APRIL - MAY 2017 | Bi-monthly

PPMAI speak

Process Plant and Machinery Association of India

Performance that never stops...

Dear Friends,

India's manufacturing has steadily grown in April, as a result of sustained growth in new orders from overseas. In the month of May, there is slight dip in the manufacturing growth.

According to Indian manufacturers, output is expected to improve amid reports of planned capacity expansions, new product launches, aggressive marketing campaigns and an improving economic scenario.

Recently, a new procurement policy has been approved by government to promote manufacturing growth. Under the new policy, preference in government procurements will be given to local suppliers. This will promote the "Make in India" initiative and also aid employment generation. This is possible through partnerships, cooperation with local companies, establishing production units in India or joint ventures with Indian suppliers, increasing the participation of local employees in services and by training them. The policy, approved by the Cabinet, is also aimed at stimulating flow of capital and technology.

India has numerous growth opportunities and is presently becoming a major economic force in the world based on its demographic dividend, enormous market potential and rising disposable income. India has fared reasonably well in sectors such as IT, power, infrastructure, education, agriculture and defence.

However, there is a need for further development and accelerating innovation, if our products and services have to meet new market demand induced by digitisation and industrial revolution 4.0. It is essential for us to identify areas where innovation is possible. Similarly, application of sensors, intelligent motors, computerized controls, production management software, artificial intelligence, and stock optimization will help in transforming the processes.

This will boost production efficiency, help in developing safer products, enable customization, support product tracking, increase environmental sustainability, increase the flexibility of plants, lower the cost of products and increase safety at work.

Let us work together towards leveraging these opportunities.

Anil Rairikar

Chairman

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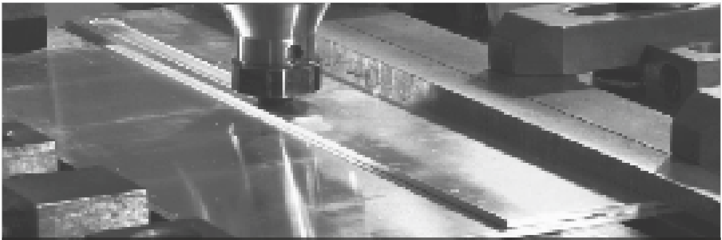
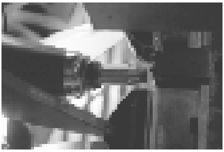
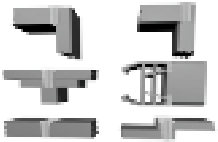


Friction Stir Welding



Close-up view of a friction stir weld tack tool.

The bulkhead and nosecone of the Orion spacecraft are joined using friction stir welding.

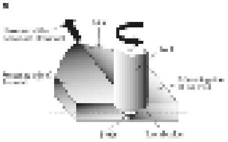


Joint designs

Friction Stir Welding (FSW) is a solid-state joining process that uses a non-consumable tool to join two facing workpieces without melting the workpiece material. Heat is generated by friction between the rotating tool and the workpiece material, which leads to a softened region near the FSW tool. While the tool is traversed along the joint line, it mechanically intermixes the two pieces of metal, and forges the hot and softened metal by the mechanical pressure, which is applied by the tool, much like joining clay, or dough. It is primarily used on wrought or extruded aluminium and particularly for structures which need very high weld strength.

It was invented and experimentally proven at The Welding Institute (TWI) in the UK in December 1991. TWI held patents on the process, the first being the most descriptive.

Principle of operation



Schematic diagram of the FSW process:
A) Two discrete metal workpieces butted together, along with the tool (with a probe).

(B) The progress of the tool through the joint, also showing the weld zone and the region affected by the tool shoulder.

A rotating cylindrical tool with a profiled probe is fed into a butt joint between two clamped workpieces, until the shoulder, which has a larger diameter than the pin, touches the surface of the workpieces. The probe is slightly shorter than the weld depth required, with the tool shoulder riding atop the work surface. After a short dwell time, the tool is moved forward along the joint line at the pre-set welding speed.

Frictional heat is generated between the wear-resistant tool and the work pieces. This heat, along with that generated by the mechanical mixing process and the adiabatic heat within the material, cause the stirred materials to soften without melting. As the tool is moved forward, a special profile on the probe forces plasticised material from the leading face to the rear, where the high forces assist in a forged consolidation of the weld.

This process of the tool traversing along the weld line in a plasticised tubular shaft of metal results in severe solid state deformation involving dynamic recrystallization of the base material.

Microstructural features

The solid-state nature of the FSW process, combined with its unusual tool shape and asymmetric speed profile, results in a highly characteristic microstructure. The microstructure can be broken up into the following zones:

- The stir zone (also nugget, dynamically recrystallised zone) is a region of heavily deformed material that roughly corresponds to the location of the pin during welding. The grains within the stir zone are roughly equiaxed and often an order of magnitude smaller than the grains in the parent material. A unique feature of the stir zone is the common occurrence of several concentric rings which has been referred to as an "onion-ring" structure. The precise origin of these rings has not been firmly established, although variations in particle number density, grain size and texture have all been suggested.

- The flow arm zone is on the upper surface of the weld and consists of material that is dragged by the shoulder from the retreating side of the weld, around the rear of the tool, and deposited on the advancing side.

- The thermo-mechanically affected zone (TMAZ) occurs on either side of the stir zone. In this region the strain and temperature are lower and the effect of welding on the microstructure is correspondingly smaller. Unlike the stir zone the microstructure is recognizably that of the parent material, albeit significantly deformed and rotated. Although the term TMAZ technically refers to the entire deformed region it is often used to describe any region not already covered by the terms stir zone and flow arm.

- The heat-affected zone (HAZ) is common to all welding processes. As indicated by the name, this region is subjected to a thermal cycle but is not deformed during welding. The temperatures are lower than those in the TMAZ but may still have a significant effect if the microstructure is thermally unstable. In fact, in age-hardened aluminium alloys this region commonly exhibits the poorest mechanical properties.

Advantages and limitations

The solid-state nature of FSW leads to several advantages over fusion welding methods as problems associated with cooling from the liquid phase are avoided. Issues such as porosity, solute redistribution, solidification cracking and liquation cracking do not arise during FSW. In general, FSW has been found to produce a low concentration of defects and is very tolerant of variations in parameters and materials.

Nevertheless, FSW is associated with a number of unique defects, if it isn't done properly. Insufficient weld temperatures, due to low rotational speeds or high traverse speeds, for example, mean that the weld material is unable to accommodate the extensive deformation during welding. This may result in long, tunnel-like defects running along the weld which may occur on the surface or subsurface. Low temperatures may also limit the forging action of the tool and so reduce the continuity of the bond between the material from each side of the weld. The light contact between the material has given rise to the name "kissing-bond". This defect is particularly worrying since it is very difficult to detect using nondestructive methods such as X-ray or ultrasonic testing. If the pin is not long enough or the tool rises out of the plate then the interface at the bottom of the weld may not be disrupted and forged by the tool, resulting in a lack-of-penetration defect. This is essentially a notch in the material which can be a potential source of fatigue cracks.

A number of potential advantages of FSW over conventional fusion-welding processes have been identified:

- Good mechanical properties in the as-welded condition
- Improved safety due to the absence of toxic fumes or the spatter of molten material.
- No consumables — A threaded pin made of conventional tool steel, e.g., hardened H13, can weld over 1 km (0.62 mi) of aluminium, and no filler or gas shield is required for aluminium.
- Easily automated on simple milling machines — lower setup costs and less training.
- Can operate in all positions (horizontal, vertical, etc.), as there is no weld pool.
- Generally good weld appearance and minimal thickness under/over-matching, thus reducing the need for expensive machining after welding.
- Can use thinner materials with same joint strength.
- Low environmental impact.
- General performance and cost benefits from switching from fusion to friction.

However, some disadvantages of the process have been identified:

- Exit hole left when tool is withdrawn.
- Large down forces required with heavy-duty clamping necessary to hold the plates together.
- Less flexible than manual and arc processes (difficulties with thickness variations and non-linear welds).

- Often slower traverse rate than some fusion welding techniques, although this may be offset if fewer welding passes are required.

Important welding parameters

Tool design

Advanced friction stir welding and processing tools by MegaStir shown upside down

FSW of two USIBOR 1500 high-strength steel sheets

The design of the tool is a critical factor as a good tool can improve both the quality of the weld and the maximum possible welding speed.

It is desirable that the tool material be sufficiently strong, tough, and hard wearing at the welding temperature. Further it should have a good oxidation resistance and a low thermal conductivity to minimise heat loss and thermal damage to the machinery further up the drive train. Hot-worked tool steel such as AISI H13 has proven perfectly acceptable for welding aluminium alloys within thickness ranges of 0.5 – 50 mm but more advanced tool materials are necessary for more demanding applications such as highly abrasive metal matrix composites or higher melting point materials such as steel or titanium.

Improvements in tool design have been shown to cause substantial improvements in productivity and quality. TWI has developed tools specifically designed to increase the penetration depth and thus increasing the plate thicknesses that can be successfully welded. An example is the "whorl" design that uses a tapered pin with re-entrant features or a variable pitch thread to improve the downwards flow of material. Additional designs include the Triflute and Trivex series. The Triflute design has a complex system of three tapering, threaded re-entrant flutes that appear to increase material movement around the tool. The Trivex tools use a simpler, non-cylindrical, pin and have been found to reduce the forces acting on the tool during welding.

The majority of tools have a concave shoulder profile which acts as an escape volume for the material displaced by the pin, prevents material from extruding out of the sides of the shoulder and maintains downwards pressure and hence good forging of the material behind the tool. The Triflute tool uses an alternative system with a series of concentric grooves machined into the surface which are intended to produce additional movement of material in the upper layers of the weld.

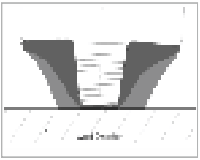
Widespread commercial applications of friction stir welding process for steels and other hard alloys such as titanium alloys will require the development of cost-effective and durable tools. Material selection, design and cost are important considerations in the search for commercially useful tools for the welding of hard materials. Work is continuing to better understand the effects of tool material's composition, structure, properties and geometry on their performance, durability and cost.

Tool rotation and traverse speeds

There are two tool speeds to be considered in friction-stir welding; how fast the tool rotates and how quickly it traverses along the interface. These two parameters have considerable importance and must be chosen with care to ensure a successful and efficient welding cycle. The relationship between the rotation speed, the welding speed and the heat input during welding is complex but, in general, it can be said that increasing the rotation speed or decreasing the traverse speed will result in a hotter weld. In order to produce a successful weld it is necessary that the material surrounding the tool is hot enough to enable the extensive plastic flow required and minimize the forces acting on the tool. If the material is too cold then voids or other flaws may be present in the stir zone and in extreme cases the tool may break.

Excessively high heat input, on the other hand may be detrimental to the final properties of the weld. Theoretically, this could even result in defects due to the liquation of low-melting-point phases (similar to liquation cracking in fusion welds). These competing demands lead onto the concept of a "processing window": the range of processing parameters viz. tool rotation and traverse speed, that will produce a good quality weld. Within this window the resulting weld will have a sufficiently high heat input to ensure adequate material plasticity but not so high that the weld properties are excessively deteriorated.

Tool tilt and plunge depth



A drawing showing the plunge depth and tilt of the tool.
The tool is moving to the left.

The plunge depth is defined as the depth of the lowest point of the shoulder below the surface of the welded plate and has been found to be a critical parameter for ensuring weld quality. Plunging the shoulder below the plate surface increases the pressure below the tool and helps ensure adequate forging of the material at the rear of the tool. Tilting the tool by 2–4 degrees, such that the rear of the tool is lower than the front, has been found to assist this forging process. The plunge depth needs to be correctly set, both to ensure the necessary downward pressure is achieved and to ensure that the tool fully penetrates the weld. Given the high loads required, the welding machine may deflect and so reduce the plunge depth compared to the nominal setting, which may result in flaws in the weld. On the other hand, an excessive plunge depth may result in the pin rubbing on the backing plate surface or a significant undermatch of the weld thickness compared to the base material. Variable load welders have been developed to automatically compensate for changes in the tool displacement while TWI have demonstrated a roller system that maintains the tool position above the weld plate.

Welding forces

During welding a number of forces will act on the tool:

- A downwards force is necessary to maintain the position of the tool at or below the material surface. Some friction-stir welding machines operate under load control but in many cases the vertical position of the tool is preset and so the load will vary during welding.

- The traverse force acts parallel to the tool motion and is positive in the traverse direction. Since this force arises as a result of the resistance of the material to the motion of the tool it might be expected that this force will decrease as the temperature of the material around the tool is increased.

- The lateral force may act perpendicular to the tool traverse direction and is defined here as positive towards the advancing side of the weld.

- Torque is required to rotate the tool, the amount of which will depend on the down force and friction coefficient (sliding friction) and/or the flow strength of the material in the surrounding region (stiction).

In order to prevent tool fracture and to minimize excessive wear and tear on the tool and associated machinery, the welding cycle is modified so that the forces acting on the tool are as low as possible, and abrupt changes are avoided. In order to find the best combination of welding parameters, it is likely that a compromise must be reached, since the conditions that favour low forces (e.g. high heat input, low travel speeds) may be undesirable from the point of view of productivity and weld properties.

Flow of material

Early work on the mode of material flow around the tool used inserts of a different alloy, which had a different contrast to the normal material when viewed through a microscope, in an effort to determine where material was moved as the tool passed. The data was interpreted as representing a form of in-situ extrusion where the tool, backing plate and cold base material form the "extrusion chamber" through which the hot, plasticised material is forced. In this model the rotation of the tool draws little or no material around the front of the probe instead the material parts in front of the pin and passes down either side. After the material has passed the probe the side pressure exerted by the "die" forces the material back together and consolidation of the join occurs as the rear of the tool shoulder passes overhead and the large down force forges the material.

More recently, an alternative theory has been advanced that advocates considerable material movement in certain locations. This theory holds that some material does rotate around the probe, for at least one rotation, and it is this material movement that produces the "onion-ring" structure in the stir zone. The researchers used a combination of thin copper strip inserts and a "frozen pin" technique, where the tool is rapidly stopped in place. They suggested that material motion occurs by two processes:

1. Material on the advancing side of a weld enters into a zone that rotates and advances with the profiled probe. This material was very highly deformed and sloughs off behind the pin to form arc-shaped features when viewed from above (i.e. down the tool axis). It was noted that the copper entered the rotational zone around the pin, where it was broken up into fragments. These fragments were only found in the arc shaped features of material behind the tool.

2. The lighter material came from the retreating side in front of the pin and was dragged around to the rear of the tool and filled in the gaps between the arcs of advancing side material. This material did not rotate around the pin and the lower level of deformation resulted in a larger grain size.

The primary advantage of this explanation is that it provides a plausible explanation for the production of the onion-ring structure.

The marker technique for friction stir welding provides data on the initial and final positions of the marker in the welded material. The flow of material is then reconstructed from these positions. Detailed material flow field during friction stir welding can also be calculated from theoretical considerations based on fundamental scientific principles. Material flow calculations are routinely used in numerous engineering applications. Calculation of material flow fields in friction stir welding can be undertaken both using comprehensive numerical simulations or simple but insightful analytical equations. The comprehensive models for the calculation of material flow fields also provide important information such as geometry of the stir zone and the torque on the tool. The numerical simulations have shown the ability to correctly predict the results from marker experiments] and the stir zone geometry observed in friction stir welding experiments.

Generation and flow of heat

For any welding process it is, in general, desirable to increase the travel speed and minimise the heat input as this will increase productivity and possibly reduce the impact of welding on the mechanical properties of the weld. At the same time it is necessary to ensure that the temperature around the tool is sufficiently high to permit adequate material flow and prevent flaws or tool damage.

When the traverse speed is increased, for a given heat input, there is less time for heat to conduct ahead of the tool and the thermal gradients are larger. At some point the speed will be so high that the material ahead of the tool will be too cold and the flow stress too high, to permit adequate material movement, resulting in flaws or tool fracture. If the "hot zone" is too large then there is scope to increase the traverse speed and hence productivity.

The welding cycle can be split into several stages during which the heat flow and thermal profile will be different:

- Dwell. The material is preheated by a stationary, rotating tool to achieve a sufficient temperature ahead of the tool to allow the traverse. This period may also include the plunge of the tool into the workpiece.
- Transient heating. When the tool begins to move there will be a transient period where the heat production and temperature around the tool will alter in a complex manner until an essentially steady-state is reached.
- Pseudo steady-state. Although fluctuations in heat generation will occur the thermal field around the tool remains effectively constant, at least on the macroscopic scale.
- Post steady-state. Near the end of the weld heat may "reflect" from the end of the plate leading to additional heating around the tool.

Heat generation during friction-stir welding arises from two main sources: friction at the surface of the tool and the deformation of the material around the tool. The heat generation is often assumed to occur predominantly under the shoulder, due to its greater surface area, and to be equal to the power required to overcome the contact forces between the tool and the workpiece. The contact condition under the shoulder can be described by sliding friction, using a friction coefficient μ and interfacial pressure P, or sticking friction, based on the interfacial shear strength at an appropriate temperature and strain rate. Mathematical approximations for the total heat generated by the tool shoulder Qtotal have been developed using both sliding and sticking friction models:

$$Q_{total} = 2–3\pi P\mu\omega(R^3_{shoulder} - R^3_{pin})\ (\text{Sliding})$$

$$Q_{total} = 2–3\pi\tau\omega(R^3_{shoulder} - R^3_{pin})\ (\text{Sticking})$$

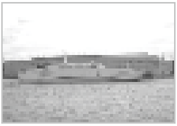
where ω is the angular velocity of the tool, $R_{shoulder}$ is the radius of the tool shoulder and R_{pin} that of the pin. Several other equations have been proposed to account for factors such as the pin but the general approach remains the same.

A major difficulty in applying these equations is determining suitable values for the friction coefficient or the interfacial shear stress. The conditions under the tool are both extreme and very difficult to measure. To date, these parameters have been used as "fitting parameters" where the model works back from measured thermal data to obtain a reasonable simulated thermal field. While this approach is useful for creating process models to predict, for example, residual stresses it is less useful for providing insights into the process itself.

Applications

The FSW process has initially been patented by TWI in most industrialised countries and licensed for over 183 users. Friction stir welding and its variants friction stir spot welding and friction stir processing are used for the following industrial applications: shipbuilding and offshore, aerospace, offshore, aerospace, automotive, rolling stock for railways, general fabrication, robotics, and computers.

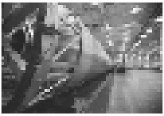
Shipbuilding and offshore



Friction stir welding was used to prefabricate the aluminium panels of the Super Liner Ogasawara at Mitsui Engineering and Shipbuilding

Two Scandinavian aluminium extrusion companies were the first to apply FSW commercially to the manufacture of fish freezer panels at Sapa in 1996, as well as deck panels and helicopter landing platforms at Marine Aluminium Aanensen. Marine Aluminium Aanensen subsequently merged with Hydro Aluminium Maritime to become Hydro Marine Aluminium. Some of these freezer panels are now produced by Riftec and Bayards. In 1997 two-dimensional friction stir welds in the hydrodynamically flared bow section of the hull of the ocean viewer vessel The Boss were produced at Research Foundation Institute with the first portable FSW machine. The Super Liner Ogasawara at Mitsui Engineering and Shipbuilding is the largest friction stir welded ship so far. The Sea Fighter of Nichols Bros and the Freedom class Littoral Combat Ships contain prefabricated panels by the FSW fabricators Advanced Technology and Friction Stir Link, Inc. respectively. The Houbei class missile boat has friction stir welded rocket launch containers of China Friction Stir Centre. HMNZS Rotoiti in New Zealand has FSW panels made by Donovans in a converted milling machine. Various companies apply FSW to armor plating for amphibious assault ships.

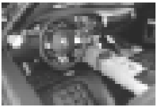
Aerospace



Longitudinal and circumferential friction stir welds are used for the Falcon 9 rocket booster tank at the SpaceX factory

United Launch Alliance applies FSW to the Delta II, Delta IV, and Atlas V expendable launch vehicles, and the first of these with a friction stir welded Interstage module was launched in 1999. The process is also used for the Space Shuttle external tank, for Ares I and for the Orion Crew Vehicle test article at NASA as well as Falcon 1 and Falcon 9 rockets at SpaceX. The toe nails for ramp of Boeing C-17 Globemaster III cargo aircraft by Advanced Joining Technologies and the cargo barrier beams for the Boeing 747 Large Cargo Freighter were the first commercially produced aircraft parts. FAA approved wings and fuselage panels of the Eclipse 500 aircraft were made at Eclipse Aviation, and this company delivered 259 friction stir welded business jets, before they were forced into Chapter 7 liquidation. Floor panels for Airbus A400M military aircraft are now made by Pfalz Flugzeugwerke and Embraer used FSW for the Legacy 450 and 500 Jets Friction stir welding also is employed for fuselage panels on the Airbus A380. BRÖTJE-Automation uses friction stir welding for gantry production machines developed for the aerospace sector as well as other industrial applications.

Automotive



The centre tunnel of the Ford GT is made from two aluminium extrusions friction stir welded to a bent aluminium sheet and houses the fuel tank

Aluminium engine cradles and suspension struts for stretched Lincoln Town Car were the first automotive parts that were friction stir at Tower Automotive, who use the process also for the engine tunnel of the Ford GT. A spin-off of this company is called Friction Stir Link, Inc. and successfully exploits the FSW process, e.g. for the flatbed trailer "Revolution" of Fontaine Trailers. In Japan FSW is applied to suspension struts at Showa Denko and for joining of aluminium sheets to galvanized steel brackets for the boot (trunk) lid of the Mazda MX-5. Friction stir spot welding is successfully used for the bonnet (hood) and rear doors of the Mazda RX-8 and the boot lid of the Toyota Prius. Wheels are friction stir welded at Simmons Wheels, UT Alloy Works and Fundo. Rear seats for the Volvo V70 are friction stir welded at Sapa, HVAC pistons at Halla Climate Control and exhaust gas recirculation coolers at Pierburg. Tailor welded blanks are friction stir welded for the Audi R8 at Riftec. The B-column of the Audi R8 Spider is friction stir welded from two extrusions at Hammerer Aluminium Industries in Austria.

Railways

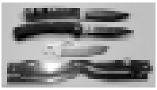
The high-strength low-distortion body of Hitachi's A-train British Rail Class 395 is friction stir welded from longitudinal aluminium extrusions

Since 1997 roof panels were made from aluminium extrusions at Hydro Marine Aluminium with a bespoke 25m long FSW machine, e.g. for DSB class SA-SD trains of Alstom LHB Curved side and roof panels for the Victoria line trains of London Underground, side panels for Bombardier's Electrostar trains at Sapa Group and side panels for Alstom's British Rail Class 390 Pendolino trains are made at Sapa Group Japanese commuter and express A-trains, and British Rail Class 395 trains are friction stir welded by Hitachi, while Kawasaki applies friction stir spot welding to roof panels and Sumitomo Light Metal produces Shinkansen floor panels. Innovative FSW floor panels are made by Hammerer Aluminium Industries in Austria for the Stadler KISS double decker rail cars, to obtain an internal height of 2 m on both floors and for the new car bodies of the Wuppertal Suspension Railway.

Heat sinks for cooling high-power electronics of locomotives are made at Sykatek, EBG, Austerlitz Electronics, EuroComposite, Sapa and Rapid Technic, and are the most common application of FSW due to the excellent heat transfer.

Fabrication

The lids of 50-mm-thick copper canisters for nuclear waste are attached to the cylinder by friction stir welding at SKB



Friction stir processed knives by MegaStir

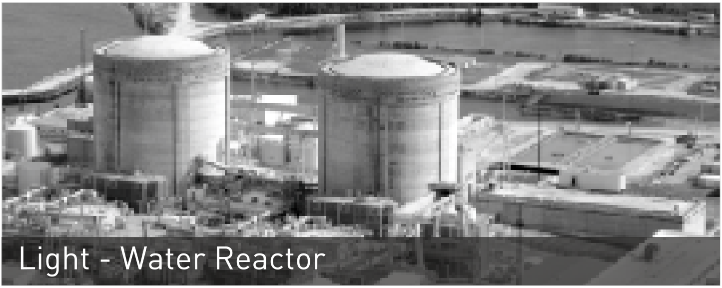
Façade panels and cathode sheets are friction stir welded at AMAG and Hammerer Aluminium Industries including friction stir lap welds of copper to aluminium. Bizerba meat slicers, Ökolüfter HVAC units and Siemens X-ray vacuum vessels are friction stir welded at Riftec. Vacuum valves and vessels are made by FSW at Japanese and Swiss companies. FSW is also used for the encapsulation of nuclear waste at SKB in 50-mm-thick copper canisters. Pressure vessels from ø1m semispherical forgings of 38.1mm thick aluminium alloy 2219 at Advanced Joining Technologies and Lawrence Livermore Nat Lab. Friction stir processing is applied to ship propellers at Friction Stir Link, Inc. and to hunting knives by DiamondBlade. Bosch uses it in Worcester for the production of heat exchangers.

Robotics

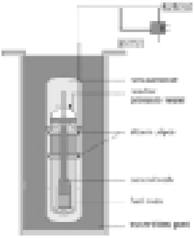
KUKA Robot Group has adapted its KR500-3MT heavy-duty robot for friction stir welding via the DeltaN FS tool. The system made its first public appearance at the EuroBLECH show in November 2012.

Personal computers

Apple applied friction stir welding on the 2012 iMac to effectively join the bottom to the back of the device.



Light - Water Reactor



The **light-water reactor (LWR)** is a type of thermal-neutron reactor that uses normal water, as opposed to heavy water, as both its coolant and neutron moderator – furthermore a solid form of fissile elements is used as fuel. Thermal-neutron reactors are the most common type of nuclear reactor, and light-water reactors are the most common type of thermal-neutron reactor.

There are three varieties of light-water reactors: the pressurized water reactor (PWR), the boiling water reactor (BWR), and (most designs of) the supercritical water reactor (SCWR).

History

Early concepts and experiments

After the discoveries of fission, moderation and of the theoretical possibility of a nuclear chain reaction, early experimental results rapidly showed that natural uranium could only undergo a sustained chain reaction using graphite or heavy water as a moderator. While the world's first reactors (CP-1, X10 etc.) were successfully reaching criticality, uranium enrichment began to develop from theoretical concept to practical applications in order to meet the goal of the Manhattan Project, to build a nuclear explosive.

In May 1944, the first grams of enriched uranium ever produced reached criticality in the LOPO reactor at Los Alamos, which was used to estimate the critical mass of U235 to produce the atomic bomb. LOPO cannot be considered as the first light-water reactor because its fuel was not a solid uranium compound cladded with corrosion-resistant material, but was composed of uranyl sulfate salt dissolved in water. It is however the first aqueous homogeneous reactor and the first reactor using enriched uranium as fuel and ordinary water as a moderator.

By the end of the war, following an idea of Alvin Weinberg, natural uranium fuel elements were arranged in a lattice in ordinary water at the top of the X10 reactor to evaluate the neutron multiplication factor. The purpose of this experience was to determine the feasibility of a nuclear reactor using light water as a moderator and coolant, and cladded solid uranium as fuel. The results showed that, with lightly enriched uranium, criticality could be reached. This experience was the first practical step toward light-water reactor.

After World War II and with the availability of enriched uranium, new concepts of reactor became feasible. In1946, Eugene Wigner and Alvin Weinberg proposed and developed the concept of a reactor using enriched uranium as a fuel, and light water as a moderator and coolant. This concept was proposed for a reactor whose purpose was to test the behavior of materials under neutron flux. This reactor, the Material Testing Reactor (MTR), was built in Idaho at INL and reached criticality on March 31,1952. For the design of this reactor, experiments were necessary, so a mock-up of the MTR was built at ORNL, to assess the hydraulic performances of the primary circuit and then to test its neutronic characteristics. This MTR mock-up, later called the Low Intensity Test Reactor (LITR), reached criticality on February 4, 1950 and was the world's first light-water reactor.

First Pressurized Water Reactors

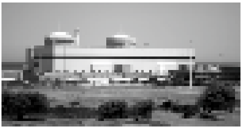
Immediately after the end of World War II the United States Navy started a program under the direction of Captain (later Admiral) Hyman Rickover, with the goal of nuclear propulsion for ships. It developed the first pressurized water reactors in the early 1950s, and led to the successful deployment of the first nuclear submarine, the USS Nautilus (SSN-571).

The Soviet Union independently developed a version of the PWR in the late 1950s, under the name of VVER. While functionally very similar to the American effort, it also has certain design distinctions from Western PWRs.

First Boiling Water Reactor

Researcher Samuel Untermyer II led the effort to develop the BWR at the US National Reactor Testing Station (now the Idaho National Laboratory) in a series of tests called the BORAX experiments.

Overview



The Koeberg nuclear power station, consisting of two pressurized water reactors fueled with uranium

The family of nuclear reactors known as light-water reactors (LWR), cooled and moderated using ordinary water, tend to be simpler and cheaper to build than other types of nuclear reactor due to these factors, they make up the vast majority of civil nuclear reactors and naval propulsion reactors in service throughout the world as of 2009. LWRs can be subdivided into three categories – pressurized water reactors (PWRs), boiling water reactors (BWRs), and supercritical water reactors (SCWRs). The SCWR remains hypothetical as of 2009; it is a Generation IV design that is still a light-water reactor, but it is only partially moderated by light water and exhibits certain characteristics of a fast neutron reactor.

The leaders in national experience with PWRs, offering reactors for export, are the United States (which offers the passively-safe AP1000, a Westinghouse design, as well as several smaller, modular, passively-safe PWRs, such as the Babcock & Wilcox MPower, and the NuScale MASLWR), the Russian Federation (offering both the VVER-1000 and the VVER-1200 for export), the Republic of France (offering the AREVA EPR for export), and Japan (offering the Mitsubishi Advanced Pressurized Water Reactor for export); in addition, both the People's Republic of China and the Republic of Korea are both noted to be rapidly ascending into the front rank of PWR-constructing nations as well, with the Chinese being engaged in a massive program of nuclear power expansion, and the Koreans currently designing and constructing their second generation of indigenous designs. The leaders in national experience with BWRs, offering reactors for export, are the United States and Japan, with the alliance of General Electric (of the US) and Hitachi (of Japan), offering both the Advanced Boiling Water Reactor (ABWR) and the Economic Simplified Boiling Water Reactor (ESBWR) for construction and export; in addition, Toshiba offers an ABWR variant for construction in Japan, as well. West Germany was also once a major player with BWRs. The other types of nuclear reactor in use for power generation are the heavy water moderated reactor, built by Canada (CANDU) and the Republic of India (AHWR), the advanced gas cooled reactor (AGCR), built by the United Kingdom, the liquid metal cooled reactor (LMFBR), built by the Russian Federation, the Republic of France, and Japan, and the graphite-moderated, water-cooled reactor (RBMK or LWGR), found exclusively within the Russian Federation and former Soviet states.

Though electricity generation capabilities are comparable between all these types of reactor, due to the aforementioned features, and the extensive experience with operations of the LWR, it is favored in the vast majority of new nuclear power plants. In addition, light-water reactors make up the vast majority of reactors that power naval nuclear-powered vessels. Four out of the five great powers with nuclear naval propulsion capacity use light-water reactors exclusively: the British Royal Navy, the Chinese People's Liberation Army Navy, the French Marine nationale, and the United States Navy. Only the Russian Federation's Navy has used a relative handful of liquid-metal cooled reactors in production vessels, specifically the Alfa class submarine, which used lead-bismuth eutectic as a reactor moderator and coolant, but the vast majority of Russian nuclear-powered boats and ships use light-water reactors exclusively. The reason for near exclusive LWR use aboard nuclear naval vessels is the level of inherent safety built into these types of reactors. Since light water is used as both a coolant and a neutron moderator in these reactors, if one of these reactors suffers damage due to military action, leading to a compromise of the reactor core's integrity, the resulting release of the light-water moderator will act to stop the nuclear reaction and shut the reactor down. This capability is known as a negative void coefficient of reactivity.

Currently-offered LWRs include the following

- ABWR
- AP1000
- APR-1400
- CPR-1000
- EPR
- VVER

LWR Statistics

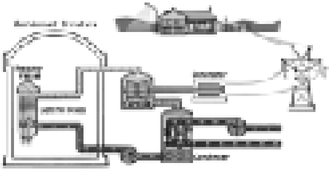
Data from the International Atomic Energy Agency in 2009:

Reactors in operation.	359
Reactors under construction.	27
Number of countries with LWRs.	27
Generating capacity (Gigawatt).	328.4

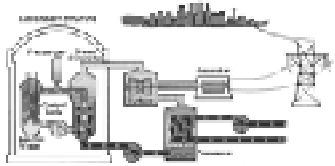
Reactor design

The light-water reactor produces heat by controlled nuclear fission. The nuclear reactor core is the portion of a nuclear reactor where the nuclear reactions take place. It mainly consists of nuclear fuel and control elements. The pencil-thin nuclear fuel rods, each about 12 feet (3.7 m) long, are grouped by the hundreds in bundles called fuel assemblies. Inside each fuel rod, pellets of uranium, or more commonly uranium oxide, are stacked end to end. The control elements, called control rods, are filled with pellets of substances like hafnium or cadmium that readily capture neutrons. When the control rods are lowered into the core, they absorb neutrons, which thus cannot take part in the chain reaction. On the converse, when the control rods are lifted out of the way, more neutrons strike the fissile uranium- 235 or plutonium-239 nuclei in nearby fuel rods, and the chain reaction intensifies. All of this is enclosed in a water-filled steel pressure vessel, called the reactor vessel.

In the boiling water reactor, the heat generated by fission turns the water into steam, which directly drives the power-generating turbines. But in the pressurized water reactor, the heat generated by fission is transferred to a secondary loop via a heat exchanger. Steam is produced in the secondary loop, and the secondary loop drives the power-generating turbines. In either case, after flowing through the turbines, the steam turns back into water in the condenser.



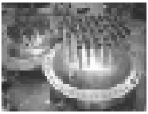
Animated diagram of a boiling water reactor



Animated diagram of a pressurized water reactor

The water required to cool the condenser is taken from a nearby river or ocean. It is then pumped back into the river or ocean, in warmed condition. The heat could also be dissipated via a cooling tower into the atmosphere. The United States uses LWR reactors for electric power production, in comparison to the heavy water reactors used in Canada.

Control



A pressurized water reactor head, with the control rods visible on the top

Control rods are usually combined into control rod assemblies — typically 20 rods for a commercial pressurized water reactor assembly — and inserted into guide tubes within a fuel element. A control rod is removed from or inserted into the central core of a nuclear reactor in order to control the number of neutrons which will split further uranium atoms. This in turn affects the thermal power of the reactor, the amount of steam generated, and hence the electricity produced. The control rods are partially removed from the core to allow a chain reaction to occur. The number of control rods inserted and the distance by which they are inserted can be varied to control the reactivity of the reactor.

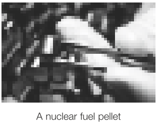
Usually there are also other means of controlling reactivity. In the PWR design a soluble neutron absorber, usually boric acid, is added to the reactor coolant allowing the complete extraction of the control rods during stationary power operation ensuring an even power and flux distribution over the entire core. Operators of the BWR design use the coolant flow through the core to control reactivity by varying the speed of the reactor recirculation pumps. An increase in the coolant flow through the core improves the removal of steam bubbles, thus increasing the density of the coolant/moderator with the result of increasing power.

Coolant

The light-water reactor also uses ordinary water to keep the reactor cooled. The cooling source, light water, is circulated past the reactor core to absorb the heat that it generates. The heat is carried away from the reactor and is then used to generate steam. Most reactor systems employ a cooling system that is physically separate from the water that will be boiled to produce pressurized steam for the turbines, like the pressurized-water reactor. But in some reactors the water for the steam turbines is boiled directly by the reactor core, for example the boiling-water reactor.

Many other reactors are also light-water cooled, notably the RBMK and some military plutonium-production reactors. These are not regarded as LWRs, as they are moderated by graphite, and as a result their nuclear characteristics are very different. Although the coolant flow rate in commercial PWRs is constant, it is not in nuclear reactors used on U.S. Navy ships.

Fuel



A nuclear fuel pellet

Nuclear fuel pellets that are ready for fuel assembly completion

The use of ordinary water makes it necessary to do a certain amount of enrichment of the uranium fuel before the necessary criticality of the reactor can be maintained. The light-water reactor uses uranium 235 as a fuel, enriched to approximately 3 percent. Although this is its major fuel, the uranium 238 atoms also contribute to the fission process by converting to plutonium 239; about one-half of which is consumed in the reactor. Light-water reactors are generally refueled every 12 to 18 months, at which time, about 25 percent of the fuel is replaced.

The enriched UF6 is converted into uranium dioxide powder that is then processed into pellet form. The pellets are then fired in a high-temperature, sintering furnace to create hard, ceramic pellets of enriched uranium. The cylindrical pellets then undergo a grinding process to achieve a uniform pellet size. The uranium oxide is dried before inserting into the tubes to try to eliminate moisture in the ceramic fuel that can lead to corrosion and hydrogen embrittlement. The pellets are stacked, according to each nuclear core's design specifications, into tubes of corrosion-resistant metal alloy. The tubes are sealed to contain the fuel pellets: these tubes are called fuel rods.

The finished fuel rods are grouped in special fuel assemblies that are then used to build up the nuclear fuel core of a power reactor. The metal used for the tubes depends on the design of the reactor – stainless steel was used in the past, but most reactors now use a zirconium alloy. For the most common types of reactors the tubes are assembled into bundles with the tubes spaced precise distances apart. These bundles are then given a unique identification number, which enables them to be tracked from manufacture through use and into disposal.

Pressurized water reactor fuel consists of cylindrical rods put into bundles. A uranium oxide ceramic is formed into pellets and inserted into zirconium alloy tubes that are bundled together. The zirconium alloy tubes are about 1 cm in diameter, and the fuel cladding gap is filled with helium gas to improve the conduction of heat from the fuel to the cladding. There are about 179-264 fuel rods per fuel bundle and about 121 to 193 fuel bundles are loaded into a reactor core. Generally, the fuel bundles consist of fuel rods bundled 14x14 to 17x17. PWR fuel bundles are about 4 meters in length. The zirconium alloy tubes are pressurized with helium to try to minimize pellet cladding interaction which can lead to fuel rod failure over long periods.

In boiling water reactors, the fuel is similar to PWR fuel except that the bundles are "canned"; that is, there is a thin tube surrounding each bundle. This is primarily done to prevent local density variations from effecting neutronics and thermal hydraulics of the nuclear core on a global scale. In modern BWR fuel bundles, there are either 91, 92, or 96 fuel rods per assembly depending on the manufacturer. A range between 368 assemblies for the smallest and 800 assemblies for the largest U.S. BWR forms the reactor core. Each BWR fuel rod is back filled with helium to a pressure of about three atmospheres (300 kPa).

Moderator

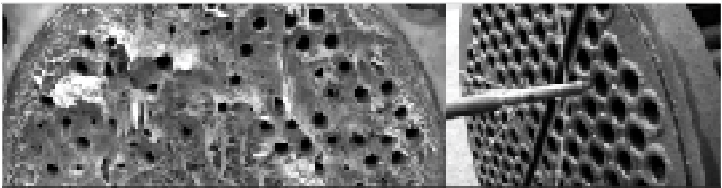
A neutron moderator is a medium which reduces the velocity of fast neutrons, thereby turning them into thermal neutrons capable of sustaining a nuclear chain reaction involving uranium-235. A good neutron moderator is a material full of atoms with light nuclei which do not easily absorb neutrons. The neutrons strike the nuclei and bounce off. After sufficient impacts, the velocity of the neutron will be comparable to the thermal velocities of the nuclei; this neutron is then called a thermal neutron.

The light-water reactor uses ordinary water, also called light water, as its neutron moderator. The light water absorbs too many neutrons to be used with unenriched natural uranium, and therefore uranium enrichment or nuclear reprocessing becomes necessary to operate such reactors, increasing overall costs. This differentiates it from a heavy water reactor, which uses heavy water as a neutron moderator. While ordinary water has some heavy water molecules in it, it is not enough to be important in most applications. In pressurized water reactors the coolant water is used as a moderator by letting the neutrons undergo multiple collisions with light hydrogen atoms in the water, losing speed in the process. This moderating of neutrons will happen more often when the water is denser, because more collisions will occur.

The use of water as a moderator is an important safety feature of PWRs, as any increase in temperature causes the water to expand and become less dense; thereby reducing the extent to which neutrons are slowed down and hence reducing the reactivity in the reactor. Therefore, if reactivity increases beyond normal, the reduced moderation of neutrons will cause the chain reaction to slow down, producing less heat. This property, known as the negative temperature coefficient of reactivity, makes PWR reactors very stable. In event of a loss-of-coolant accident, the moderator is also lost and the active fission reaction will stop. Heat is still produced after the chain reaction stops from the radioactive byproducts of fission, at about 5% of rated power. This "decay heat" will continue for 1 to 3 years after shut down, whereupon the reactor finally reaches "full cold shutdown". Decay heat, while dangerous and strong enough to melt the core, is not nearly as intense as an active fission reaction. During the post shutdown period the reactor requires cooling water to be pumped or the reactor will overheat. If the temperature exceeds 2200 degrees Celsius, cooling water will break down to hydrogen and oxygen, which can form a (chemically) explosive mixture. Decay heat is a major risk factor in LWR safety record.

PIUS reactor

PIUS, standing for Process Inherent Ultimate Safety, was a Swedish design concept for a light-water reactor system. It relied on passive measures, not requiring operator actions or external energy supplies, to provide safe operation. No units were ever built.



How to repair the common problems of Heat Exchanger Fouling and Corrosion

Heat exchange fouling is defined as the accumulation and deposit of unwanted substances that form on the external and internal surfaces of a variety of processing equipment called heat exchangers. This nuisance material can include, but isn't limited to, algae, scale, insoluble salts, and suspended solids.

Heat exchangers are specially designed process equipment which transfer heat semi-continuously or continuously from a hot fluid to a cold fluid, indirectly or directly, through a heat transfer surface that separates the two fluids successfully.

The major components of heat exchangers consist primarily of plate coils, tubes, and pipe bundles. When fouling forms on the surface of this process equipment, it can have a significantly negative impact on the unit's operational efficiency.

In today's industries, fouling can cause major economic drain. Major industry fouling costs for industrialized nations are estimated over $4.4 billion USD. This is said to be a loss of 0.25% to 30% of their GDP. It is estimated that 15% of maintenance costs are attributed by fouling. Some heat exchanger costs which are associated with fouling include:

1 Production loss associated with efficiency deterioration.
2 Production loss associated with unplanned and planned operation shutdown due to fouling.
3 Maintenance costs from removal of heavy fouling deposits with the use of chemicals /anti-fouling devices.
4 Maintenance costs associated with replacement of plugged or corroded equipment.

Cleaning costs for industries range between $40,000 to $50,000 per cleaning, per heat exchanger.

Effects of Fouling on Heat Exchangers

Fouling and corrosion can cause minor and major problems for the majority of industries who rely on heat exchangers to keep their operation running efficiently. Some major detrimental fouling effects for heat exchange units include:

- Loss of transferred heat. This can be seen by the sudden pressure increase and temperature drop in the charge outlet.
- Under-deposit pollution and corrosion.
- Blocked process pipes.

Where fouling in a heat exchanger has become hot, as in steam generators, it can cause problems with the formation of local hotspots. This can result in the ultimate failure of the equipment. If an event like this occurs, it can lead to problems with increased maintenance costs and production losses. As a result, low thermal conductivity can occur due to the decrease in the charge outlet temperature combined with the thickness of the fouling layers. This results in a reduction of thermal efficiency of heat exchangers.

Common Types of Fouling

Fouling comes in many forms. Some of the most common fouling found in industries includes:

CHEMICAL FOULING

Chemical fouling is formed when there are chemical changes within the fluid. These changes cause a layer of fouling to form onto the surface of the tube equipment. One of the most common examples of chemical fouling is known as scaling. This can be seen in a boiler or kettle which is caused by the hardening salt deposits onto heating elements. When the salt solubility reduces, it can cause an overall increase in the temperature. This type of fouling can be minimized by maintaining careful control over the temperature of the tube wall that is in contact with the fluid. With the occurrence of this type of fouling, it can only be removed by mechanical de-scaling or chemical treatment processes. Some industries may use high pressure water jets, drills, or wire brushes.

BIOLOGICAL FOULING

Biological fouling is generally caused by the overgrowth of different organisms within the fluid. This is then deposited onto the surface area of the heat exchanger. The type of biological fouling is typically influenced by the material choices used. One notable material that can influence the layers of fouling is that of non-ferrous brasses, which are poisonous to some organisms. When biological fouling forms, it's normally removed by mechanical brushing processes or chemical treatments.

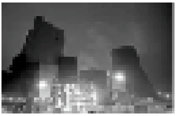
DEPOSITION FOULING

Deposition fouling occurs when fluid particles settle onto the inorganic surface area. This is generally seen when the velocity of fluid falls below critical levels. This type of fouling can be helped with the proper management of the combined particles/fluids. This can be calculated to make sure minimum velocity levels are higher than critical levels. Vertically mounting the heat exchanger can also help with the minimization of fouling formation as gravity helps to pull the particles away from the heat transfer surface. This can help in low velocity levels. Deposition fouling can be removed by mechanical brushing processes.

CORROSION FOULING

Corrosion fouling is when a layer of corrosion materials build up on the inorganic surface area or tubing. This creates a high thermal resistant layer of corrosion. By carefully choosing the construction materials, the effects can be minimized. For example; corrosion resistant materials, including nickel-based alloys and stainless steel, are now available to manufacturers of heat exchange units.

How to Monitor a Heat Exchanger for Signs of Fouling

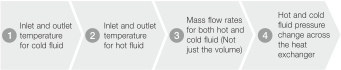


Proper monitoring of a heat exchanger is crucial to maximizing refinery yield, reducing operating costs and minimizing fouling build-up. Heat exchanger monitoring is vitally important as the process is the "recycling program" of an industry. Monitoring the heat exchanger helps industries measure the heat transfer efficiency over time. Over time, the efficiency of the heat exchanger will change as fouling starts to form.

Understanding the heat transfer efficiency can help make monitoring of the system much easier in the long run. Learning the proper equations and as many parameters as possible can help keep the system running efficiently throughout its operation.

Information for Precise Heat Exchanger Monitoring

The following gives you an idea of the information that should be monitored when working with heat exchange units:



Heat Exchange Monitoring Tips

To help keep the heat exchange system running effectively, it is advisable to consider some of these simple tips:

1. Understand all available data associated with pressure, flow, and temperature indicators.
2. Find out and assess what flows, pressures, and temperatures are recorded by operators on their daily routines.
3. Continuously check the pressure. DP or differential pressure tracking on the shell side or the tube of a heat exchanger can be extremely valuable information. If the differential pressure builds up over a period of time, it means that something is restricting the flow.
4. To record any temperature data information, it is best to utilize a handheld temperature gun. Infrared temperature guns can help you monitor the temperature of the system effectively throughout its operation.

Monitoring of a heat exchanger doesn't have to be hard. By utilizing today's technology, along with tracking the system manually, any industry can keep track of their heat exchanger.

Fouling Mechanisms and Stages

Fouling can easily be divided into a range of different mechanisms and stages. Several fouling mechanisms generally occur at the same time, with each one requiring different techniques when it comes to prevention. With these different mechanisms, there are some of them that represent the numerous stages in the fouling process. These major fouling stages and mechanisms are as follows:

1. **Initiation / Delay Period**
   This is the period of clean surface area before the fouling accumulates. Relatively small accumulations of fouling can help to improve heat transfer heat. A relatively clean surface area can help give the heat exchanger a negative fouling rate, along with a negative total fouling amount.
2. **Particulate Fouling and Particle Formation, Flocculation, and Aggregation.**
3. **Mass Migration and Transport to Fouling Sites.**
4. **Phase Separation and Deposition**
   This period involves initiation or nucleation of the fouling attachment and sites leading to formation of deposit.
5. **Growth, Hardening, and Aging of Fouling**
   This period sees an increase in the strength of the deposits. It also affects the erosion and removal of fouling.

Mechanical repair requires industries to stop the operation process of their heat exchanger, and have it fully dismantled in order to conduct a full and complete clean of the system. Some of the common cleaning methods which are generally used include:

- **Steam Blasting**

  Features the use of high pressure steam lines

- **Hydro-blasting**

  Features the use of high pressure water jets

Both of these techniques are designed to remove the fouling build up on the surface areas of each of the components. However, like with many other cleaning techniques, these aren't 100% effective and successful at the removal of fouling deposits. This may leave the surface area on the components rough to the touch, even after they have been treated. Another downside is the intensity of manual labor required to dismantle and clean the heat exchanger. Having this process equipment offline for long period can cost time and money.

Chemical Cleaning of Fouling in Heat Exchanger Tubes

Chemical cleaning techniques range dramatically in the chemicals used and the results that are gained. This type of cleaning method also features many advantages which are more beneficial against mechanical repair. These advantages include:

- Quicker cleaning process
- Less labor intensity
- Access to difficult to clean components that mechanical cleaning may struggle to clean

Chemical cleaning solutions provide the opportunity to clean fouling more effectively without the need to dismantle the heat exchanger. Over all, this speeds up the entire process and allows the equipment to get back up and operational in a reduced time. This can help to save time and money associated with taking the system offline for a period of time.

Basic Chemical Cleaning Process

The following steps are generally used in the chemical cleaning procedure:

1. **Alkaline Clean**

   Starting with an alkaline clean, this process is designed to remove the build-up of organic materials, including fats and oils, leaving the surface area of the equipment exposed and ready for treatment.

2. **Rinse**

   Rinsing should be done following each cleaning step. This is generally completed using a high flow water flusher. This removes any loose debris, along with any remaining residue from chemicals used.

3. **Acid Cleaning**

   The surface area of the equipment is then treated with the appropriately mixed acid blend. This chemical is designed to help dissolve and soften the fouling materials more successfully.

4. **Rinse**

   Rinsing the equipment again helps to remove any sludge, debris, or residual acid from the heat exchanger after the acid cleaning process.

5. **Passivation**

   The passivation process is the final stage of cleaning and is required to help add a protective coating to the surface area of the base metal components which have been exposed during the cleaning process. These areas are more vulnerable to oxidation if they are continuously exposed to open air.

Heat Exchange Repair of Division Plates from Corrosion or Fouling

Heat exchanger tube plates or division plates tend to be affected by corrosion and fouling in the same manner that tube bundles are. This damage can cause problems with inefficient performance and continuous leakages. To comply with industry standards, it's important for these sealing faces to have a good clean finish.

Heat Exchanger Manufacturing to Combat Fouling

In the design process of a heat exchanger, fouling is taken into consideration. Generally, when they're constructed, the manufacturer applies different methods of construction to help provide increased heat transfer in certain areas that may be affected by fouling.

Fouling tendencies all depend on the heat exchanger type and the fluids which are used. Throughout the designing stage, many manufacturers consider the following to help with minimizing the occurrence and build-up of fouling:

- Where applicable, allocate more fouling fluid to the tube side.
- Design the exchanger for a fouling fluid velocity of 3ft/sec on the shell side and 5ft per second on the tube side.
- Constantly try to keep the fluid velocity regular.
- Allow easier cleaning access of the heat exchanger.
- In winter, don't throttle the water flows.
- When servicing with water, make sure the wall temperature of the tube isn't too hot, which would create unwanted deposits of salt or render any chemicals used ineffective.

Types of Heat Exchangers

In many industries there are different heat exchangers used for different tasks. Although different, they are all very important to the proper operation and efficiency of the industry.

Shell and Tube Heat Exchangers

Shell and tube heat exchangers contain a combination of multiple tubes in which a constant stream of liquid flows. The tubes, which are attached to these heat exchangers, are divided into two separate sets. The first set of tubes contains liquid which is to be

Continued on page no. 22

Praj all set to unveil India's first integrated bio-refinery for renewable fuels & chemicals

- Praj's 2nd generation smart bio-refinery technology paves the way for stepping up ethanol blending program.
- Praj's advanced bio refinery technology demonstrates integrated production capability of 1 million litre per annum (MLPA) of ethanol from variety of biomass
- First of its kind plant capable of producing different bio-fuels and chemicals
- Energy efficient process equipped with zero liquid discharge system

Pune, India, 4th May 2017: Praj Industries announced a **breakthrough in scale up of its 2nd generation ethanol technology** with successful completion and start-up of smart bio-refinery. India's first integrated bio-refinery is built on the company's proprietary platform technology - "enfinity" for manufacturing ethanol from agri-waste.

Second generation demo plant can produce **one MLPA of ethanol by processing a variety of agri-residue** like rice and wheat straw, cotton stalk, bagasse, cane trash, corn cobs & stover, etc. into ethanol, with superior product yields. With continual research and development, **further pipeline of other renewable fuels and chemicals** is underway to be produced from this technology platform.

Talking about this landmark achievement, Mr Pramod Chaudhari, Executive Chairman of Praj Industries said: "Praj's 2G demo plant is a testament of our technology leadership in the bio-energy space. This innovative technology has substantial **potential to enhance energy security** and help India become **energy self-reliant.** It uses abundantly available cellulosic biomass while effectively addressing the challenge of agricultural waste management and **mitigating pollution**. Commercialization of 2nd generation ethanol technology will give an **impetus to rural economy** and create additional employment opportunities."

Mr Chaudhari added further, "The menace caused by burning of farm residue can be addressed effectively by converting biomass into ethanol to be used as a transportation fuel. Such biofuels are of **immense national importance** as they can help partially meet India's growing requirement for crude oil resulting in **forex savings**. Progressively increased ethanol blending will help achieve **GHG emission reduction** targets agreed at **COP 21 Paris summit.**"

In India, an **eco-system for 2nd generation ethanol** is in the making to achieve the **aspired 20% blend ratio**. As a part of this drive, 10 to 12 Second generation ethanol projects are expected to be finalized, with average capex of around Rs 600 crore each. Each of these plants will have the capacity to produce 100,000 litres of ethanol per day.

Praj is at the forefront of this development and has **already signed MoUs with IOCL and BPCL as their technology partner** for certain project sites. Meanwhile experts from Oil Marketing Companies (OMCs) and their engineering consultants have already **visited demo plant and endorsed the success of Praj's technology.**

About Praj Industries Limited: Praj is a global process solutions company driven by innovation and integration capabilities, offers solutions to add significant value to Bio-ethanol facilities, Brewery plants, Water & Wastewater treatment systems, Critical Process Equipment & Systems, Hipurity solutions and Bio-products. Over the past three decades, Praj has focused on Environment, Energy and Agri process led applications. Praj has been a trusted partner for process engineering, plant & critical equipment and systems with over 750 references across five continents. Solutions offered by Praj are backed by its state of the art R&D Center called Praj Matrix. Led by an accomplished and caring leadership, Praj is a socially responsible corporate citizen. Praj is listed on the Bombay and National Stock Exchanges of India.

Transitional provisions for GST

By Mr. Aniket Kulkarni
Chartered Accountant, Aniket Kulkarni & Associates

Introduction

1. One of the biggest tax reforms, i.e., GST is going to be implemented by next month!! (tentatively 1-7-2017) in India under which majority of the existing indirect taxes like Excise, Sales tax, VAT, etc., are going to subsumed under one heading. The migration process has already been started and the business entities, whether operating at a large scale or small in the economy have started getting themselves enrolled under the GST Act, 2016. The question that arises before the industry is, what will happen to their unutilized CENVAT credit, pending refunds, stock kept in the ware-house, goods sent out to the job worker and the like? Transitional provisions will play an extremely important role in the GST regime. They lay down the **blueprint** for dealing with the ongoing transactions, contracts, etc., whilst the new law gets enacted.

The transitional provisions are given under the revised model GST law from **sections 165 to 197.**

Key points to be considered

2. In order to take the benefit of such transitional provisions, a company must carefully take into account certain key points as are enlisted below :

2.1] Amount of CENVAT credit carried forward in a Return

The amount of Cenvat credit claimed on inputs, capital goods and input services carried forward in the last return filed for Excise and Service Tax immediately before the appointed day shall be transferred to the electronic credit ledger of the business concerned, provided the amount of credit is admissible under the existing laws as well as in GST.

On the same lines, credit of VAT and Entry tax reported in the last respective VAT/Entry Tax returns shall also be allowed to be carried forward.

2.1.1 Critical points

- Company must properly record the amount of Cenvat credit availed in its books of account.
- A company must file its last return for Excise, VAT, Service tax carefully in order to avoid loss of eligible Cenvat credit.

2.2] Capital goods

2.2.1 Unavailed CENVAT credit on Capital goods not carried forward in a return

The company can also take the credit of unavailed credit in respect of capital goods, i.e., the balance amount of credit that remains after subtracting the credit already availed from the total eligible Cenvat credit available on capital goods.

2.2.1.2 Critical points

- The company must maintain proper documentation of capital goods received prior to the appointed day in order to avail their credit under the GST Act.
- Credit of only those capital goods would be available as are defined under Rule 2(a) of the Cenvat Credit Rules, 2004 and also available under the GST law.
- The company must defer the purchase of any capital goods like furniture, etc., the credit of which is not available under the earlier law.

2.2.3 Tax paid on capital goods lying with agents to be allowed as credit

Where the capital goods belonging to the principal are lying with agent, then the company can claim the Cenvat credit in respect of the same subject to the fulfillment of certain conditions :

- The agent is a registered taxable person
- Both, the principal and agent declare the details of the stock of capital goods lying with such agent on the date immediately preceding the appointed day in such form and manner and within such time as may be prescribed in this behalf.
- The invoices had been issued not earlier than 12 months immediately preceding the appointed day.

The agent can also claim the Cenvat credit provided that the principal has either not availed of the ITC in respect of such capital goods or, having availed of such credit, has reversed the credit to the extent availed.

2.2.3.1 Critical point

The company must maintain proper account of its goods lying with any or all of its agents in order to avoid loss of credit.

2.3] Credit of eligible duties and taxes

2.3.1 Inputs held in stock and inputs contained in semi-finished or finished goods

A registered taxable person who is manufacturing exempted goods or exempted as well as non- exempted goods or providing exempted services or exempted as well as non-exempted services, works contract services, or an assesses availing of benefit of Notification No. 26/2012-ST dated 20.06.2012, or a first stage or second stage dealer or a registered importer, can take credit of the eligible duties and taxes paid in respect of inputs subject to the **following conditions :**

- Such inputs and/or goods are used or intended to be used for making taxable supplies under this Act
- The said taxable person passes on the benefit of such credit by the way of reduced prices to the recipient
- He is eligible for ITC on such inputs under the Act
- He must have the possession of the invoices and/or other prescribed documents evidencing payment of duty under the earlier law in respect of such inputs
- Invoices issued should not be earlier than 12 months from the appointed day, and
- The supplier of services is not eligible for any abatement under the Act.

2.3.1.1 Critical Points

Credit of only those inputs would be allowed to be carried forward as is available under the existing law.

In case of goods imported by a trader under the earlier law, presently only credit of SAD @ 4% is available as against credit of IGST @ 18% (assumed) in case the goods are procured post-implementation of GST. In order to avoid such huge loss of credit, a trader must well plan its purchases of imported goods.

2.3.2 Input or input services during transit

In case of Input or input services that are received on/after the appointed day on which duty /tax has been paid earlier then the assesse can claim its credit subject to the condition that the invoice or other taxpaying document of the same is recorded in the books of account of the assessee within a period of 30 days from appointed day.

2.4] Composition Scheme

I. Where an assessee paying tax under the normal scheme of the earlier law has opted to pay tax under the composition scheme of the GST Act, then the amount of Cenvat credit carried forward in a return will not be allowed to be carried forward if the person is paying tax under composition scheme.

ii. Even the unavailed amount of CENVAT on capital goods shall not be allowed to be carried forward under the GST Act.

iii. In case an assessee is switching over from the composition scheme to the normal scheme under the GST Act, then it can take credit of eligible duties and taxes in respect of inputs held in stock, inputs held in semi-finished or finished goods subject to the fulfillment of certain conditions:

(I) Such inputs and / or goods are used or intended to be used for making taxable supplies under this act;

(ii) The said taxable person is eligible for input tax credit on such inputs under this Act;

(iii) The said taxable person is in possession of invoice and/or other prescribed documents evidencing payment of duty under the earlier law in respect of inputs; and

(iv) Such invoices and /or other prescribed documents were issued not earlier than twelve months immediately preceding the appointed day.

2.5] Treatment of sales return

2.5.1 Exempted goods

In case the registered taxable person has removed any exempted goods before six months from the appointed day and the same are returned back within six months on or after the appointed day, then no tax shall be payable under the GST Act. If the goods are returned after six months, then tax shall be levied on the same at the rate applicable under the GST Act.

In case the goods are returned by a person who is not registered under the GST Act, then no tax shall be payable at the time of return of goods by such person.

2.5.2 Duty paid goods

In case the registered taxable person has removed any duty paid goods before six months from the appointed day and the same are returned back within six months on or after the appointed day, then the company shall be eligible for refund under the GST Act only if the goods are returned by a person who is not registered under the GST Act.

In case the goods are returned by a registered taxable person, then such transaction shall be considered as a supply and, accordingly, chargeable to tax.

2.5.3 Goods sent on approval basis

In case the registered taxable person has sent any goods on approval basis before six months from the appointed day and the same are either rejected or not approved by the buyer and returned back to the company within six months on or after the appointed day, then no tax shall be payable on such goods if the same are returned within 6 months from the appointed day.

In case the goods are returned after the period of 6 months, then such goods shall be subject to tax under the GST Act and tax thereon shall be paid by the person returning the goods.

Further, if the goods are not returned within 6 months, then such goods shall be subject to tax under this Act and tax thereon shall be paid by the company, i.e., the person who has sent the goods on approval basis.

2.6] Job Work

2.6.1 Inputs or semi-finished goods removed for job work and returned on or after the appointed day

If inputs as such or after partial processing or semi-finished goods have been sent under the earlier laws to a job worker for job work and returned under the GST regime then no tax is liable to be paid if such goods are returned back within 6 months from the appointed day.

If the said goods are not returned within a period of 6 months, then the company has to reverse the input tax credit availed under the earlier law on such goods.

The job worker and manufacturer are required to declare the details of inputs held in stock by the job worker on behalf of the manufacturer on the appointed day in such form and manner and in such time period as may be prescribed.

2.6.2 Finished goods sent out for any process or activity not amounting to manufacture

Excisable goods which are removed without payment of duty for any process not amounting to manufacture, irrespective of the fact whether manufacturer is registered or not under the earlier law, if returned after 6 months from the appointed day then ITC shall be liable to be recovered in terms of section 184, else no tax will be paid.

2.6.2.1 Critical Point

A company must make sure that the goods sent on job work are returned back within the permissible time, else there would be loss of ITC due to sheer negligence.

2.7] Treatment of contracts or agreements

In case of any contract/agreement entered into a by a company prior to the appointed day, the price of a particular good or service is revised upward or downwards, then the company may issue a supplementary invoice or debit/credit note, respectively, in respect of the same under the GST Act within 30 days of such price revision.

Where the tax liability of the company is reduced due to downward revision of price, then the company may be able to take that benefit only if the recipient has reduced his corresponding input tax credit to such reduction of tax liability.

2.7.1 Critical Point

Existing contracts with vendors and customers may have to be revisited in the light of final GST law provisions. In other words, the company must insert a price escalation clause in its agreements with vendors and customers

2.8] Treatment of pending refund claims

2.8.1 Pending refund claims of Cenvat credit to be disposed off under the earlier laws

Every claim for refund filed by any person before or after the appointed day, for refund of any amount of CENVAT credit, duty, tax or interest paid before the appointed day shall be disposed off in accordance with the provisions of the earlier law and any amount accruing there upon shall be paid in cash.

If the amount of credit has been fully or partially rejected, the amount so rejected shall lapse.

2.8.2 Pending refund claims of duty in case of exports

In case an assessee exports any goods or services before or after the appointed day on which tax has been paid under the earlier law and the company has applied for refund of such tax or duty, then such refund claim shall be processed according to the provisions of the earlier law.

2.8.3 Refund of tax in case of non-provision of service

If an assessee files any claim for refund of tax deposited under the earlier law in respect of services not provided by it, then such refund claim shall also be processed in accordance with the provisions of the earlier law and any amount eventually accruing to it shall be paid in cash.

2.8.3.1 Critical Point

The company must keep a track of all its pending refund claims under the transitional period.

There is no provision in respect of appeal for refunds which would be rejected refunds once GST is implemented. Such a scenario needs a solution under the GST law.

2.9] Treatment of pending adjudication proceedings

In case of any appellate proceedings filed by a registered taxable person relating to claim for Cenvat credit or any output duty or tax liability initiated before, on or after the appointed day, then such proceedings shall be disposed of in accordance with provisions of the earlier law. If any amount becomes admissible to the company, then such amount shall be paid in cash to it.

If any amount becomes recoverable, then such amount shall be recovered from it as arrears under the GST Act and the amount so recovered shall not be allowed as input tax credit to the company.

2.10] Treatment of Input Service Distributor (ISD)

The ISD shall be allowed to distribute the input tax credit on input services received by it before the appointed day under the GST Act even if the invoices relating to such services are received on or after the appointed day.

2.11] Treatment of goods lying with agents

In case any inputs or capital goods belonging to the company are lying with its agent on the appointed day, then the registered taxable person can take the credit in respect of those goods provided :

(I) The principal and the agent both declare the stock of goods lying with agent

(ii) Invoice for such goods should not be more than 12 months old preceding the appointed day.

The agent can also take the credit in respect of goods lying with him, provided that the agent is registered under the GST Act and the principal, i.e., the company has not availed of the input tax credit in respect of such inputs or capital goods.

2.12] Treatment of tax deducted at source

If the company has sold any goods in respect of which TDS was required to be deducted and has also issued an invoice in respect of the same before the appointed day but the company has not received the payment before the appointed day, then no TDS shall be deducted under the GST Act.

2.13] Carry Forward of CENVAT Credit

A registered taxable person, other than a person opting for the composition scheme, shall be entitled to carry forward under the CGST Act, the amount of CENVAT credit shown in the return furnished under the earlier laws for the period ending on the day prior to the appointed day.

Similarly, the credit of VAT and entry tax available to a taxable person as per the last return furnished for the period ending on the day before the appointed day shall be eligible for carry forward under the UTGST Act. However, such returns under the earlier laws applicable to the respective Union Territory must be furnished within a period of 90 days from the appointed day.

The carry forward of such credit under the CGST Act and UTGST Act shall not be eligible if any of the following conditions is satisfied:

I. Where the said amount of credit is not admissible under the GST Act; or

ii. Where the supplier has not furnished all the returns required under the existing laws for a period of 6 months prior to the appointed day; or

iii. Where the said amount of credit is in respect of goods sold under such exemption notifications as are notified by the Government.

A. Issues in Carry Forward of CENVAT Credit

While an effort has been made by the Government to ensure that the balance of CENVAT and VAT credit is available for carried forward by a taxable person, there are certain issues that require further clarity:

CENVAT credit is a pool in which all credits are accumulated. The determination of composition of the pool to ensure that it contains only eligible credit as per the GST laws is a tedious task.

The provisions relating to carry forward of CENVAT credit balance do not specify the eligible duties and taxes. Hence, the balance of Education Cess and Secondary and Higher Education Cess which may be a part of CENVAT credit balance as on the appointed day should be available for carry forward. However, this might be subject to dispute by the tax authorities, considering that such balance was of little use under the earlier laws, and in the absence of express provisions under the GST Act available for their carry forward.

Under the Finance Act 1994, a service provider is eligible to avail CENVAT credit of the amount of tax paid under reverse charge. The liability to pay tax under reverse charge arises on the date of payment to the service provider. The date of payment to the service provider for services on which service tax has to be paid on reverse charge may be after the appointed day. In such case, service tax shall also be required to be paid after the appointed day. Whether the credit of service tax paid in such cases can be carried forward or not is an area of concern.

B. Availment of unavailed credit on capital goods

A registered taxable person shall be allowed to carry forward the unavailed CENVAT and Input Tax Credit on capital goods, which has not been carried forward in the returns furnished under the earlier laws, subject to the condition that such credit is admissible under the earlier laws and the GST Act.

Unavailed CENVAT / Input TAX credit = Amount of credit admissible under the earlier laws – Amount of CENVAT / Input Tax credit availed.

C. Availment of credit on goods held in stock to be allowed in certain circumstances

A registered taxable person, who was not liable to be registered under the earlier law or was engaged in the manufacture of exempted goods or provision of exempted services, or who was providing works contract services and was availing the benefit of Notification No. 26/2012-ST dated 20 June 2012 or a first stage dealer or a second stage dealer or a registered importer shall be entitled to take credit of eligible duties and taxes in respect of inputs held in stock and inputs contained in semi-finished or finished goods held in stock on the appointed day subject to the following conditions :

1. Such inputs or goods are used or intended to be used for making taxable supplies under the GST Act;
2. The said taxable person is eligible for input tax credit on such inputs under this Act;
3. The said taxable person is in possession of invoice or other documents evidencing payment of tax under the earlier laws;

4. Such invoices or prescribed documents were issued not earlier than 12 months immediately preceding the appointed day;

5. The Supplier of services is not eligible for any abatement under the Act.

The quantum of credit in this regard shall be calculated in such manner as may be prescribed.

Such credit shall also be allowed to any registered taxable person other than a manufacturer or a supplier of services, who does not have is his possession any invoice or any other documents evidencing payment of duty in respect of inputs @40% of CGST subject to the conditions that he should be in possession of invoice evidencing purchase, the purchase should not be made 12 months or more before the appointed date and the goods should be sold within 6 months.

3. Some more key implementational concerns that need meticulous deliberations

- Re-configuration of accounting system
- Proper classification of goods and services under the GST law to avoid classification issues.
- T software will have to be customized
- The taxable person has to be conscientious regarding compliance with anti-profiteering measures during any revision in the prices.
- Restructuring of existing warehouses of the company to examine if the benefits of such warehouses would still accrue.
- Re-calculation of the working capital due to change in tax rates or taxability of certain transactions, like self-supply, etc., under the GST regime.

How to Repair the Common Problems of Heat Exchanger Fouling and Corrosion - Continued from page no. 16

cooled or heated. The second set of tubes contains liquid, which triggers the exchange of heat. This liquid either removes the heat from the first set of tubes or warms it.

Plate Heat Exchanger

Plate heat exchangers generally feature thin joined plates that are maintained by a smaller rubber gasket. The plate surface area is large and features an opening which water can flow through. As the water flows over the plates, it extracts the heat and cools the liquid.

Regenerative Heat Exchanger

These types of heat exchangers flow fluid along both their sides through either plates or tubes. As the exiting fluid is quite hot, it is used to help warm incoming cooler water. This maintains a constant temperature within the heat exchanger.

Adiabatic Wheel Heat Exchanger

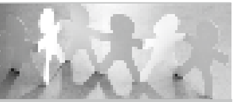
This heat exchanger generally works when a middle fluid is used to help with heat storage. This is then transported to the other side of the exchanger via the use of a large rotating wheel. This wheel helps to transfer or extract heat within the system.

CONCLUSION

Both of these techniques are designed to remove the fouling build up on the surface areas of each of the components. However, like with many other cleaning techniques, these aren't 100% effective and successful at the removal of fouling deposits. This may leave the surface area on the components rough to the touch, even after they have been treated. Another downside is the intensity of manual labor required to dismantle and clean the heat exchanger. Having this process equipment offline for long period can cost time and money.

Welcome NEW MEMBER

PPMAI welcome the following member/s who newly joined the Association and look forward to their prolonged association and active participation in all our programmes.



Sr. No.	Name of the company	Name of the company	Activity
1.	**ELECTRONICS DEVICES WORLDWIDE PVT. LTD.** 31, Mistry Industrial Complex, Cross Road A, MIDC, Andheri (East), Mumbai – 400093 Tel : 026870311 / 18 Email : info@edmail.in, sigmaweld@edmail.in	**Mr. Nilesh Chinoy** Marketing Director Mob: 9820785022	Manufacturer and Supplier of: Welding Inverters, Induction Heating Machines, Induction Cap sealing Machines Complete solution for Welding and Induction Heating & Di Electric pre-heaters.

forthcoming programs

Forthcoming PROGRAMS 2017

- Managing Foreign Currency Exposures – Corporate Risk Management Strategy
- Goods Service Tax (GST)
- Pressure Vessel Design / Heat Exchanger
- Metallurgy for Non-Metallurgists
- Stainless Steel Welding
- Tower Internals

Words of Wisdom

- Enthusiasm is the fuel of life; it helps you to get where you are going.
- You are a wise man today if you have learned from yesterday's blunders.
- It's not always what you say that makes the difference; sometimes it's the way you say it.
- It's how you handle your problems and troubles that count, not the troubles themselves.
- The winners in life's game are not those who have never tasted of failure, but rather those who have failed again and again, but who never gave up. Winners benefit from each failure and see it as a step to victory.
- Hatred in our hearts causes our enemies to triumph over us. Forgiveness causes us to triumph over them.
- Good things come to those who wait. Better things come to those who try.
- A project becomes a mountain when you see the entire job looming before you. If you break it up into smaller, more reachable goals, then you will be much less apt to procrastinate.

ADVERTISEMENT **TARIFF**

PPMAI Speak Bi-Monthly Bulletin

Full Page Colour	Amount
Back Cover Outside / Inside	₹ 25,000.00
Inside Front Cover	₹ 25,000.00
Inside Full Page	₹ 20,000.00

Specification of our publication is as follows:

Period : Bi-monthly
Print Size : A-4
Print Process : Offset 4 colour
Paper used for cover : 170 gsm Sinarmass Coated Art Paper with matte lamination
Paper used for inside : 130 gsm Sinarmass Coated Art Paper

Advt. Size Artwork should be A/4 size for full page advt. (210 mm width x 297 mm height). All advertisement will be in 4+4 cmyk Colours.

Payment:

- Payment for banner advertisement should be made in advance by Cheque / DD in the favour of, "Process Plant and Machinery Association of India" payable at Mumbai along with release order

PPMAI Website

Internet today has made the world small place and easily reachable nay it is the best and fastest medium to reach and access global markets. Airing advertisements on website is definitely an economical way to propagate your company and publicize your products world-over. Keeping this in mind, we have earmarked seven strips for advertisements on our website.

www.ppmai.org
gives you an opportunity to advertise worldwide

We are pleased to inform you that PPMAI website www.ppmai.org is now fully revamped with new look and features.

₹ 10,000/- per annum
(exclusive of service tax)

Advertisers may modify their advertisement matter every quarter.

- The rate includes free link to your existing website
- The banner will be designed and provided by the advertiser as per specified size
- The banner will be in the form of JPEG or GIF file and its size will not exceed 20kB

Payment:

- Payment for banner advertisement should be made in advance by Cheque / DD in the favour of, "Process Plant and Machinery Association of India" payable at Mumbai along with release order

PPMAI eSpeak Journal | soft copy (Published twice in a month)

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- Advertisers may change their advertisement matter every quarter
- The rates quoted are exclusive of service tax
- The size of the ad should be around 40 kb max. Logos or Images will not be entertained
- A format will be provided by PPMAI wherein the advertiser can furnish the advertisement matter

Payment:

- Payment for banner advertisement should be made in advance by Cheque / DD in the favour of, "Process Plant and Machinery Association of India" payable at Mumbai along with release order

PPMAI Newsletter | soft copy (Published twice in a month)

₹ 10,000/- per annum
(Rupees : Ten Thousand per annum)

- Advertisers may change their advertisement matter every quarter
- The rates quoted are exclusive of service tax.
- The size of the ad should be around 40 kb max. Logos or Images will not be entertained.
- A format will be provided by PPMAI wherein the advertiser can furnish the advertisement matter.

Payment:

- Payment for banner advertisement should be made in advance by Cheque / DD in the favour of, "Process Plant and Machinery Association of India" payable at Mumbai along with release order

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