Impact of system closure on performance of bleach plant process equipment

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ABSTRACT

Present paper discusses the effects of system closure, by adopting filtrate recycling, on bleach plant performance and their materials of construction. It discusses the status of bleach plants prior to start of filtrate recycling practice and move on to discuss the impact that pollution control measures have on corosivity of bleached pulp washer filtrates. The increased corosivity has resulted in frequent failures of washers. This, in turn, led to development of newer and better resistant materials for fabricating process equipment and their components, and application of electrochemical protection systems. Performance of newer materials vis-a-vis conventional materials has been discussed in the light of changed process environment. A comparison of blea h plants in the mills of developed countries has been made with those of two Indian mills. Consequently, suggestions are put forward for undertaking tests, in Indian bleach plants, which in turn may help in adopting strategies so that plant machinery is more dependable and economical even after pollution control measures and newer bleaching processes are in use.

Introduction

Lot of attention is being focussed on various aspects of environmental (gaseous / liquid) pollution and on ways and means to control it. An aspcct on management of paper and pulp mill machinery stems from the observation that pollution control measure e. g. closure of mill by adopting filtrate recycling is, among other factors, responsible for increasing aggressiveness of liquors and gasesus media encountered by machinery material in different sections of a pulp and paper mill. This has led to markedly severe corrosion attacks on the materials thereby shortening the life of process equipment considerably in bleaching sections (1-3) .paper machine section etc. (4-8). This in turn, means more frequent and unscheduled shutdowns, maintenance and/ or replacement of process equipment and search for newer and more corrosion resistant materials. So on the one hand, whereas adopting pollution control measures is becoming statutory, the same measures also threaten to affect the dependability and economy of machine construction. It is, therefore, of importance to know the effects of pollution control measures on the machinery materials of pulp and paper mill.

Bleach section, in a paper mill, is responsible for discharging comparatively greater amount of pollutants. Incidentally this is also the section where process equipment materials face harshest of the environments. According to a studay (9), about 50% of the cost due to corrosion is spent on bleach plant machinery material. Present paper, therefore, discusses the effect of pollution control measures on bleach plant machinery material.

2. Status of Bleach Plant Prior to and after anti-pollution steps

Generally, bleach plants in most paper mills consist of chlorination (C), chlorine-di-oxide (D), Alkali Extraction (E) and Hypochlorite (H) stages. The bleaching sequence could be CEHDED, CEDED etc. Though most Indian mills still use, the old,

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Table 1 : Average filtrate conditions in typical Bleach washers

Stage	pH	Temperature (°C)	Residual Cl_2 (mg/l)	Chloride (mg/l)
C	2.0	35	90	1250
D1	2.4	58	56.5	576
D2	4.2	73	21.7	360
E	10.3	48	—	850
H	10 0	37	1 2 Kg. / ton	1450

CEH bleaching sequence. Data of interest from corrosion point of view, for washer filtrates of different stages are shown in Table 1. Data for C stage corresponds to that observed in North American and Canadian mills (10) where as those of D,E and H Stages are of Scandinavian mills (11,12). It may be worth mentioning here that bleach plants in Scandinavian mills generally have lower temperature and higher pH in comparison to North American mills. The data indicates that (i) C and D stage washers should be more corrosive since the liquor is acidic and having residual chlorine, chloride, and higher temperature. These are the condition very much conducive to localised attack e.g. pitting, crevice corrosion. (ii) H and E washers should be less corrosive as the filtrate is alkaline. Among these, H stage should be more corrosive since here residual oxidant concentration is higher.

Experience in various mills, in fact, indicated C and D stages as areas of growing concern due to materials in them experiencing corrosion with increasing severity. As such, surveys were performed for compiling a list of materials, used for making various process equipments for these stages, in mid sixties by TAPPI and CPPA (13-15). These surveys showed the application of steel pipe with protection by painting and/or plastic covering, 316 and 317 stainless steels (SS) at most places and only rarely hastelloy C as metallic materials. In fact SS 317/317 L had been developed specially for bleach plant equipment e.g. chlorination washers in the early fifties (16). One of these surveys (15) also indicated handling and washing of stock between successive bleaching operations as one of the more corrosion prone areas in the bleachery.

Between 1965 and 1972. there was a significant increase in the report on corrosion failure of stainless steel components in bleached pulp washers. This was also the time when recycling practices were first introduced. Consequently, the alkaline pulping committee of CPPA performed another survey, in 1973, to determine the environmental conditions and corrosion problems encountered in chlorinated pulp washers (17). Prominent conclusions of this survey were-(i) When corrosion of washers was severe, washer filtrate exhibited higher than average values for temperature, Cl^- ion and free chlorine concentrations. (ii) SS–317L in chlorination washer construction did not ensure, in itself, a long drum life.

Occurrence of frequent corrosion failures, also led to conduct corrosion tests in North American and Scandinavian mills in the later half of seventies (10-20, 18). The tests were conducted to observe :

(a) Comparison of corrosion resistance of various candidate materials. The tested metals included traditional construction material as SS 316L, 317 L and also the most promising alternative alloys. (Composition of commercially available bleach plant alloys are shown in Appendix—A)

(b) The relation between bleaching plant environment and corrosion.

(c) To identify, in case of Canadian mill survey (10), for each alloy the filler metal which produces better corrosion resistant weldment.

The aims for the above mill tests were :

(a) To help the mills in selecting cost-effective constructional material and its corresponding filler metal for the increasingly corrosive environment.

APPENDIX—A

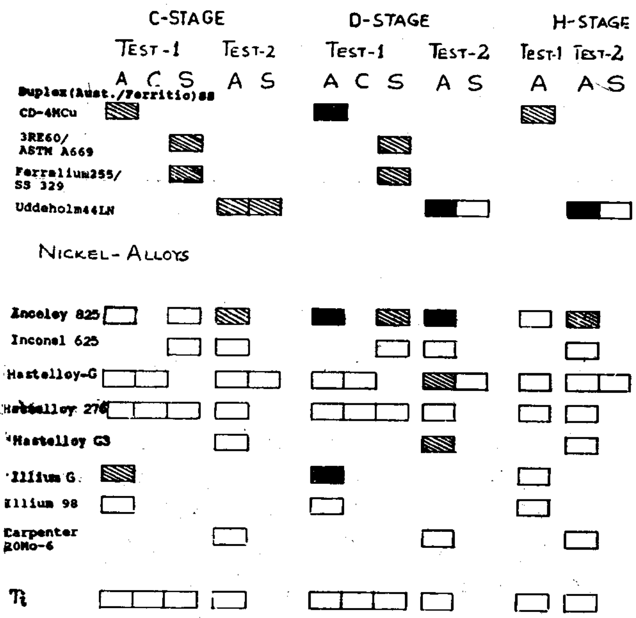
Composition of Commercially Available Bleach Plant Alloys

Alloys	Cr	Ni	Mn	C	N	Si	P	S	Mo	Fe
1. **Austenitic SS**										
a. 304	18.1	11.5	1.92	0.04	—	0.59	—	—	0	Bal
b. 316	17.3	11	1.47	0.04	0.06	0.46	—	—	2.63	Bal
c. 316L	16	13	1.6	0.33	—	0.1	0.021	0.01	2.8	Bal
d. 317	18.2	14	1.84	0.037	0.10	0.38	—	—	3.48	Bal
e. 317L	18	14	1.9	0.02	—	0.5	0.029	0.009	3.2	Bal
f. 317LM	18	14	1.2	0.02	0.07	0.7	0.029	0.008	4.0	Bal
g. 317LMN/ 1.4439	18	14	1.5	0.03	0.13	0.5	—	—	4.3	Bal
h. 832SL	16.8	14.7	1.3	0.045	0.04	0.45	—	—	4.19	Bal
i. 904L/B-625/ 20Cr25Ni4.8Mo	20	25	1.8	0.02	—	0.04	0.025	0.004	4.2	Bal
j. Avesta254SMO	20	18	0.5	0.02	0.21	0.5	0.015	0.002	6.1	Bal
k. Avesta254SLX	19.8	24.6	1.6	0.01	0.04	0.63	0.019	0.001	4.39	Bal
l. H-20Mod/ Haynes H-20M	22	26	0.8	0.03	—	0.06	0.013	0.01	4.2	Bal
m. JessopJS700	21	25	1.7	0.03	—	0.05	—	—	4.5	Bal
n. JessopJS777	21	25	1.7	0.025	—	0.5	0.03	0.03	4.5	Bal
o. AL-6X	20	24	1.7	0.02	—	0.03	0.021	0.001	6.6	Bal
p. AL-6XN	20	24	1.7	0.02	0.2	0.3	0.021	0.001	6.0	Bal
q. Sanicro 28 (Sandvik)	26.9	31.7	—	0.02	0.023	—	—	—	3.4	Bal
r. Nitronic 50	21	14	6.2	0.05	0.22	0.3	0.022	0.011	2.2	Bal
s. Crucible T-317X	19	15	1.75	0.02	—	0.5	—	0.005	5.5	Bal
t. VDM Cronifer 19/25 HMO	21	25	1.3	0.02	0.14	0.3	0.018	0.010	5.9	Bal
u. UR SB8	25	25	1.0	0.01	0.2	0.2	0.018	0.002	4.8	Bal.

Alloys	Cr	Ni	Mn	C	N	Si	P	S	Mo	Fe
2. Ferritic SS										
a 29-4	29	0	0.1	0	0.01	0.1	—	0.01	4.0	Bal
b. 29-4-2	29	2	0 1	0	0.01	0.1	—	0.01	4.0	Bal
c. 29-4C	29	—	—	0.03	0.3	0.1	—	0.01	4.0	Bal
d. 26-1S	26	0.5	0.75	0.06	—	0.75	—	—	0.75 –1.5	Bal
e. Nyby Monit	25	4	0.3	0.02	0.01	0.2	—	—	4.0	Bal
f. SS 2326	17.6	0.4	0.32	0.015	0.01	0.32	—	—	2.12	Bal
g. E-Brite	25.9	—	—	0.002	0.006	—	—	—	1.0	Bal
h. Crucible SC-1	26	2.5	0.3	0.03	0.03	0.3	—	—	3.0	Bal
i. Schomac 30 2	30.6	0.22	0.03	0.002	0.01	0.15	0.014	0.015	1.99	Bal
3. Duplex (Aust./Ferritic) SS										
a. Ferralium255/ SS 329	25	5	0.7	0.03	0.16	0.3	0.021	0.002	2.8	Bal
b. CD-4MCu	26	5.5	1.0	0.04	—	1.0	—	—	2.0	Bal
c. 3RE60/ ASTM A669	18.6	4.9	1.62	0.03	0.07	1.7	—	—	2.72	Bal
d. Uddeholm44LN	24	6.3	1.67	0.02	0.18	0.65	—	—	1.65	Bal
4. Nickel alloys										
a. Incoloy 825	22	40	0.3	0.02	—	0.2	—	0.002	2.9	28.5
b. Inconel 625	22	63	0.1	0.01	—	0.2	0.01	0.007	9.5	3.9
c. Hastelloy-G (H-G)	22	47	1.3	0.01	—	0.4	0.014	0.002	6.4	19.8
d. Hastelloy G3	22	Bal.	0.7	0.01	—	0.3	0.011	0.002	7.1	19.9
e. HastelloyC276	16	56	0.5	0.01	—	0.1	0.011	0.002	15.6	5.6
f. Carpenter 20Mo-6	24	Bal.	0.3	0.02	—	0.3	0.021	0.004	5.6	31.0
g. Illium G	22.5	56	0.5	0.01	—	0.1	0.011	0.002	6.5	0
h. Illium 98	20	80	—	—	—	—	—	—	—	—

(b) To adopt control strategies in mills so as to make environment less aggressive.

Results of the three mill tests (10-12, 18) are shown in Figure 1. Analysis of the results shows that :



Unsatisfactory , Useful , Superior

A - American , C - Canadian , S - Scandinavian Mills

Test 1 : References 10 - 12 , 18 ; Test 2 : References 3, 21, 22

Figure 1-Comparison of Commercially available Bleach Plant Alloys in Bleached Pulp Washers of North American and Scandinavian Mills

(a) Traditional alloys SS 316, 317 can no longer be used for fabricating various components of C and D stages of bleachery.

(b) Austenitic stainless steels with high Mo, Cr, Ni contents e g. 904L, 254 SMO ; Ni based alloys (hastelloy) could be the better cost-effective choice. In case of American and Swedish mills, some new austenitic, ferritic and duplex stainless alloys have also been observed to show acceptable behaviour. The acceptability of a particular alloy will depend upon its performance and cost.

(c) Canadian bleach plants appear to be most corrosive This is perhaps due to the fact that Canadian mills are relatively advanced in their filtrate recycling practices (10).

(d) Swedish mills appear to be least corrosive, as these mills observe comparatively lower temperature (Temperature in C-stage liquid phase was generally less than 20°C while that of D-stage liquid phase was 40-50°C). In case of North American mills, C-stage filtrate temperature ranges from 20-60°C, where as that of D-stage from 30-80°C) and higher pH of washer filtrates (1). This is evident from the survey of Wallen (11) which shows SS 316 as widely used in handling and washing of chlorinated pulp, whereas North American mills were normally using 317L for similar purposes.

To further support the apprehensions about increase in corrosivity, one may refer to the example of a kraft mill at Great Lakes which adopted closed cycle concept by going in for counter current washing. An advanced status report (19), prepared after 16 months of its operation with closed cycle concept, shows that (i) High Mo stainless steel (Avesta SLX 254) made D/C and D1 washers show very little pitting/crevice corrosion. (ii) Many SS 317 components in D/C, D1 and D2 washers suffer severe pitting. (iii) Washers and most components in E1 and E2 stages are of SS 316 and do not show much pitting/crevice corrosion.

The above observations leaves no one in doubt that closure of mills have led to increased corrosivity of bleach washers. In order to know the factors responsible for increasing corrosiveness, a comparison of conditions of chlorination stage washer filtrate conditions may be made from Table 2 (2) It indicates increase in temperature and Cl^- ion concentration over a period of about 15 years due to "closure" of mills. As indicated, these two factors were suspected for increase in corrosivity in an earlier survey also (17). This table also gives the filtrate conditions of proposed closed bleach plants, which presumes that these plants would reduce residual bleaching chemicals to very low (<15ppm) levels. It is amply clear that bleach sections washers are going to be more and more corrosive in future.

3. Strategy to cope with newer and more corrosive conditions

Presuming that C and D stages of bleaching process will remain in vogue in coming years and that mill closure has to be adopted as a pollution control measures, strategy has to be planned to control corrosion and/or to minimise its ill effects. Following are three different alternatives :

Table 2 : Variation in conditions of Chlorination washer Filtrate due to "Closure" of Mills

Survey	Year	pH	*Temperature	**Residual Cl_2	Chloride
CPPA	1964	2.0	16	110	—
CPPA	1973	2.0	25	110	917
TAPPI	1976	2.1	33	90	780
CPAR	1977	1.8	38	30	—
PAPRICAN	1979	2.0	39	90	1705
Proposed Closed Bleach Plants	—	2.0	60–75	?	3000–5000

* Temperature in °C

** Residual Cl_2 and Chloride in mg / 1

(a) Careful material selection.

(b) Electrochemical protection.

(c) Better control of residual oxidants.

A cost effective choice may then be made taking into account :

— Capital cost of washer (formed of a new material or lined/coated with a non metal).

— Capital cost and running cost of Electrochemical protection system.

— maintenance abilities and cost.

— Effect of changes in operating conditions (e. g. possible changes in washing efficiency due to non-metallic coating on washer)

— Credibility of new technology (new materials or protection techniques).

— Increased chemical cost (increased use of antichlor e.g. caustic or SO_2 invariably increased total Cl_2 and ClO_2 consumption in a closed bleach plant).

We now discuss the above alternatives for combating corrosion with appropriate materials and electrochemical protection.

(a) New Materials

(i) Metals- Metals are to be chosen over non metals for moving parts (e g. washers) as they are tougher, have better fatigue resistance and if they have sufficient corrosion resistance, require practically no maintenance. Since the last corrosion test program (10-12,18), new materials namely among the stainless steels and Nickel-based alloys have developed for bleach plant and similar applications. These newer alloys have also undergone corrosion exposure in a later series of mill test (3,21,22). Following can be interpreted from these tests-

— Premium bleach plant alloys for future should be Avesta 254 SMO, Sanicro 28, (Austenitic stainless Steels with Cr ≈ 20-27%, Ni ≈ 18-33% and Mo ≈ 3 4-6 0%) Hastelloy G-3 and Carpenter 20Mo-6. VDM Cronifer 19/25 HMO, AL-6XN, UR-SB8 (all austenitic SS) and 29-4C (ferritic SS) could also be competitive.

— Alloys close to the SS 317 L cost-level namely Nitronic 50 and 1.4439 (317 MN) (all austenitic SS) could be promising alternative.

— Ti, Hastelloy C-276, Inconel 625, 29-4-2 perform exceptionally well but are expensive. 904L and related alloy perform slightly below the level required for a premium alloy.

— Swedish plants, in general, are still lesser corrosive as compared to their North American counter parts, though the corrosivity of former plants has increased

— In case of hypowashers (which are lesser corrosive than C,D or D/C washers), 904L for liquid phase and 316 for gas phase of Scandinavian mills (3) are suitable. Whereas 317L, when welded with a higher Mo content filler metal, in case of American mills that do not carry usually high residual oxidants, in H stage (21) appear to be acceptable choice.

(ii) **Non-Metals**—Faced with increasingly corrosive bleach solutions, attention is being focussed also on the possible applications of non-metals This is basically because of their better chemical resistance for the type of solutions being encountered in bleach plants. There are, however, certain difficulties in accepting non-metals as cost-effective answer to metals. A major problem is improper design or fabrication of equipment with non-metals which has led to most failures (23). Notwithstanding these obstacles, many articles have appeared on the performance and use of non-metals in pulp mill environments. Ref 24, 25 are some of these. Thus polyvinyledene fluoride (e.g. Kynar) piping and linings serve well even in high concentrations of bleaching chemicals and offer alternative to Ni- based alloys or Ti. FRP stock lines and hoods, when properly designed, are usually competitive with those of SS FRP coated drum washers have been used successfully in highly corrosive environments. Premature failure of coated drums have been associated with poor quality fabrications. FRP coated washers, however, have limitations of operating temperat re ranges from 60-82°C. A new washer with all FRP cylindrical portion—which was bonded to steel end disc and trunnions, themselves coated with FRP is in operation since two and a half years as reported in 1983 (25).

(b) Electrochemical Protection

This is another alternative, developed only recently (2, 26), for minimising corrosion by appllying external electrical potential to the equipment which is to be protected. This technique is based on passivation phenomenon shown by certain class of metals. Interestingly steels, Ni alloys fall in this class. Detailed principle of this technique can be seen elsewhere (2, 20). The advantage with this protection system is that (i) its cost is comparatively low and it fits easily in existing washers (ii) capital cost saving are such that if life of washer is extended from five to ten years by protection, the system will have a payback period of one year. This calculation does not consider any savings due to (i) maintenance or down time cost and (ii) lowering in antichlor (NaOH or SO_2) consumption. Due to these reasons, commercialisation of the technique has found ready acceptance. In a time span of about seven years, there were about 80 installations worldwide by the end of 1985 (22).

4. Current status

The strategies discussed above have been in practice since last about fifteen years with a view to combat corrosion whereas there has been increasing filtrate recycling. What is the current status of bleach plant corrosion vis-a-vis the environment prevailing in them today ? To look into this aspect, another survey was conducted in 1985 and its findings, appeared in 1988 (16), were compared with 1973 survey findings (17). One finds that :

(a) Average vat temperatures have increased from 25 to 44 C. Higher temperature often means more complete consumption of Cl_2 in tower hence lesser residual chlorine which means lesser corrosive conditions But corrosion rate increases with temperature.

- Some bleach plants now operate with very acidic conditions (lower pH) resulting from full recycling of chlorination effluents.
- Use of ClO_2 stage shower water has increased corrosion enormously. However, water saving is important enough so that more corrosive conditions have been encountered by upgraded metallurgy and/or installing electrochemical protection system.
- Cl^- levels have almost trippled, on average (from 920 to 2950 ppm). This again reflects adoption of full recycling of chlorination effluent.
- ClO_2 substitution, due to recycling of ClO_2 in shower water, has increased from an average of 1.9% to 9.8% of equivalent Cl_2 (almost 5 times). This makes chlorination stage significantly more corrosive.

(b) Two out of three washers are now made of material more resistant than 317L and 336L is no longer used. Instead, higher alloyed materials e.g. 254 SMO (Aust SS), Ti and FRP coated washers are in vogue.

- Kynar has taken over as material for washer clothing instead of 317L.
- About 36% of surveyed mills have installed electrochemical protection system, introduced in late seventies.
- Typical chlorination washer has been in service for 6.5 years in comparison to 6 8 years as reported in 1973.
- Life expectancy of chlorination washer (drum life) has risen from 8.4 years in 1973 to 10 4 years in 1985.

Thus one may conclude that deposite the increase in corrosivity due to recycling, the washer life expectancy has been increased by about 20%. This speaks of the credibility of the strategies which were planned to minimise corrosion.

5. Status of Indian Mills

It will be interesting to look at the mills in India with regard to (i) filtrate recycling and (ii) bleach plant environment and its corrosiveness. On the basis of a survey (27) done by National Productivity Council, India following facts can be mentioned about these mills :

(a) Mills generally use CEH or CEHH as bleaching sequence. None of the surveyed mills uses chlorine-di-oxide bleaching.

(b) Most mills (11 out of 13 surveyed mills) do not observe closed bleaching cycle. One mill has reported to be using hypowasher water in alkali stage and alkali stage water in launders. However, fresh water is being used for chlorination washer. Two mills have reported to use alkali stage back water for washing chlorinated pulp.

In view of the above, the bleach plants of Indian mills are expected to be less corrosive but creating more water pollution.

(c) In chlorination stage, washer filtrate has average pH≈2.5 (ranging between 1.5 to 5), temperature≈30°C (20–50°C) Cl− ion concentration≈1300 ppm and residual Cl_2≈71 ppm. These conditions appear to be less corrosive than those observed in North American and Scandinavian mills (refer to Table 1 and 2). Perhaps this is due to the fact that surveyed plants neither use chlorine di-oxide bleaching nor they are practicing filtrate recycle.

To substantiate the idea about corrosiveness, tests were performed in two Indian mills during 1987-88. These are first ever reported corrosion tests about Indian mills (28, 29). These tests were performed in mills not practicing recycle. Washer filtrate conditions are given in Table 3. For tests, conventionally used austenitic stainless steels were selected. These coupons were exposed for 3–6 months. Results of the tests are shown in fig. 2. in terms of degree of pitting and crevice corrosion. One observes following from these result—

Table 3 : Average filtrate conditions of Bleach Washers of Indian Mills involved in Corrosion Test Programme.

Parameters Stages	Temperature (°C)	pH	Residual Oxidant (ppm)	Chloride ions (ppm)
Chlorination	29	2.8	0	621
Mill A Hypochlorite1	33	7.5	2 38	941
Hypochlorite2	32	8.1	19.5	450
Chlorination	44	2.1	17	899
Mill B Bufferedhypo	45	6.9	257	1907
Hypochlorite	41	7.4	220	911

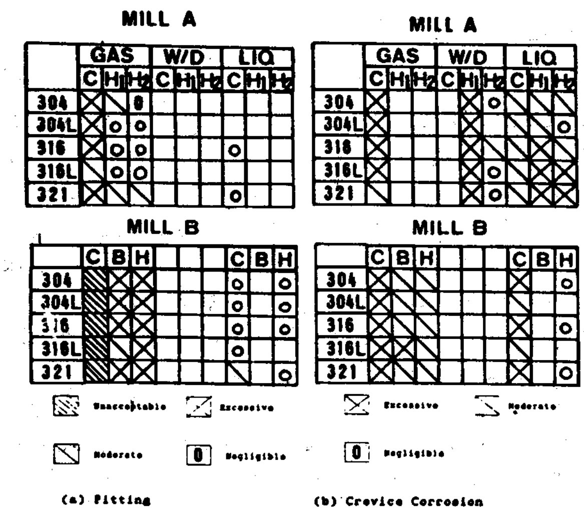


Figure 2 - Material Performance in Bleached Pulp Washers of Indian Mills Involved in Corrosion Test Programme.

(a) Chlorination section is most corrosive of all. Gaseous phase of this section in both mills is severe to the extent that even 316L is badly corroded. Thus for components of process equipment likely to be exposed to such conditions e g. shower pipes, open surfaces of pumps, valves and vats etc. higher alloyed stainles steel or Nickel base alloys are to be likely choice. Utility of 316L in liquid phase appears doubtful, as it experiences significant crevice corrosion.

(b) Gaseous phase of hypowashers of mills B is corrosive enough to prohibit use of any of the tested materials in these environment. However, in mill A, 304L/316L may be used wherever these are to be exposed to gas phase.

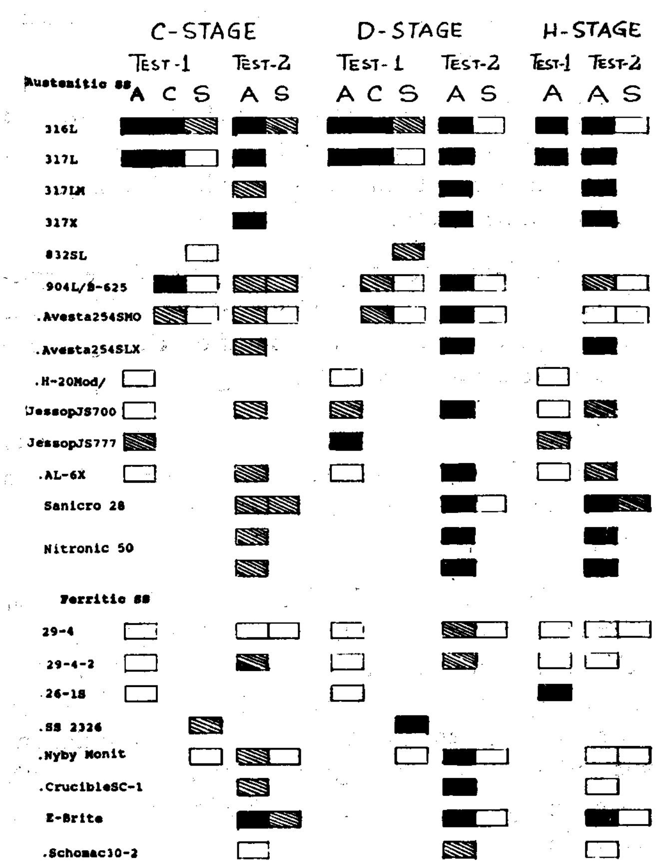
(c) Liquid phase of hyphowashers, in mill B, is safer in the sense that none of tested material experience significant corrosion. This is also due to the fact that exposed coupons had scale formed on them which appears to protect them However, scaling isn't good always as it hinders movement of liquid and slurry.

(d) Hypowasher filtrates, in mill A, are observed more aggressive than those of mill B. Each one of the tested materials is to be used with caution since these experience moderate to excessive crevice corrosion.

(e) On the basis of general corrosion, in case of mill A, one observes that filtrates of H_1 washer are less corrosive than H_2 washer. This could be due to the practice of using sulphamic acid in this washer. In experiments conducted independently, it was found that addition of sulphamic acid to bleach liquor (calcium hypochlorite solution) help decrease corrosivity of latter. Sulphamic acid, therefore, appears to be acting as inhibitor. To substantiate this finding, further experiments are under progress.

(f) Rotary drums, in process, passes through gaseous and liquid environment periodically. Under such conditions (W/D), H_1 washer appears maximum aggressive. For such environments, even 316L is not suitable choice. No such problem was observed for tests conducted in H_2 washer, where 304L/316L could be used.

(g) Overall it is observed that washers of mill B are more corrosive than those of mill A. This could probably be associated with higher temperature, lower pH and higher Cl^- ion and residual oxidant concentration in case of washers of former mill. It may be worth noting that filtrate conditions of washer in North American and Scandinavian mills changed in in the similar fashion when filtrate recycling was started.



A comparison of the above mill test results with those obtained in their North American and Scandinavian counterparts reveals that chlorinated pulp washer in Indian mills are not as corrosive as in latter mills. However, they are aggressive enough to warrant testing of 317L or other higher alloys for their suitability In hypowahers, whereas 316L appear to be suitable material (even 304L is enough to use at some places) in Indian mills, 317L and 904L appear to have adequate resistance in their counterparts of Nroth American and Scandinavian mills.

Lesser harsh washer filtrate conditions in Indian mills appear to be due to non-closure of mills and to chlorine-di-oxide bleaching not in use. In future, both these conditions are going to appear soon Further, in future, larger capacity mills also will be erected. All these changes are expected to increase corrosivity as has happened in case of mills in developed countries. Their conditions of early seventies, just prior to starting filtrate recycling, appear to be the present state of Indian mills. We, in India, have to remain prepared against this expected change. In view of the present situation, as a sequel to earlier performed mills tests, it is proposed to perform experiments in mills/laboratory on following lines :

(a) Study on the performance of newer available bleach plant alloys, non-metals including composites in mills having (i) chlorine-di-oxide bleaching, (ii) practicing filtrate recycling.

(b) Perform laboratory tests on the above materials in liquid environments simulating with those likely to be observed in washers after closing of the mill and the use of D stage bleaching

An important part of the above tests should be to study corrosion attack on weldments. This will help in deciding the suitable filler metal over a given base metal.

(c) Development of Electrochemical protection systems for washers made from 304L, 316L, 317L etc. steels. It is quite possible that a 304L/316L SS washer protected by such a system could be the cost effective answer for present environments of chlorination/ hypowashers. Whereas higher alloyed washers with protection systems will be suitable for the needs of future bleach plants.

6. **Conclusion :**

Pollution control may be practiced in two ways – one of these is to get filtrate treated so as to make it less polluted (below the prescribed limit) prior to discharging. The other is to recycle the filtrate inside mill itself. The first method is considered to be very much cost-involving and further it requires sources of fresh water which are becoming scarce day-by-day. Consequently second method has been adopted globally as a water pollution control strategy. For similar reasons, chlorine is to be replaced more and more by chlorine-di-oxide in bleaching sequence In future, hence, mills in developing countries will have to adopt these two practices in order to ensure as less pollution creating process as possible. Further, future mills will be of higher capacity (due to increased demand of paper) requiring lesser down-time. However, practicing pollution control measures, as has been observed, increase corrosivity of filtrates of bleach plant. This will make corrosion attack more severe resulting into more unscheduled shut-downs and hence down time. This is contrary to what is expected from mills supposedly turning higher outputs It requires steps so as to have process equipments fabricated from newer, better corrosion resistant materials and/or to employ electrochemical protection systems which may ensure essentially least possible down time due to corrosion factors.

The paper described the experiences of developed countries in this endeavor. Developing countries like India are going to face similar situation in another 10-15 years as those by developed countries due to pollution control measures Learning from their experience, we can immediately plan tests as suggested and chalk out strategies in order to have a more corrosion resistant and less pollution creating bleach plant instead of waiting for another decade or so when the problem actually hits us.

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