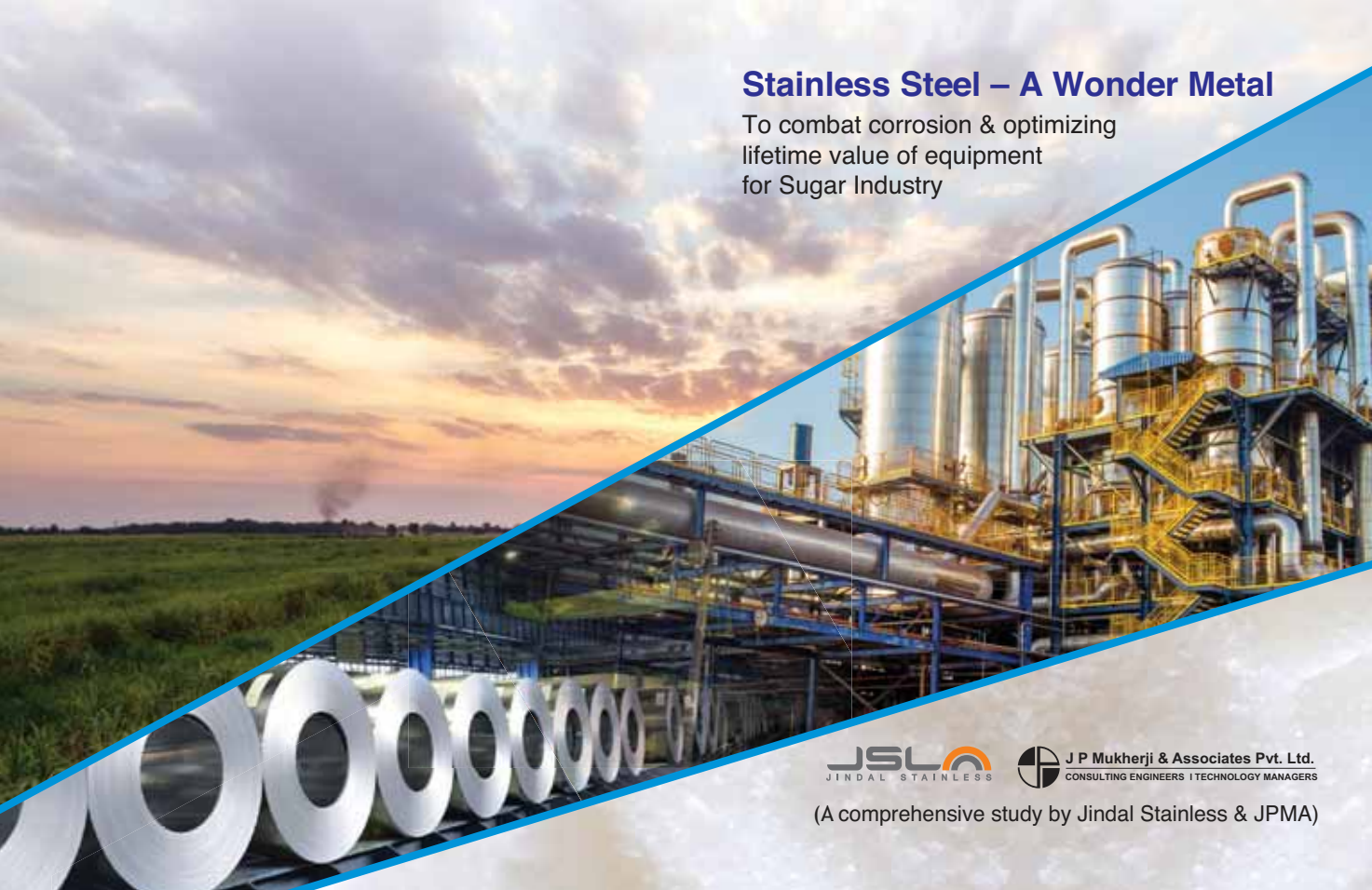
Stainless Steel – A Wonder Metal

To combat corrosion & optimizing
lifetime value of equipment
for Sugar Industry



JSL JINDAL STAINLESS

J P Mukherji & Associates Pvt. Ltd.
CONSULTING ENGINEERS I TECHNOLOGY MANAGERS

(A comprehensive study by Jindal Stainless & JPMA)

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Supported by :

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THE SUGAR TECHNOLOGISTS' ASSOCIATION INDIA

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Message

Corrosion, that is degradation of material due to reaction with its environment, is a universal problem. Globally, the annual corrosion costs tantamount to 4% of the world's GDP. Rapid strides of industrialization in India, using material that is prone to corrosion, has led to an annual estimated loss of 40 billion US dollars, about 4% of the size of total economy.

Stainless Steel is characterised by qualities far superior to competing materials. Its zero maintenance, excellent mechanical properties, good bending properties, improved life cycle costs, temperature and shock resistance render it the best fit material for the sugar industry. Jindal Stainless team has been working very closely with the sugar Industry for over two decades. We have developed stainless steel grades which not only take care of corrosion, but are food compatible and drastically reduce life cycle costs as well.

In coordination with J.P. Mukherji & Associates, we have worked extensively and visited multiple sugar factories and equipment manufacturers. We have identified components, which if converted to stainless steel, can add immense value.

I congratulate J.P. Mukherji team and many other sugar factories and equipment manufacturers for extending their support in developing this report. I'm sure this report will be able to take their businesses to the next level of efficiency. I also take this opportunity to recognize the efforts of the Sugar Technologist's Association of India, for providing our team with the right network and platform. I am confident that the solutions offered by stainless steel can surpass all other alternatives, and will also be in the interest of the larger goal of sustainability.

Abhyuday Jindal
Managing Director
Jindal Stainless

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J. P. MUKHERJI
& ASSOCIATES
PRIVATE LIMITED
Consulting Engineers

Dr MS SUNDARAM
Managing Director, JPMA Pvt. Ltd.

Message

India is the second largest producer of sugar after Brazil in the world. Sugar industry is the second largest agro-based industry in India. Sugar production being seasonal in nature, continuous uninterrupted production is essential for viability of a plant. Therefore, material of construction plays a very important role in production with cost economy. The acidic nature of the sugarcane juice and toxicity associated with gaseous products encountered in the manufacture of sugar, pose a serious challenge to sugar industry. There is a growing trend to progressively use stainless steel to overcome the problem.

The prime objective of this technical report is to identify the best material of construction for different unit operations in the manufacture of raw sugar, plantation white sugar and redefined sugar. Several sugar factories were surveyed to analyse production conditions. The main considerations in the selection were corrosion resistance and its effect on the amount of energy required, surface finish and its effect on scaling and cleaning.

It is heartening to note that the report contains the challenges and concerns faced by sugar industries, its solutions to overcome these challenges with cost effective and long-term solutions with added benefits over the life cycle cost.

A glance through this report will show that it as an unusual type of publication. Though, this report is primarily on application of stainless steel in sugar industry, however, sustainability of the industry is also highlighted by applying the best material to have minimal maintenance costs and longer life of the equipment.

I commend the efforts put in preparing such a practical and comprehensive compilation. I am sure that the user will find this report valuable and benefit immensely from it.

Best wishes,

Dr M S SUNDARAM
Managing Director

JINDAL

Editorial

At Jindal Stainless, we constantly endeavour towards value creation through sustainable development. We work closely with our customers to enhance their processes by providing technical information on stainless steel, help them in their component designs and extend support in fabrication by providing onsite training and maintenance workshops to OEMs and fabricators.

Over the past few decades, we have developed multiple grades of stainless steel to match the needs of the sugar industry in terms of corrosion resistance, hygiene, reduced maintenance and higher strength to weight ratio. In coordination with J.P. Mukherji & Associates, along with many other sugar factories and equipment manufacturers, we have worked extensively and visited multiple sugar factories and equipment manufacturers. We have identified components, which if converted to stainless steel, can add immense value.

Our interactions with the industry has revealed that stainless steel is perceived as an expensive metal, thus restricting an extensive usage, other than it being considered difficult to fabricate. To address these concerns, we have attempted to quantify the benefits of using stainless steel in terms of savings over complete life cycle of the product, albeit with slightly higher initial investments. Moreover, we interacted with various equipment manufacturers and technical teams at sugar factories to understand fabrication related issues. We have started suggesting solutions in fabrication through our channel partners to alleviate the concerns.

We have mapped all 300 product categories and applications used in sugar industry with the construction material used in each. Further analyses of the application requirements, criticality of applications and inputs from various stakeholders on areas of improvement revealed that there are 29 new applications where stainless steel can add value in terms of reduction of maintenance costs and equipment downtime, and improve the life of equipment. Here, we have attempted to compare the life cycle costs and accrued savings between the present material and stainless steel.

Inside, you will also find information on stainless steel grades and their applications, best practices for fabrication of stainless steel, and life cycle costs. We hope that this knowledge bank serves as a useful and practical guide for addressing the concerns of your industry regarding usage of this exemplary metal.

Company Profile

Jindal Stainless Group

Founded by Shri O.P Jindal in 1970, Jindal Stainless is one of the largest stainless steel conglomerates in India and ranks amongst the top 10 stainless steel conglomerates in the world. Jindal Stainless group has an annual steel melt capacity of 1.8 MTPA with an annual turnover of US $ 3.1 billion (as on March'18). The group has two stainless steel manufacturing complexes in India in the state of Haryana and Odisha other than an overseas unit in Indonesia. The integrated operations from mining to manufacturing of finished products has given us the edge of cost competitiveness and operational efficiency, making us one of the best stainless steel producers in the world. The group has a country wide network of 14 sales offices in India with over 13 global offices across the world.

The guiding vision and mission of Jindal Stainless is to provide trustworthy and innovative stainless steel solutions. Lighter and stronger at the same time, stainless steel is inherently corrosion resistant, durable, recyclable and beautiful. Unsurprisingly, stainless steel is the preferred choice in industries like nuclear energy, construction & architecture, automotive & transport, oil & gas, desalination processes, fertilizer, storage, chemical processes, dairy industry, food processing, brewery, sugar, white goods and of course, kitchenware. The cutting-edge technology in the Special Products Division and state-of-the-art research & development wing of Jindal Stainless is complemented by superior knowledge of supply chain systems. At Jindal Stainless, we take pride in being amongst the largest producers of coin blanks and razor blade grade of steel in the world. Strongly rooted in the Indian philosophy of "Vasudhaiv Kutumbakam", we strive to empower local communities by augmenting their employability. We also provide comprehensive healthcare, education facilities and vocational training for promoting self reliance.

Manufacturing Complexes

Jindal Stainless (Hissar) Ltd.

The Hissar plant of the group was established in year 1975 when Shri O P Jindal, envisioned a self reliant India for meeting its stainless steel demand. Stainless steel then was no less than a luxury metal and India was completely dependent on imports to fulfil its demand which attracted 300% duties. Today, the Hissar plant is fully integrated with capacity of 8,00,000 tpa. It is also the world's largest producer of stainless steel strip for razor blades and largest producer of coin blanks, serving India and several international mints. The product range includes slabs & blooms, hot rolled coils, strips, plates, coin blanks, precision strips and cold rolled coils.

Jindal Stainless Ltd.

The Jajpur (Orissa) manufacturing unit is a state-of-the-art manufacturing unit with a capacity of 1 mtpa. The complex, equipped with captive power generation (2 x 125MW) facility, is eventually scalable up to 3.2 mmtpa of stainless steel production. The plant has adapted latest and world class technologies from SMS Siemag, Germany and SIB Electrotherm Russia.

In the near future, Jindal Stainless plans to set up a 300 acres stainless steel industrial park adjacent to its Jajpur facility to support and develop downstream industries. It'll be a world-class stainless steel manufacturing hub. The company also plans to continue its focus on development of new value added stainless steel grades, processes improvements, customised products and cost reduction through different production processes.

J.P. Mukherji & Associates Pvt. Ltd.

J.P. Mukherji & Associates Pvt. Ltd., Pune, India is a globally known company in operation since 1972, offering total engineering consultancy services for cane sugar industry in agriculture, production of raw, refined & white sugar factory, sugar refinery, cogeneration & ethanol plants including special equipment design & technology improvement. Their services encompass the full spectrum of setting up of a new sugar complex from concept to commissioning, from site selection till commissioning and handing over the complex to the owner. The company specializes in BMRE (Balancing / Optimization, Modernization, Rehabilitation, Expansion) and troubleshooting services for existing sugar plants and energy audit.

JPMA has executed the projects in 25 countries and executed more than 200 + projects globally.

Sugar Industry - A Snapshot

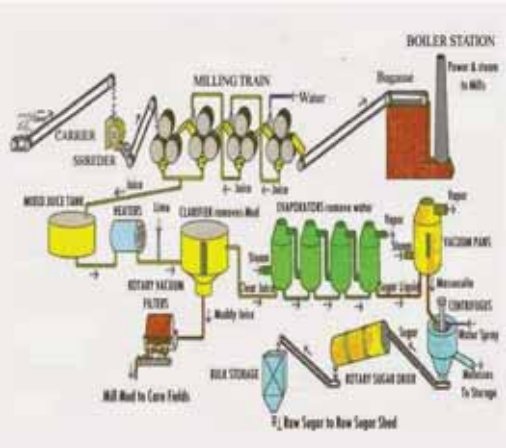
Sugar Industry Overview

History of sugar in India goes back to 350 AD, where the process & technology of producing it was first invented during the Gupta Period. The English word “Sugar” comes from its Sanskrit origin “Shakara” meaning gravel or sand. Later, in 1813, it was a British chemist Edward Charles Howard and two American engineers Norbert & David Weston, who invented the modern methods of redefining sugar.

Till 1930, most of the sugar requirement in the country was being met through imports. In 2019, we have more than 550 odd sugar mills and 5000+ big and small machinery manufacturers, now exporting sugar to various other countries. Today, India is not just the second largest sugar producing country in the world but is also the leading exporter of sugar and sugar machinery and a leader in nurturing world class technocrats, exporting them to operate factories across the globe. India has now been given the status of a leader in sugar technology, manufacturing some very innovative sugar engineering equipment and also the leading suppliers in the world, displacing many local giants in different countries.

Along with manufacturing world class equipment, Indian scientists and technocrats have also experimented and developed many modern juice extraction and purifying technologies, combined with higher energy efficiency, water conservation and treatment and pollution control equipment.

Sugar Plant Design & Factory Layout



Sugar Industry- Challenges & Concerns

Sugar production is a cyclic activity having an average duration of 6 months. Thus, uninterrupted production in a restricted time period is essential for viability of a sugar producing plants. Therefore, material plays a very important role in production.

Sugar manufacturing plants have to deal with corrosive and abrasive environments often resulting in disruption of crop processing which makes producing sugar an excessively expensive exercise. An estimation has emerged that in India, losses due to corrosion in sugar factories are around USD 250 million annually. Long usage of carbon steel as a material for factory equipment has resulted in rust degeneration and rapid wear, thus increasing the production cost and quality problems. In spite of their best efforts to repair and maintain plants during idle season, sugar industry has to face unscheduled break downs which causes loss of time during peak crushing and processing seasons.

While we are working closely with sugar industry to address these challenges, however, we felt the need to move a step further in establishing the economics part by reducing life cycle costs. In the next section, we have made an attempt to list the applications with calculation details, where stainless steel can be of immense help in addressing concerns of sugar industry and also result in huge savings in the years to come.

Application Study

Application Study

All applications in sugar Industry were reviewed and the concerns associated with corrosion, abrasion and other wear & tear of the material were identified. Out of more than 300 applications in the industry where the metal is used, we identified components on the basis of following priorities which concerns the industry the most: 1. Higher abrasion and corrosion of the equipment- High Maintenance. 2. Lower life of the equipment. 3. Hygiene. 4. Better Strength.

In sugar industry, various applications (300 in total) are divided into following process groups- Juice Extraction (35 Applications), Process House (185 Applications), Steam Generation (46 Applications), Power Generation (6 Applications) and Plant Water System (29 Applications).

All these applications were discussed in detail and analyses were done for the applications which are more critical for the industry. Thereafter, it was discussed and debated, in which applications, stainless steel can add value. An attempt was made to work out life cycle costs of critical applications in terms of existing material in use and proposed change over to stainless steel. Accordingly, we worked out life cycle cost of 28 applications, where stainless steel can add value in terms of reduced life cycle costs, reduced maintenance and reduced downtime thereby increasing life of the equipment. By shifting over to stainless steel, we analyzed that life cycle cost can be reduced up to 60% in these applications. As many of these applications were quite complex, following assumptions were made while calculating life cycle costs-

1. In all cases, Plant Crushing Capacity of 2500 TCD is taken as reference and all dimensions are worked out accordingly.
2. Dimensions of the equipment are indicative and for ease of calculations, all dimensions have been converted to rectangular dimensions.
3. Wherever possible, lesser thickness of stainless steel is recommended without compromising on the strength of the equipment.
4. For improving hygiene, stainless steel grades with higher food compatibility are considered.
5. For optimizing inventory, we have minimized the variation in stainless steel grades.
6. Based on the feedback from various factories, maintenance cost of MS products is kept at an average of 10% per annum.
7. Scrap value of Mild Steel is considered @ Rs. 23/Kg & Stainless Steel @ Rs. 73/ Kg based on the market feedback.
8. Although the process of raw sugar manufacture is similar to that of plantation white sugar, the color removal process (sulphitation) is eliminated in raw sugar. The application study in this report will be applicable to both raw sugar and plantation white sugar.
9. Photographs used were mostly taken from running sugar factories.
10. Life Cycle Cost is worked out as per details given below-

a) Length (L), Width (W) & Thickness (T) dimensions were taken for a 2500 TCD plant. Where these applications were circular or in other shapes, these were converted into rectangular dimensions by using circumference formulas like L=2πr.; W= 2πr, T= Sheet thickness. Dimensions mentioned are indicative and can be different from different plants (mm)

b) Density of Material both Mild Steel & Stainless Steel (r) = 7.8 (g/ cm^3)
c) Weight of Material (w) = (L x W x T x 7.8) / 10^6 (Kg)
d) Basic Rate of Material (R)= Metal prices are indicative & reference is based on current price of the materials are subject to change (D)

e) Raw Material Cost (RMC) = w x R (D)

f) Life of the Equipment (L) = Estimated life based on theoretical calculations (Years)

g) Maintenance Cost (MC) = 10% of the initial investments in case of mild steel per year x No of Years and minimal costs for stainless steel x No of Years (D)

h) Material Wear (mw) = Based on the estimations from the industry and material properties (mm / year)

i) Salvaging Thickness (t) = Thickness of the material left at the time of salvaging (mm)

j) Scrap Rate (SR) - Market rates prevalent in the industry (Prices are subject to change) (D)

k) Scrap Weight (sw) = L x W x t x 7.8 / 10^6 (Kg)

l) Salvaging Cost S = SR x sw (D)

Life Cycle Cost LCC = (RMC + MC- S)/ L (D/ Year)

During application study, various factories in Haryana, Uttar Pradesh & Maharashtra (12 Nos) were visited to get the practical insights of various applications & the concerns associated with the same. Many of the OEM officials were contacted to understand the manufacturing point of view as well. Following are the details of applications studied:

Cane Carrier

It's the moving apron which conveys the cane into the factory and feeds them to the mills.

Width = 2040 mm approx., Horizontal loading length = 40 m approx. Cane carrier and its structure is built in mild steel of 8 mm thickness.

Acidic juice from the cane causes abrasion and corrosion. Periodic maintenance is required to ensure suitable life.

The MS plate and the SS cladding can be replaced with a single 204Cu Stainless Steel plate for higher durability and longer life.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	5	10
Salvaging Thickness	t	mm	3	4
Life Cycle Cost	LCC	Rs/Year	55,786	39,218
Savings		%		30%

For more details refer the main brochure from page no. 33.

Cane Shredder

They prepare or shred the cane prior to crushing in the mills.

The side plates of the shredder assembly are normally made up of 10 mm carbon steel plates. The juice spillage results in corrosive wear of side plates which are normally changed every two years.

Stainless steel plates offer a long lasting, corrosion resistant solution.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	2	6
Salvaging Thickness	t	mm	5	5
Life Cycle Cost	LCC	Rs/Year	28,150	14,045
Savings		%		50%

For more details refer the main brochure from page no. 35.

Rake Type Elevator

It is used to transport prepared cane or bagasse from one milling unit to the next. Analysis of mill stoppages shows that intermediate carriers are responsible for maximum downtime on most mills and has high failure rates when crushing rates are high.

The bottom troughs are often fabricated of 8 mm MS plates with SS cladding. The liner which is welded to bottom plate does little to avoid corrosive juice to reach in between the gaps and result in failure of troughs. The poorly welded or uneven liners also sometimes show wear and fatigue signs.

Periodic maintenance is required to ensure suitable life. It is proposed to fabricate the complete bottom trough out of stainless steel sheets with thickness of 6 mm.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	5	10
Salvaging Thickness	t	mm	3	3
Life Cycle Cost	LCC	Rs/Year	38,997	14,956
Savings		%		62%

For more details refer the main brochure from page no. 37.

Donnely Chutes

It is a vertical chute to feed the prepared cane or bagasse in the milling unit.

The chutes are 3 to 6 m in length and the width is that of the milling unit. The chutes are constructed of MS plates of 8 mm thickness in trapezoidal shape. The surface is completely exposed to shredded cane / bagasse and is prone to wear due to continuous friction of cane against its surface and corrosive cane juice. A liner of SS 304 of 3mm Thickness is fixed on chutes to reduce the wear effect.

As a better solution, fabrication is recommended with stainless steel grade – 204Cu. This eliminates the requirement of 3 mm liner plate, which shears due to improper fitting/welding.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	5	10
Salvaging Thickness	t	mm	3	3
Life Cycle Cost	LCC	Rs/Year	26,559	10,004
Savings		%		62%

For more details refer the main brochure from page no. 39.

Imbibition Piping

To aid in the extraction process, hot/cold water is added before the final milling unit. Juice extracted from the final milling unit is added before the penultimate milling unit and so on, until the second milling unit. The imbibition pipes carry this hot water at around 80° C.

The conventional pipes of mild steel tend to corrode and are always under high thermal stress. The average life of the mild steel pipes of 6mm thickness is two years.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	2	6
Salvaging Thickness	t	mm	2	3
Life Cycle Cost	LCC	Rs/Year	38,737	17,426
Savings		%		55%

For more details refer the main brochure from page no. 41.

Raw Juice Buffer Tank

The raw juice from the milling train generally has a pH between 5 to 5.5. The juice is corrosive and with sand in the juice, the net effect of corrosion with abrasion results in a rapid deterioration of mild steel. The raw juice tank is constructed with mild steel sheet of 10 mm thickness.

The tank requires protective coating every season and usually lasts up to 8 years with extensive maintenance.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	7	15
Salvaging Thickness	t	mm	3	3.50
Life Cycle Cost	LCC	Rs/Year	13,278	9,168
Savings		%		31%

For more details refer the main brochure from page no. 43.

Raw Juice Piping

The raw juice from the milling is pumped to the raw juice tank and further to intermediate or buffer tanks. The pipes travel from milling station to the tanks and are in operation for the entire crushing season.

The typical mild steel pipes cannot sustain the corrosion and abrasion due to fine particles in juice and shows severe wear in single or two crushing seasons.

It's life can be significantly enhanced with the use of stainless steel pipes.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	4	15
Salvaging Thickness	t	mm	4.00	3.50
Life Cycle Cost	LCC	Rs/Year	37,986	25,467
Savings		%		33%

For more details refer the main brochure from page no. 45.

Juice Sulphiter

The cane juice from the milling station is sent for further processing in the factory. The juice is heated using different type of contact and non-contact heaters and treated with lime and sulphur dioxide gas. A typical 2500 TCD factory has a sulphitation vessel of 150 HL capacity.

Corrosion in the vessel and reduction in thickness are common problems that occur due to high temperature and acidic nature of the juice. Although there are no moving parts, the process itself creates lot of scaling, pitting and corrosive wear on the surface.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	6	12
Salvaging Thickness	t	mm	2	2.40
Life Cycle Cost	LCC	Rs/Year	32,786	23,634
Savings		%		281%

For more details refer the main brochure from page no. 47.

Juice Sulphiter, Sparger & Vent Piping

A long metal tube with holes around its periphery is used to mix SO2 gas with the juice/syrup and is generally made up of SS 304 in 3 mm thickness.

The sparger is heavily corroded due to the acidic environment in the vessel. Hence, it is suggested to use 316L for this application.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	SS-304	SS-316L
Total Life	L	Years	1	2
Salvaging Thickness	t	mm	1	1
Life Cycle Cost	LCC	Rs/Year	18,663	15,210
Savings		%		19%

For more details refer the main brochure from page no. 49.

Juice Sulphiter, Sparger & Vent Piping

Removal of trapped air / gaseous vapour (SO2) is very important for eliminating turbulence at sulphited juice withdrawal points. Various designs includes 2 sets of venting from each compartment diametrically opposite to each other having inclined take off from the shell to ensure best possible removal of trapped vapours.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	2	5
Salvaging Thickness	t	mm	4	4
Life Cycle Cost	LCC	Rs/Year	1,374	874
Savings		%		36%

For more details refer the main brochure from page no. 51.

Reaction Tank (Juice)

The juice is mixed with milk of lime and the syrup, with phosphoric acid in respective reaction tanks. Normally the retention period for each are 40 minutes and 8 minutes respectively. Addition of lime & phosphoric acid with juice / syrup is done in reaction tank.

Sulphited or defecated juice from rotary screen is collected in sloped bottom trough and transferred to sulphited juice receiving tank by gravity for further heating process.

Tank for storage of sulphited juice, For 2500 TCD: Dia 4 m H - 2 mtr, retention time 10 min.

These tanks are fabricated out of 10mm thick MS sheets, The approx length x width of sheet consumed is, 2000 x 12560 mm. The service temperature goes up to 80˚C and heated juice often leaves scales (Calcium sulphate) which is very difficult to remove and cause deterioration of base metals.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	4	8
Salvaging Thickness	t	mm	4	4
Life Cycle Cost	LCC	Rs/Year	24,982	21,220
Savings		%		15%

For more details refer the main brochure from page no. 53.

Clarifier with accessories

When the juice has undergone treatment, it must be allowed to settle down. The settling is carried out in clarifiers. Syrup clarification is undertaken in many factories to improve the turbidity of syrup. However, since syrup is viscous, settling clarifiers would not work and floatation clarifiers are used.

The outer shell of clarifier is made up of mild steel plate of 10 mm thickness and 12 m diameter shell. Since the internals are generally made of SS, it is also prone to galvanic corrosion.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	7	14
Salvaging Thickness	t	mm	3.0	2.4
Life Cycle Cost	LCC	Rs/Year	138,975	110,340
Savings		%		21%

For more details refer the main brochure from page no. 55.

Mud Feed Mixer

In order to make the otherwise waste mud to form a useful component and extract residual sucrose from the mud, it is mixed with fine bagacillo in the mud mixer. The mixed mud is fed to vacuum filter.

This mud mixer is usually a U shaped MS construction of 10 mm thick plate. The operation involves mixing of mud and bagacillo results into severe abrasion on the surface of mixer. It is also subjected to corrosive wear. A mud feed mixer requires periodic maintenance and generally gives a working life of 2-3 years in MS construction.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	3	6
Salvaging Thickness	t	mm	4	4
Life Cycle Cost	LCC	Rs/Year	18,213	13,683
Savings		%		25%

For more details refer the main brochure from page no. 57.

Bagacillo Blower

The bagacillo blower facilitates conveying the bagacillo from boilers to mud mixers, by providing a constant stream of induced draft.

It is of 550 mm dia. and its life expectancy very low, i.e. around 4 months or, a sugar season.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	1	4
Salvaging Thickness	t	mm	1.0	3.50
Life Cycle Cost	LCC	Rs/Year	3,710	2,700
Savings		%		27%

For more details refer the main brochure from page no. 59.

Sulphur Burners

The juice and syrup are treated with SO2 gas to reduce the colouring compounds. Sulphur melt is fed to sulphur burners along with air to produce sulphur dioxide gas.

Sulphur melter is mild steel fabrication.

Holding capacity of this melter is approximately 24 hrs. Each compartment has its own steam coil with inlet and outlet arrangement. For sulphur melting process, generally 7ata steam from boiler is used.

The vessel is subjected to highly corrosive wear, scaling etc.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	2	5
Salvaging Thickness	t	mm	4	4
Life Cycle Cost	LCC	Rs/Year	10,385	9,914
Savings		%		5%

For more details refer the main brochure from page no. 61.

Catchall

During evaporation and crystallisation process, entrainment refers to the carry over of liquid (juices or syrup) with the vapor stream out of the vessel. This results in loss of sugar and hence needs to be contained. This is achieved using entrainment separators, sometimes also known as catchalls or save-alls.

The deposition of sugar on catchall vanes results in corrosion and faster wear of vanes. Material of construction of vanes is mild steel of 6mm thickness.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	2	5
Salvaging Thickness	t	mm	2	2.0
Life Cycle Cost	LCC	Rs/Year	20,561	13,010
Savings		%		37%

For more details refer the main brochure from page no. 63.

Interconnecting Pipes

Multiple effect evaporation is used in all sugar factories today to reduce the steam consumption of the factory. The interconnecting vapour pipes of evaporators and batch pans, continuous pans carry these vapours from one stage to other.

The mild steel fabricated 8 mm thick vapour pipe is prone to atmospheric corrosion.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	6	12
Salvaging Thickness	t	mm	2	2.4
Life Cycle Cost	LCC	Rs/Year	16,472	11,874
Savings		%		28%

For more details refer the main brochure from page no. 65.

NCG Piping

Exhaust steam or vapour contains non-condensable gases (NCG) which are removed from the vessel since their accumulation reduces the heat transfer coefficient of the vessel. Noxious gas pipes as per IS 1239 are provided to remove this gases and several problems arise in the pipes.

- Corrosion: Carbon dioxide combines with condensate to form carbonic acid, which is highly corrosive. Oxidation of metal components of the evaporator also leads to pitting corrosion.
- System binding: If non-condensable gases are not vented from the system, they can accumulate to the extent where flow of steam and condensate is blocked, thereby hindering the efficiency of the evaporator.
- Heat transfer reduction: Non-condensable gases act as insulators, forming a film on the tubes of the evaporator and reducing the transfer of heat to the process stream. This forces equipment to work harder, and meet heating demand, leading to reduced efficiency and increased power consumption.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	6	12
Salvaging Thickness	t	mm	2	2.4
Life Cycle Cost	LCC	Rs/Year	16,472	11,874
Savings		%		28%

For more details refer the main brochure from page no. 67.

Sugar Elevator with Buckets

Bucket elevators are used to transport the sugar from process house to the sugar bins. The buckets are fitted on two strands of chain to carry the sugar to an approximate height 10 -11 m.

This is where the sugar comes in contact with corrosive metals and gets contaminated.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	3	9
Salvaging Thickness	t	mm	1	1.2
Life Cycle Cost	LCC	Rs/Year	782	578
Savings		%		26%

For more details refer the main brochure from page no. 69.

Electrostatic Precipitator

It is is employed in co-generation plant of the sugar mills to trap and remove the dust particles (fly ash etc.) from the exhaust gas stream of the Boiler. As particles below 10 microns cannot be removed by any mechanical process, ESP is the only effective solution.

The Flue Gas ducting of ESP is normally made up of 6mm thick Carbon Steel sheets. Apart from weathering, these ducts undergo erosion. A normal duct consumes approx 2000000 sq metres of sheet which is difficult to maintain.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	4	8
Salvaging Thickness	t	mm	2	1.6
Life Cycle Cost	LCC	Rs/Year	12,293	8,611
Savings		%		30%

For more details refer the main brochure from page no. 71.

Induced Draft (ID) Fan

In an induced draft system, the fan is at the exit end of the path of flow, and the system is under negative pressure i.e. the pressure in the flow area is below atmospheric pressure, because the air is being drawn through the fan. The turbulent air that passes through the fan carries fine particles at a very high speed, which results in severe erosion on the fan blades.

It is observed that the 8 mm fan blades wear in one year and need change/repair of impeller.

LIFE CYCLE COST ANALYSIS				
Material of Construction	Symbol	Unit	MS	SS-204Cu
Total Life	L	Years	1	4
Salvaging Thickness	t	mm	4	4
Life Cycle Cost	LCC	Rs/Year	13,404	6,346
Savings		%		53%

For more details refer the main brochure from page no. 73.

Stainless Steel - A Wonder Metal

Stainless Steel - A Wonder Metal

Stainless steel is the generic term used to represent the family of corrosion resistance alloys. It is called Stainless steel as it does not stain, rust or corrode. Its properties are further enhanced with other elements such as Molybdenum, Nickel and Nitrogen. Stainless steel is produced in a variety of grades for usage in various industries as per requirement.

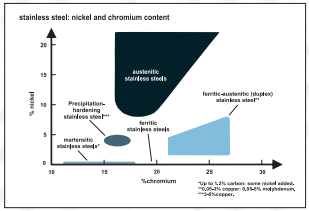
One of the unique features of this metal, is that it can be reused and recycled, making it environment friendly. Over 50% of the new stainless steel is made from re-melted scrap-metal making it a 'Green Metal'. Stainless steel is also dubbed as 'Wonder Metal' because of its distinguished characteristic like low maintenance, weldability, aesthetic appeal, durability, low life cycle cost, good erosion and corrosion resistance. These qualities make it an ideal material for many applications for usage not just in sugar industry, but in various other end-use sectors.

Apart from corrosion resistance, some other sterling properties of stainless steel makes it a preferred choice for the sugar Industry. They are:

- Hygiene: The easy cleaning ability helps maintain hygiene conditions
- Strength-to-weight advantage: Reduced material thickness over conventional grades, and therefore cost saving.
- Ease of fabrication: Stainless steel can be cut, welded, formed, machined, and fabricated as readily as traditional steels
- Impact resistance: Higher impact resistance compared to steel
- Long-term value: When the total life cycle costs are considered, it is often the least expensive material option
- Environmental compatibility in use: Stainless steel is durable and requires minimum of maintenance and eliminates requirements for additional potentially hazardous materials such as paint, fire protective coatings, cleaners and solvents
- Scrap value: It is 100% recyclable and a preferred raw material input by steel makers.

Categories of Stainless Steel:

Stainless steels are broadly categorized based on the atomic structure and alloying elements resulting in range of properties required for various end use. These are:



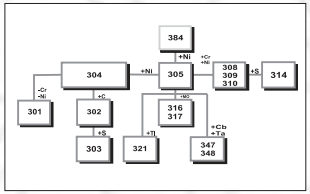
Austenitic Stainless Steels

- The most widely used type of stainless steel, popularly known as 300 and 200 series grades and are non-magnetic in nature
- 200 Series grades are alloyed with chromium, nickel, and manganese
- 300 Series are alloyed with chromium and nickel

- When nickel is added to stainless steel in sufficient quantities (also manganese and nitrogen in case of 200 series grades), the crystal structure is changed from ferrite to austenite.
- Basic composition of the austenitic stainless steel is 18% Cr and 8% Ni. This is Grade 304, sometimes loosely referred to as 18/8 or 18 / 10.
- If additional corrosion resistance is required, 2-3% molybdenum (Mo) is added, termed Grade 316.
- The carbon content of almost all stainless steels is low (often 0.08%C max.). There are also 'Low carbon' or 'L' grades (0.03% C max) and stabilized grades alloyed with titanium (Ti) or niobium (Nb) to prevent corrosion occurring in the region next to the weld in welded structures.
- Grade 304 is easy to form and weld and is readily brake or roll formed into a variety of components for applications in the industrial, architectural, and transportation fields.
- Apart for 304, there are various other grades in 300 and 200 series which are selected based on corrosion resistance and high temperature requirements.

Basic properties:

- Excellent corrosion resistance
- Excellent clean-ability and hygiene factor
- Fabricated and formed with ease
- Excellent weld-ability
- Hardened by cold work, not by heat treatment
- Usually used in the fully annealed condition in which they are essentially non-magnetic
- Ability to handle both extremely low (cryogenic) temperatures and, depending on the load and permissible distortion, higher service temperatures of around 600°C, or even higher, if scaling resistance is the only consideration.

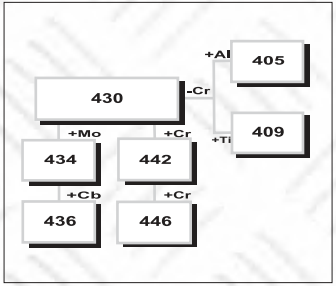


Ferritic Stainless Steels

- These are nickel-free stainless steels. They have a varying chromium (Cr) content of 12-18%, but a lower carbon (C) content than the martensitic.
- The popular grades are 409, 430, 439 and 441 which are suitable for a wide range of application in sugar industry. Some of them offer high wear resistance, while others offer higher corrosion resistance.
- Easy to form and machine for thinner gauges and is commonly used in automotive exhaust systems, appliances, boilers, cooking utensils, and indoor architecture.
- The most commonly used ferritic steel is type 430 and in some applications, this can be used as a replacement for austenitic grade 304. Type 430 is often found in washing machine drums, kitchen sinks, cutlery, indoor panels, dishwashers and other cooking utensils.
- There are many grades of stainless steels in all these categories which are suitable for various equipments in sugar industry based on their alloying elements and required properties.

Basic properties:

- Moderate to good corrosion resistance which increases with the chromium content
- Magnetic, non-hardenable and always used in the annealed condition
- Weld-ability is poor which generally limits their applications as welded components to thin gauge material
- More difficult to form (i.e. bend, draw, etc) than the austenitics



Martensitic Stainless Steels

- Very hard and strong, though not as resistant to corrosion as austenitic or ferritic grades.
- Also classified as the 400 Series and contains approximately 13% chromium.
- Developed to be hardened by heat treating for applications where hardness, strength, and wear resistance are required.
- Commonly used to make knives, fasteners, surgical equipment, and turbine blades.
- The common specifications are 410, 420, 431 and CA-6NM.

Basic properties:

- Moderate corrosion resistance
- High strength, hardness levels can be developed
- Very limited weldability
- Common uses include applications as knife blades, surgical instruments, fasteners, spindles, nozzles, shafts, impellers and springs.
- Available as bars, strips and casting

Duplex Stainless Steels

- Have a structure of approximately equal amounts of ferrite and austenite
- The chromium content varies from 18-28%.
- The nickel content of 4.5-8% is insufficient to develop a fully austenitic crystal structure. Most grades contain molybdenum in the range 2.5-4% plus a small nitrogen addition which enhances both strength and pitting resistance.
- Strong, flexible and are used in the paper, pulp, shipbuilding and petrochemical industries.
- Newer duplex grades are being developed for a broader range of applications.

Basic properties:

- High resistance to stress corrosion cracking
- An increased level of passivity due to higher Cr, Mo and N
- Good weld-ability and form-ability
- Higher tensile and yield strengths (compared with austenitic and ferritic stainless steels)
- Common uses include applications as heat exchanger panels and tubes, materials handling equipment, tanks and vessels where high chloride concentrations are

present, e.g. sea water cooling, desalination, food pickling plants and aggressive mine waters.

Precipitation Hardening Stainless Steel

- Martensitic or semi-austenitic steels are also classified as Precipitation Hardening Stainless Steels.
- Made to achieve enhanced properties with the addition of elements such as aluminium, copper and niobium.
- Compositions formulated in a way, in which they are machinable.
- Can be hardened by a single 'ageing' treatment at a fairly low temperature and can, therefore, be done without distorting the product.
- Ideal for production of long, straight high strength shafts for pumps and also valve spindles.
- The most common grade is 17-4PH (S17400 or '630' or 1.4542). High strength wire can be produced in grade 17-7PH(S17700 or '631' or 1.4568).

Stainless steels can be logically classified into Austenitic, Ferritic, Duplex, Martensitic and Precipitation Hardening groups. The choice of a specific grade is determined by the application and the conditions under which it will operate. Nearly all applications can be covered by austenitic & ferritic grades, however in certain applications, especially where sulphur is involved, duplex is being used overseas for SO2 gas applications. With careful selection and good fabrication, however, the majority or corrosive conditions can be handled by one of the family of stainless steels. Stainless steel is now available in various textures and colours and can also add aesthetics value.

Annexure

01 - Life Cycle Cost Benefits

S.No	Sugar Mill Section	Equipment	Component	Savings in Life Cycle Cost p.a. conversion MS- SS
1	Mill House	Cane Carrier-Primary / Auxillary	Wear Plates	30%
2	Mill House	Cane Carrier-Primary / Auxillary	Side Plates	30%
3	Mill House	Cane Carrier-Primary / Auxillary	Support Structure	30%
4	Mill House	Cane Shredder	Side Plates	50%
5	Mill House	Rake Type Elevators	Bottom Trough	62%
6	Mill House	Rake Type Inter Carrier	Bottom Trough	62%
7	Mill House	Donnelly Chutes	Plates	62%
8	Mill House	Imbibition Piping	Pipes	55%
9	Mill House	Raw Juice Buffer Tank	Tank	31%
10	Mill House	Raw Juice Carrying Pipes	Pipes	33%
11	Process House	Juice Sulphiter	Sulphiter Vessel	28%
12	Process House	Juice Sulphiter	Spargers	19%
13	Process House	Juice Sulphiter	Vent Pipes	36%
14	Process House	Reaction Tank - Juice	Tank	15%
15	Process House	Reaction Tank- Syrup	Tank	15%
16	Process House	Mill House	Juice Clarifer/Syrup Clarifier	21%
17	Process House	Mud Feed mixer	Mixer	25%
18	Process House	Mud Overflow Recirculation Tank	Tank	25%
19	Process House	Bagacillio Blower	Casings	27%
20	Process House	Sulpher Burners	Burner	5%
21	Process House	Sulpher Burners	Melters	5%
22	Process House	Evaporator	Catchall	37%
23	Process House	Evaporator	Interconnecting Pipes	28%
24	Process House	Batch Pans/Continuos Pans	Vapour Pipe	28%
25	Process House	Evaporator	NCG Pipes	28%
26	Process House	Quintuple	NCG Pipes	28%
27	Packing	Sugar Elevators	Buckets	26%
28	Boiler	Electro Static Precipitators	Flue Gas Duct	30%
29	Boiler	ID Fan	Impeller Vanes	53%

02 - Grade Properties & Application

Grade / Type	Properties	Applications
J4	• High strength to weight ratio • Excellent formability & wear resistance • Excellent weldability and good corrosion resistance than mild steel	• Cane Conveyor: Side Plates, Chain Links, Pin, Bushes and Rollers • Milling, Donnelly Chutes • Rake Elevators, Plates, Juice Trays • Juice/Syrup tanks and Hoppers
J204 Cu	• High strength to weight ratio • Excellent formability and wear resistance • Good weldability and corrosion resistance	• Milling: Juice Trays, Gutters, Sulphur station • Tubes: Juice Heaters, Evaporators, Pans and Condensers • Crystallizers and Centrifugals
JSLAUS	• High yield strength as compared to Cr-Ni stainless steel • Excellent formability & weldability • Has good corrosion resistance/resistance to S02 environment during processing of mixed juice and syrup	• Juice Tanks and Pipelines • Trough & Screw • Conveyor Condensers and Crystallizers
J304/304L	• Good corrosion and oxidation resistance • Superior weldability, ductility and toughness	• Sulphidation and clarification segment including boiling house • Vacuum filter, condenser & syrup tank
J316/316L	• Superior resistance to corrosion at many aggressive environments • Superior resistance to pitting and crevice corrosion • Higher strength and better creep resistance at higher temperature • Good weldability, ductilit and fabricability	• Raw cane handling at carriers, cane knives and condensers • Filtration, clarifiers and crystallizers • Diffusers and mills • Centrifugals, sugar bins and filling
J409 M	• Resistance to corrosion on abrasion • Good formability and weldability • Excellent performance at elevated temperature	• Diffusers and mills • Centrifugals, sugar bins and fillings • Clarifiers and crystallizers • Filtration and condensers • For dry and semi-dry handling
J439	• Good resistance to inter-granular/pitting corrosion • Fully Ferritic microstructure • Very good weldability and ductility	• Sugarcane juice ducts and heaters • Evaporators and boiling pans • Crystallization units and dryers

03- Chemical Properties & Mechanical Properties

Grade	%C(Max)	%Mn (Max)	%P (Max)	%S (Max)	%Si (Max)	%Cr (Max)	%Ni	%Mo	N PPM	Others	UTS (MPa Min)	YS (MPa Min)	Elon % (Min)	Hardness RB (Max)
J4	0.10	8.5-10	0.08	0.01	0.75	15-16	1-2	-	2000	Cu = 1.5-2	650	325	40	100
J204 Cu	0.10	6.5-9	0.06	0.01	0.75	16-17.5	1.5-3.5	-	1000-2000	Cu = 2-4	620	310	40	100
JSL AUS	0.08	6-8	0.07	0.01	0.75	16-18	4-6	-	1000	Cu = 1 .5-2	550	205	40	95
J 304	0.07	2.00	0.045	0.03	0.75	17.5-19.5	8-10.5	-	1000	-	515	205	40	92
J 304 L	0.03	2.00	0.045	0.03	0.75	17.5-19.5	8-12	-	1000	-	485	170	40	92
J 316	0.08	2.00	0.045	0.03	0.75	16-18	10-14	2-3	1000	-	515	205	40	95
J 316 L	0.03	2.00	0.045	0.03	0.75	16-18	10-14	2-3	1000-	-	485	170	40	95
J 409 M	0.03	0.8-1.5	0.03	0.03	1.00	10.8-12.5	1.50	-	300	Ti=0.75 max	450	275	20	90
J 439	0.03	1.00	0.04	0.03	1.00	17-19	0.50	-	300	Ti= 0.2+4 X (C+N) min, 1.1 max Al= 0.15 max	415	205	22	89

04- List of Equipment Manufacturers

S. No.	Company	City	Contact Person	Designation	Telephone No.	Email Address
1	UTTAM indl Engg Pvt LTD	Ghaziabad	Mr. J S Dhikkar/ Mr. RK Jain	Director	0120-4944444	js.dhikkar@uiel.co.in
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3	Standard type Foundry	Ghaziabad	Mr. Ajay Arora	GM	9810493549	ajay@uttam.co.in
4	Mahashakti Engineering Co.	Ghaziabad	Mr. Digvijay Singh	MD	9899495151	mahashaktigzy@yahoo.com
5	Profile Engineers	Ghaziabad	Mr. Puneet Agggarwal	GM	9810639564	profileengineers@gmail.com
6	Universal Heavy Engineering Company	Sharanpur	Mr. Pawan Arora	MD	9917029994	pawanchec@gmail.com
7	Godson Engineers &Counsultants	Bareilly	Mr. Anil Sawhney	Properietor	9412287080	godsonengineers@gmail.com
8	Three Star Engg Works pvt ltd	Ghazibad	Mr. Arshad Saifi	Exe Director	9958227852	info@threestarengg.com
9	Ultratech Engneering	Gaziabad	Mr. Anupam Kamboj	MD	9818391622	anupam@ultratec.in
10	Chemical system	Delhi	Mr. Anoop Kesarwani	Director	9810021812	anupkesarwani@sugarchem.com
11	Sundersons Engineers Pvt. Ltd.	Ghaziabad	Mr. Anirudh Kamboj	MD	9810016866	sundersons119@gmail.com
12	Superior Engineering & Mfg. Co.	Meerut Cantt	Mr. S.B Shabarwal	MD	0121-2660469, 9412206413	sureshindustrial@hotmail.com
13	Sathe Engineering	Ghaziabad	Mr. Azad Kaushik	Mktg Manager	0120-2700252	
14	Khanna Engineering	Ghaziabad	Mr. Subhash Khanna	Properietor	9818052969	khanna_engineering@yahoo.in
15	K.V.R. Engineering Works	Ghaziabad	Mr. Mohit Kumar	GM	98106010o8	infokvr@gmail.com
16	Gurdev Engg & Industrial Pvt. Ltd.	khatauli	Mr. Paramvir Singh Dhadli	MD	9917520000	gurdevengineers@gmail.com
17	Chandel Engineering Pvt. Ltd.	Kanpur	Mr. Chandel	MD	0512-2692369	chandel-engg@gmail.com
18	Enviropol	Greater Noida	Mr. Rajeev		0120-4540881	bd@enviropolenigineers.in
19	Stotz Gears	Gaziabad	Mr. Pradeep Kaira	MD	9810241055	stotz.pk@gmail.com
20	Multi Max (Heat Exchangers)	Meerut Cantt	Mr. Ashish Kaushik	MD	8755744178	ashishkaushik@multimax.in
21	Miltech Engg Works	Muzzafar Nagr	Mr. Akash Gupta		9319415616	info@milteck.com
22	Shamraj Enercon	Pune	Mr. Jayant Marudgan	MD	9822025367	purchase.shamraj@gmail.com
23	Shrijee Engg	Ahmadnagar	Mr. Anil Agarwal	MD	9820021958	anil@shrijee.com
24	Excel Engineers & Consultants	Pune	Mr. Sanjay Desai -CMD/ Mr. Sayed	CMD	9665039921	sanjay@regreenexcel.com
25	S.S. Engineers	Pune	Mrs. Swasti Patil	MD	020 30612300	swasti@ssengineers.com
26	Mojj Engineering System Ltd.	Pune	Mr. Sunil kagwad	Marketing Head	7722023441	sunil.kagwad@mojjpune.com
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28	Skylark	Sangali	Mr. Pramod Wategave	MD	9922442227	pramod@skylarkprecitech.com
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