-fluent streams, even after tertiary treatment, remains more or less unaffected. Since one-step separation on molecular or ionic level is not feasible in conventional waste treatment systems, a special intermediate step is required in waste disposal systems to remove the desired species, or waste components, and this multistep procedure makes the capital investment requirement excessive. With the development of the membrane Technology (MT), there has been extensive exploratory research, and engineering studies during the last two decades mostly in Western countries and in Japan, on the applications of MT—Electrodialysis (ED), Reverse Osmosis (RO), and Ultrafiltration (UF)—for the recovery of useful products, and water, along with pollution abatement, from industrial effluents.

Successful commercialization of MT in industrial processing and in desalination fields prompted to initiate a series of R & D Work at the chemical Engineering Department, IIT-Bombay, in the field of MT in industrial processing, and pollution abatement in chemical industries, with particular reference to Pulp, Paper, and in Cellulose based industries. (Ref. I-7).

Since 35 to 45% of the total pollutional load in an integrated Pulp and Paper Mill is generated in the multi-stage bleaching plant, an attempt has been made in this work to evaluate the applicability of UF/RO technology in rendering the bleaching plant effluents useable in the process operations.

PLAN OF WORK

Since over 60% of the total colour load is concentrated in the alkali-extraction stage (E), and the combined C and E stage effluents are highly precipitating type, it was thought desirable to eliminate the E stage from the conventional CEHH sequence into i) CHHH, and ii) HCHH. Preliminary investigations indicated, that, CHHH sequence could be better suited (as compared to HCHH sequence) in UF/RO systems with reference to clarity, and pH of the combined effluents (C with Hi , and therefore extensive experimental work was concentrated with CHHH sequence effluents the help of UF/RO technology. H_2 and H_3 stage effluents were not evaluated. since both H_2 and H_3 stage effluents could be recycled in the bleaching plant without any pretreatment.

*Chem Engg. Dept.,
Indian Institute of Technology Bombay, india.

Before taking the effluents inside the UF/RO modules, the feed was passed through a sand filter, followed by two stage cartridge filters, consisting of 50 μ followed by 5μ.

For evaluating membrane performance with respect to Chloride and tds% rejection, elimination of colour load, permeate flux rate under different flow velocity, and feed pressure, experiments were carried out in UF/RO test cell, described in our earlier communication (Ref 6).

Further experiments were carried out in spirally wound UF/RO modules having active membrane area (Cellulose acetate based) of 2.80 m^2, placed in a epoxy coated m.s. pressure vessel of 8 cm dia X 150 cm length as per the details mentioned in our previous communications.

Colour load was measured by spectrophototometer, tds gravimetrically, and the chloride content by selection electrode method in a Orion Ion analyzer (model 701 A, Orion Research, USA).

RESULTS & DISCUSSIONS

Pollution load distribution of different effluent streams, discharged in a well managed integrated Kraft Pulp & Paper Mill may be represented as follows :

Source of effluent	Volume per tonne of paper M^3	Gallons	BOD load/tonne paper BOD (kg)	Population eq. (BOD basis)
Chipper House	46	12,500	1.50	33
Pulping/washing/and recovery House	22	4,800	11.50	246
Muiti-stage Bleaching House	108	23,500	17.00	370
Paper Machine House	40	8,500	5.00	110
Combined effluent	216	49,300	35	759

As depicted above, major portion of the pollution load is generated in the Multi-stage bleaching plant, and normally it comes out from the first two stages (C & E in a CEHH sequence).

Combined bleaching plant effluent characteristics for the CEHH and CHHH (first two stages) sequences is presented as follows :

	CEHH sequence	CHHH sequence
pH	7.50	6 to 6.50
tds (ppm)	3400 ppm	2200 ppm
Chloride as NaCl	2500 PPM	1900 ppm
Mixing characteristics	colloidal precipitation observed, highly coloured	No precipitation observed, clear solution

The following advantages could be pinpointed in favour of CHHH sequence, for treatment in UF/RO system :

(a) Feed pretreatment cost could be reduced considerably,

(b) Reduced membrane fouling, and consequently increased permeate flux rate during UF/RO treatment,

(c) Significantly reduced tds and chloride content in the feed, and therefore reduced osmotic pressure, and improved permeate flux at a particular feed pressure.

(d) Feed pH is more favourable to CA based membrane modules, and consequently longer membrane service life.

(e) Operational costs (dominated by membrane replacement and feed pretreatment costs) is expected to be reduced considerably.

Impact of feed flow rate, and feed pressure on permeate flux rate is presented in fig. 3.

Due to concentration polarization problems at the membrane interface, increased hydrodynamic load to the membrane system (measured in terms of feed flow rate) gives pronounced effect on the minimization of concentration polarized modulus (CPM), and consequently on the improved rate of permeate flux.

% Rejection of colour load, Chloride and tds in the feed, under varying conditions of feed pressure and flow rate is presented in fig. 4.

With RO membrane, as expected, % colour rejection, and tds, and chloride could be found to be varying within 85 to 95%, whereby chloride, and tds load in the permeate, in two stages, might be reduced to the level of 40 to 80 ppm.

With UF membrane, colour rejection could be found to be above 80%, while chloride, and tds

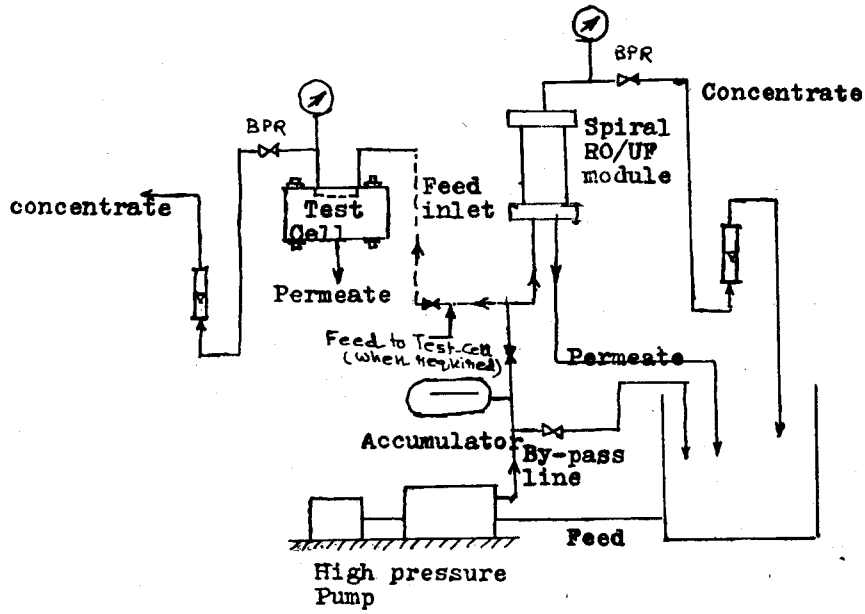


Fig.I EXPERIMENTAL SET-UP FOR RO/UF TEST RUN

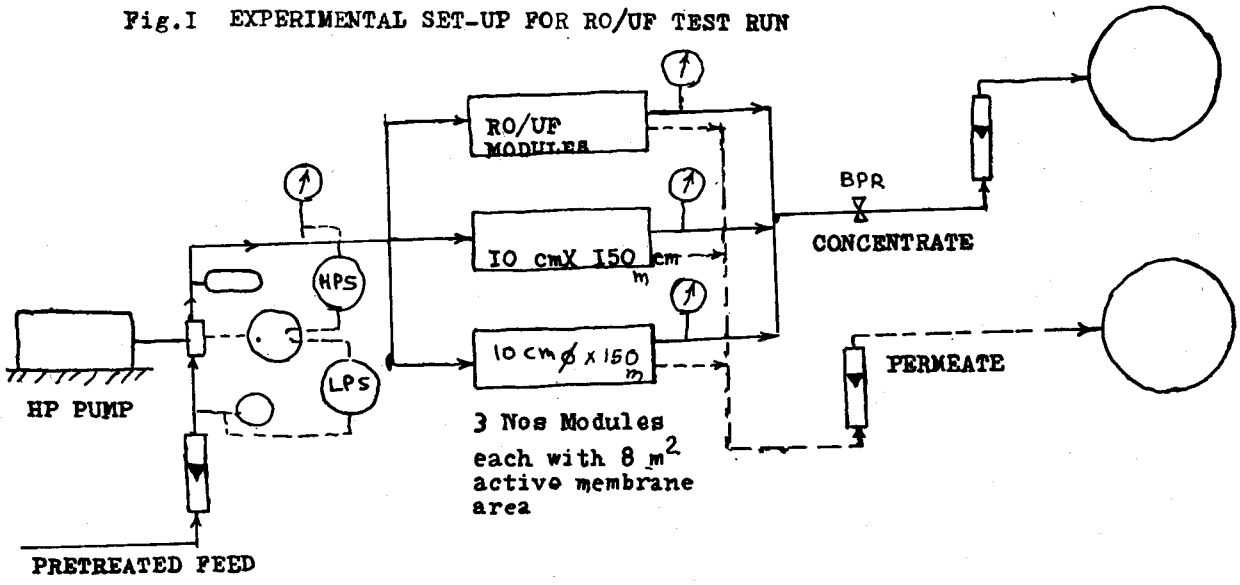


Fig.2 EXPERIMENTAL SET-UP FOR BIG SCALE RO/UF TEST RUN

rejection could be maintained around 30 to 40% although permeate flux was improved to the extent of 70 to 100%, compared to RO operation.

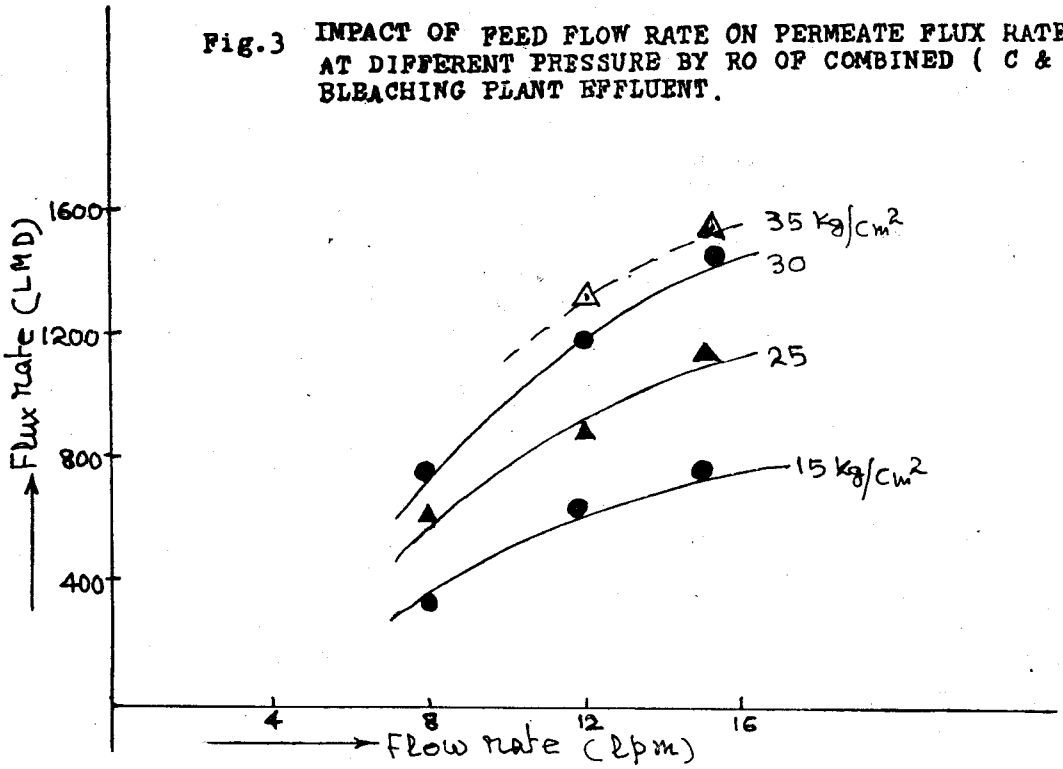
These results indicate, that, two stage membrane filtration, consisting of UF, followed by RO, is expected to give good amount of benefit to the Pulp and Paper industry, through abatement of pollution problem, along with reclamation of water as permeate flux for recycling.

A bigger capacity UF/RO unit, having active membrane area of 17 m^2, has been installed, and standardized, and further work is in progress to evaluate the following :

(1) To develop optimal pretreaement system for the maximization of permeate flux rate of useable quality for reutilization.

(2) To ascertain optimal level of feed recovery as permeate flux.

Fig.3 IMPACT OF FEED FLOW RATE ON PERMEATE FLUX RATE AT DIFFERENT PRESSURE BY RO OF COMBINED (C & H_I) BLEACHING PLANT EFFLUENT.



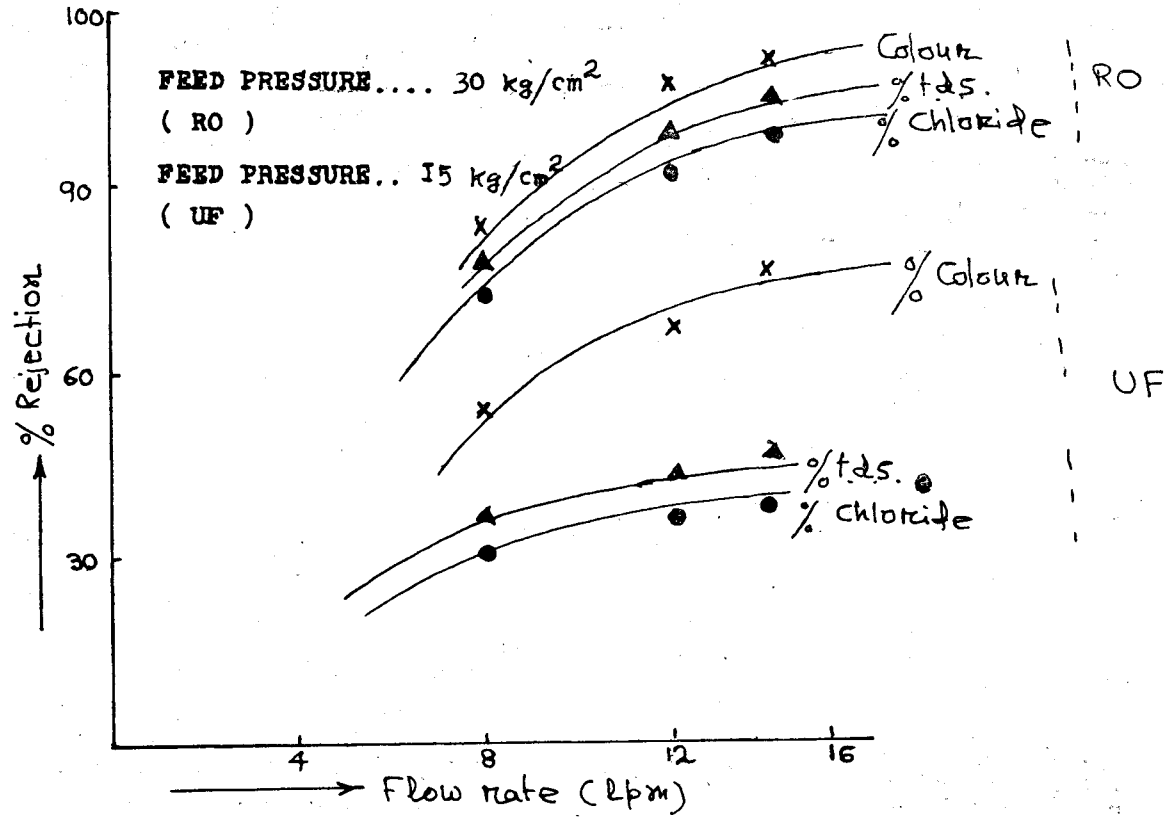


Fig.4 IMPACT OF FEED FLOW RATE ON % REJECTION OF TDS, CHLORIDE, AND COLOUR LOAD BY RO/UF OF COMBINED (C & H_I STAGES) EFFLUENTS

(3) To evaluate a design equation (based on the correlationship of the hydrodynamic load and feed properties, expressed in terms of N_{Re}, N_{Sh} and N_{Sc} with the CPM) for the prediction/permeate flux within/of the operational constraints, to be utilized for designing a 10 TPD UF/RO Pilot plant for recycling of water, along with pollution abatement from Bleaching plant effluent.

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