An Approach to Corrosion Auditing in Indian Sugar Factories

R. Bhaskaran, N. Palaniswamy, N.S. Rengaswamy, and M. Raghavan, *Central Electrochemical Research Institute*
M. Jayachandran, *H.H. The Rajah's College*

In a sugar factory there are many components that can undergo corrosion. The sugar industry is the second-largest agro-processing industry in India. A cost of corrosion survey was conducted in a few sugar factories by using the present-value method. It concludes that the direct annual cost of corrosion in the sugar industry as a whole is ~U.S. $14 million. It also shows that nearly U.S. $2.2 million per year could be saved by using type 409M stainless steel (UNS S40900) in place of ordinary mild steel.

Corrosion always has been recognized as one of the most serious problems affecting every core industrial sector, and the annual loss from corrosion is great. Studies undertaken in the U.S., the U.K., Japan, Australia, Kuwait, Germany, Finland, Sweden, India, and China have shown an annual cost ranging from ~1 to 6% of the Gross National Product (GNP) of any given country. For India, the cost was ~2% of the GNP for the year 1984 to 1985.[1] A recent study[2] estimated that the total cost of corrosion in the U.S. ... billion (3.1% of the GNP).

Different approaches exist ... the cost of corrosion. The auth... fer the present-value—or dis... cash flow—method. This tec... converts all expenditures ass... with corrosion into equivalent ... costs, using the sum of these ... costs to arrive at the annual cos... rosion. This article discusses th... this approach to determine the ... corrosion in the Indian sugar in...

The sugar industry is the s... largest agricultural processing ... in India and is of considerable ... tance to rural economies. The c... has 506 factories, with a total ... of 11 million tons (10 billion k...

According to the Indian Sug... Association (New Delhi, India), ... sugar industry's total investment ... billion and its total annual sa... $4.2 billion.

Sugar production consists of ... of processes that can be rou... vided into four major manufa... stages:

- Stage 1—Cane to raw juice
- Stage 2—Raw juice to cl... juice
- Stage 3—Clarified juice to ...
- Stage 4—Syrup to sugar.

This article highlights the co... problems faced by the sugar in... and the costs it must bear com... them. Table 1 lists the corrosion ... lems encountered at each stage ... sugar factory, there is a large n... of components—all of which c... dergo erosion-corrosion (abrasive ... combined with corrosion). Be... the material of construction is m... mild steel, general corrosion an... sion-corrosion are common m... nance problems. In some instanc... alternative, cost-effective, and mo... rable construction material may ... an economical solution.

Corrosion Auditing

Each year, the sugar industr... mally spends a considerable su...

TABLE 1

DESCRIPTION OF PLANT COMPONENTS, FUNCTION, AND CORROSION PROBLEMS OF A TYPICAL SUGAR FACTORY

ame of the System	Parts of the System	Material of Construction	Function	Typical Corrosion
unloader	Electrically operated trolley, column structure, wheels, and rails	Mild and cast steel	Transport of sugar cane from lorries and trucks to feeder table.	General and wear corrosion
der table	Structurals, chains, and drives	Mild steel	Sugar cane is dumped here for further processing.	General corrosion
carrier	Structurals, chains, slats, and drives	Mild steel	Transport of sugar canes to the milling section	General and wear corrosion
kicker	Drum with steel blades	Mild steel	Sugar cane is shredded into fine pieces for easy squeezing.	Acid attack, general and wear corrosion
leveller	Knife, hub, hood (top cover), and drives	Mild and cast steel	Sugar cane is shredded into fine pieces for easy squeezing.	Acid attack, general and wear corrosion
fibrizer	Hammer, hub, anvil plate, hood, and drives	Cast and mild steel	Sugar cane is shredded into fine pieces for easy squeezing.	Acid attack, general and wear corrosion
milling on	Check, trash beams, trash plate, scrubbers, roller shaft roller shell, Messachesert knife, roller bearings, underfeeder roller, intercarrier, juice pipes and tanks	Cast iron, mild steel, forged iron, and SS.	Cane is crushed here to extract the raw juice.	General, wear, acid attack, and pitting corrosion
filter screen	Filter screen	Mild steel	Removal of bagasse and fine particles from the raw juice.	Wear corrosion
collecting	Tank	Mild steel	Used to collect raw juice.	Acid attack
weighing tank	Tank	Mild steel	Raw juice is weighed.	Acid attack
receiving	Tank	Mild steel	Weighed juice is received here for further processing.	General corrosion and acid attack
carrying lines	Pipes	Mild steel	To carry the raw juice from juice receiving tank to juice clarifier.	Wear corrosion and acid attack
ration unit	Lime slaker, lime classifier, and lime stirrer.	Mild steel	Preparation of milk of lime and pumping into juice sulfitation station.	Alkaline attack
ation unit	Melter, melt receiving chamber, and vapor pressure chamber (furnace)	Mild steel and mild steel with steam jacket.	Preparation of sulfur dioxide (SO_2) gas for sulfitation.	SO_2 gas attack
juice	Shell, tubes, and valves	Cast iron, mild steel, and SS	For settlement of impurities.	Scale formation
sulfiter	Cylindrical vessel with stirrer	Mild steel	Simultaneous mixing of raw juice, lime, and SO_2.	SO_2 gas attack

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TABLE 1 (CONTINUED)

Name of the System	Parts of the System	Material of Construction	Function	Typical Corrosion
Secondary juice heater	Shell, tubes, and valves	Cast iron, mild steel, and SS	To reduce the water content in the juice.	Deposition of sludge
Juice clarifier		Mild steel	For separation of clear juice from precipitated impurities (mud).	Acid attack and wear corrosion
Mud collecting tank (or) mud mixer	Tank	Mild steel	Precipitated impurities at the clarifier are collected here and mixed with fine bagacillio particles for further processing.	Acid attack
Rotary vacuum filter	Filter screen, condenser, and pipelines.	Mild steel	To filter out juice and separate the impurities.	Acid attack and bacte and wear corrosion
Evaporator	Calendria tube plates, tubes, shell, and save all	Mild and SS	To evaporate water from the juice.	Acidic vapor attack
Syrup sulfiter	Tank, pipelines, and SO_2 gas outlet lines	Mild steel	Used for better mixing of SO_2 gas with the syrup for the purpose of bleaching.	SO_2 gas attack
Pan supply tank	Rectangular tank	Mild steel	To store the syrup and then supply the same to the vacuum pan.	General corrosion
Vacuum pan	Body, calendria, vapor lines	Mild and SS	Sulfited syrup and other high-purity intermediate products are boiled to produce a mixture of sugar crystals (massecuite) and mother molasses.	SO_2 gas attack, pitting, general corrosion
Crystallizer	Air-cooled, water-cooled, vacuum, and vertical accessories	Mild steel	To reconcentrate the syrup and cool successively so as to obtain sugar crystals.	Internal corrosion in pipelines
Centrifugal	Pug mill, mixer, melt tank, and pipelines	Mild steel	The sugar crystals are separated from mother liquor.	Wear and general cor
Injection and spray system	Pipelines	Mild steel	Used for recirculation of hot and cold water within the process.	Internal corrosion fro low-pH water
Sugar drying and bagging unit	Multitray hopper graders	Mild steel	Sugar from centrifuge is dried in the multitray hopper, graded according to grain size in the graders, bagged, weighed, and stored in the godown.	General corrosion

placing corroded and damaged parts in most industry sectors. In this study, the authors analyzed the cost of corrosion by considering a service life of 18 years according to the guidelines of the U.S. Treasury Department (Washington, D.C.).[5]

India requires the sugar industry to pay 35% of its net income as tax. This factor also is taken into account while computing the cost of corrosion; a 12% interest rate considers a 10% bank rate plus 4% net profit minus 2% inflation rate.

Table 2 presents data generated on 25 major components in a typical sugar factory. It indicates annual expenditure, present worth factor, tax credit, present value, annual cost factor, and equivalent annual cost—in that order. The total annual cost of corrosion per sugar factory comes to ~$27,600. This figure is based facility's expenditure (cash fl corrosion-related activities, s painting, maintenance, and r ment. Figure 1 shows the distri pattern.

Directly extrapolating $27, each of the country's 506 fa yields a ~$14 million annual corrosion for the Indian sugar try. This is only the direct cost.

TABLE 3

COMPARISON OF MILD STEEL AND 409M SS

Types of Steel	Cash Flow		Present Worth Factor	Present Value	Annual Cost Factor
	Initial	Annual			
Mild steel	—	14,127	7.25	1,02,420	0.14
409M SS	70,380	—	—	70,380	0.14
					Net saving per year

FIGURE 2

Corroded piping in a sugar factory crystallizer.

analysis, taking into account the indirect costs, probably would show a higher figure. Nearly $2.2 million could be saved each year by using 409M SS instead of ordinary mild steel.

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R. BHASKARAN is a Senior Research Fellow at the Central Electrochemical Research Institute, Karaikudi, Tamilnadu 630006, India. He specializes in the economic aspects of corrosion control and carries out corrosion auditing in the sugar and pulp & paper industries. He has organized national congresses on corrosion control in various locations in India and has authored several publications on the impact of metallic corrosion on society and the annual cost of corrosion in different countries.

N. PALANISWAMY is Group Leader, Electrochemical Protection & Biofouling Group, at the Central Electrochemical Research Institute. He has 26 years of experience in the field of corrosion and its control. He is involved in cathodic prot… and biological corrosion and has authored… papers and holds four patents. He has a d… degree in science from Madurai Kamaraj University, received the Best Paper Award… 2002 International Congress on Emerging Corrosion Control Strategies for the New Milennium, and is a member of NACE.

N.S. RENGASWAMY is an Emeritus Sci… the Central Electrochemical Research Insti… has 42 yeras of research and development… experience in the field of corrosion and its… He has authored 140 publications and hol… patents. He is associated with 30 sponsored… projects and 43 consultancy assignments… a doctorate in engineering from the Indian… of Science and received the National Masc… Award in 1989 from the Electrochemical S… of India.

M. RAGHAVAN is Director of the Central Electrochemical Research Institute. He has… years of R&D experience in the area of ele… chemistry. He is involved in several R&D sponsored and consultancy projects in th… and has 150 research publications to his c… has directed the R&D activities of the insti… the past 5 years. He has a doctorate in eng… from Madurai Kamaraj University.

M. JAYACHANDRAN is Reader and Head… of Commerce, at H.H. The Rajah's College… Pudukottai, Tamilnadu 622003, India. He h… than 30 years of teaching experience in the… commerce and economics. He has a docto… commerce from Bharathidasan University… member of the PG and Research Board of Bharathidasan University, and is Coordina… DDE, Pudukottai Centre, BARD, Trichirapa…