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Pakistan Foundry Association is moving forward towards enhancing the Technological levels of our foundry. I congratulate Dr. Fazal-e-Khalid, Vice Chancellor of UET for being elected as the Chairman of Managing Committee of Foundry Service Center and acknowledge the tireless effort of Mr. Alamgir Chaudhry and SMEDA team. I look forward to a very productive and efficient use of this facility and urge all our members to visit and establish close liaison with Foundry Service Center.

I am delighted to announce the beginning of transition of conventional foundries to modern foundries in Pakistan, with the training workshop on “Iron Casting Methoding” by Mr. Nabeel Khan, a UK based global foundry technologist having 23 years of international experience in the metal casting industry across the three continents and extensively involved in the foundries. This way forward will play a vital role in enabling foundry men to do castings based on calculated parameters and use modern software for value addition in castings. Based on success of our first workshop, 4-5 more such workshops will be organized in near future.

I appreciate the sincere services of Mr. Nabeel Khan to stand alongside with Pakistan Foundry Association and thank Mr. Asim Qadri for identifying him as a resource and support to Pakistani foundries.

Significance of year 2015 has further increased with installation and use of Magma soft in private sector marking the beginning of modern foundry era and instilling a culture of consciousness and waste reduction in the foundry sector.

Sikandar Mustafa Khan
President - PFA
The clear issues which the Pakistan foundry industry must tackle are skills development and adaptation of modern technology, delegates were informed.

The Pakistan Foundry Association organised a presentation and interactive session on 17 August on Skills, Capabilities, and Process Control in Global Foundries - Way Forward for Pakistani Foundry Industry, by Mr. Nabeel Khan, a UK based global Foundry Technologist with more than 23 years of experience in the metal casting industry. Mr. Khan has been extensively involved with global automotive foundries most significantly in Australia, New Zealand, Malaysia, Thailand, Indonesia, Iran, towards the development of foundry systems and process control measures for the production of "zero defect castings".

Mr. Khan presented an overview of the Pakistani foundry industry and spoke about the key challenges our industry is confronted with. The interactive session generated interest and involvement among the audience who also added towards defining the main issues and their causes. He went on providing with a brief insight into the trends in the modern foundry industry, process control capabilities focusing on the role of methoding engineer and the need to enhance methoding engineering skills across the board. He then concluded by suggesting the way forward. Below is a brief review of his talk.

Pakistan Foundry Industry –Current State:
The main drivers of the Pakistani Foundry Industry are Auto, Agri-implements including tractors, Sugar, Cement, Mining and Defence Castings. These are generally influenced by quality, price, casting design and types. Millat Tractor greatly influences the dynamics of ferrous casting industry as most foundries are vendors for Millat parts and quality, price, casting design are driven by Millat. The industry is developing at a very slow pace and is generally lacking maturity in the areas of systems, processes and process control. Huge inputs required to bring these at par with global quality systems and processes.

Key Issues and Challenges:
The foundry industry in Pakistan seems to be suffering from status quo syndrome with little willingness to undergo the change in mind set for adopting new technology, Mr Nabeel Khan emphasised. The skill level of foundry engineers/technicians is generally not up to the mark. There is reluctance on the part of engineers to start career in the Foundry industry. The employers are also not keen to employ and retain qualified engineers or technicians primarily due to i) lack of essential knowledge about foundry practices and processes, ii) reluctance to spend time on the shop-floor and iii) lack of initiative and innovative ideas.

Most foundries are cost driven. There is little awareness about the quality parameters of the cast products, therefore the cost driven culture prevails.
Foundries need some degree of automation—from melting, moulding, pouring, fettling to heat treatment. Only a few units have automatic/semi-automatic moulding lines. Melting/Pouring and Melt Treatment technology (like auto pour/press pouring furnaces/vacuum treatment), methoding generally do not exist. With the exception of few foundries the sand quality level is questionable which limits the use of organic binders systems and hence sand reclamation levels are poor. Defect analysis capability (simulation software / microscopy / spectro-analysis labs / mechanical testing) is seldom used and is only seen in limited foundries.

**Trends in the Modern Foundry Industry:**

The Role of Methoding Engineer in a Foundry
Elaborating on the role of methoding engineer in the foundry, Mr. Khan commented: "The methoding engineer is the link between the pattern equipment, the moulding process, the condition of the liquid metal, the mould filling, the solidification process, the ways the foundry clean (or "fettle") and even the heat treatment" of a casting.
Driving the Industry Forward:
Mr. Khan strongly emphasised on the need for the PFA, Foundry Service Centre and Academia to work together closely to develop a sustainable foundry industry in the country.

Suggested initiatives:
• Promotion of cluster development programmes. Creation of common facilities for modern design, manufacturing tools, simulation, defect analysis and testing.
• Conservation of natural resources, waste reduction, sand recycling in clusters.
• PFA to act as a bridge between academia and the foundry industry. Introduce Foundry courses with collaboration of Academic Institutes. Organise internships in foundry sectors to encourage students to enter in the foundry industry.
• Production of a foundry-man skills set list.
• Develop programs to uplift the skill levels of the cluster foundry engineers.
• Methoding engineering skills to be enhanced across the board.
• Signing of memorandum of understanding with global Foundry Institutes (China, India) for the exchange of information and knowledge sharing.

Acknowledgements
Mr. Nabeel Khan concluded his talk by acknowledging and thanking Prof. Dr. M Iqbal Qureshi for providing an overview of the current state of the foundry industry and the challenges it is facing.
Mr. Khan also thanked Mr. Asim Qadri, Director Operations - Qadri Group of Foundries and Mr. Abdul Rasheed, secretary PFA for giving an insight into the state and issues of the foundry industry and appreciated their assistance in organising and facilitating this talk.
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There has been huge growth in the production of aluminium road wheels over the past decade, with the great majority being manufactured by the low-pressure diecasting process. The quality requirements of these safety critical castings are as high as any aluminium component made today and Foseco has developed a range of products aimed at improving the quality of the castings produced while also improving the profitability of the process.

This concept of an integrated solution package for a particular casting and process will be further developed in the future.

The application of aluminium wheels on light vehicles has become hugely popular over the past ten years. The reasons behind this are both technical as well as aesthetic as the castings are safety critical as well as pleasing to the eye. Aluminium wheels need to offer mechanical strength and lightness, toughness and rigidity, dimensional precision and style with a perfect aesthetic finish and so today aluminium wheels have become a technologically advanced product required to offer a high level of quality, reliability and safety.
Fig.2 Range of INSURAL 140 lining inserts and INSURAL ATL in service

The wheel is a safety critical component, which has a decisive effect on the performance of the vehicle and is responsible for propulsion, steering, supporting the vehicle, braking as well as suspension. Consequently it must possess characteristics of mechanical strength, plastic reserve and fatigue strength capable of resisting fracture during the full life cycle. In addition to this, roundness and balance must also be maintained over time.

Testing will include dimensional accuracy, alloy composition, hardness, grain size and eutectic structure, fatigue testing and die penetrant inspection after fatigue testing, x-ray inspection, pressure tightness, crash test, detailed visual inspection, radial load testing – all this means that aluminium wheels receive as much inspection as any other aluminium casting and more than most.

The process by which aluminium wheels are manufactured is almost always low-pressure diecasting and this process can be segmented into the following process steps:

- Alloy material selection
- Melting
- Holding
- Melt transfer by ladle
- Melt treatment in the ladle
- Transfer into the low-pressure furnace
- Die filling and solidification
- Removal and initial inspection
- X-ray inspection
- Heat treatment
- Machining
- Painting
- Pressure test and visual inspection

The Foseco approach is to develop a range of products and services which can add value to the foundry in all of these process steps.

**ALLOY MATERIAL SELECTION**

To achieve the mechanical properties - particularly the elongation - it is essential that the iron content of the alloy is controlled and so commonly primary ingot is used along with foundry returns and the swarf and chippings from the machine line. Around 40 per cent of the as-cast wheel is removed during the process and so, although the swarf and chippings from machined wheels will have a very large surface area and be the potential source of oxide inclusions, it is commercially essential that this material is recycled and the value retained. A separate process to melt and clean this material is normally used and the use of a powerful cleaning flux, such as COVERAL® GR 6512, is an integral part of this process.

Once cleaned to an acceptable quality level this material can be used, under control, as part of the alloy charge, either as cast ingot or in liquid form.

**MELTING**

Melting in wheel foundries today tends to be by tower melter or reverberatory furnace and there are three key properties that are expected from the furnace itself - high melting rate, energy efficiency and the ability to avoid oxide formation.

In the melting and holding zone there is a strong
AlSi7Mg as-melted before treatment
AlSi7Mg after 10 minutes FDU treatment
AlSi7Mg after 10 minutes MTS 1500 treatment

Fig.5 Graph showing relative effectiveness of cleaning from FDU and MTS 1500 treatment. Features are oxides and pores within the sample

need for a refractory material that is compatible with aluminium-silicon alloys, which has good mechanical strength and is non-wetted by aluminium alloys, resisting the growth of corundum. The lining material must also have a high resistance to mechanical damage in impact areas and have as long a service life as is practical.

ALUGARD* CE-S is a high alumina, low cement castable specifically designed for use with aluminium-silicon alloys and is well proven in aluminium tower and reverberatory melting furnaces. The ALUGARD CE-S lining will offer a long service life and good resistance to corundum growth and be easy to clean.

Within the range of refractory products there is also a lighter weight material for the furnace door, roof and upper walls, TRIAD* 45 AL and BLU-RAM* HS.

For general maintenance and repair DURAGUN* 66AL can be used for application by trowelling or gunning methods.

The same range of refractory materials can also be applied if the melting takes place in a reverberatory furnace.

Product selection is vitally important as is correct installation and Foseco can advise and sometimes supervise the installation of their refractory lining products.

In melting furnaces temperature measurement can also offer advantages if it is fast and accurate. Highly conductive ISO-PRIME or 3M SILICIUMNITRID thermocouple sheaths can both achieve these aims with the latter also offering longer service life.

Correct refractory selection and fast response thermocouples can help to maintain the high quality standard of the aluminium alloy melt, the essential foundation of a sound foundry process.
MELT TRANSFER
Once melted the alloy is then poured into a transfer ladle in which the melt treatment is made prior to the ladle being moved to the low-pressure casting machines. This treatment of grain refinement, strontium modification, cleaning and hydrogen adjustment (degassing and sometimes regassing) can take around ten minutes and so temperature loss can be an issue. Good insulation and easy cleaning is therefore an essential characteristic of the lining material and Foseco has two options to offer.

INSURAL* 140 is supplied as a pre-cast insert which has already been fired to over 700°C and when installed within the INSURAL 10 insulating backing will offer excellent insulation and non-wetting properties. When installed using the INSURAL 140 lining system the ladle will have a heat loss of less than 3°C per minute, depending upon the capacity, and will also be very easy to keep clean and free of oxide build-up.

If the service life of the ladle lining is of particular importance then INSURAL 270 offers good insulation and oxide resistance coupled with excellent erosion resistance. INSURAL 270 will therefore offer an extended service life.

MELT TREATMENT
To achieve the required quality of melt it is necessary to carry out a controlled melt treatment in the transfer ladle.

To ensure the correct eutectic structure is achieved and that excellent elongation properties are assured, the alloy is modified with strontium. This can be done by using pre-modified ingot, which has already had a strontium addition, or by adding aluminium-strontium master alloy prior to degassing.

In addition to the strontium modification the alloy is also grain refined with titanium and boron to achieve optimum mechanical properties and to reduce the chances of shrinkage in thicker sections. In addition to an improvement in elongation and the consistency of mechanical properties, grain refinement also increases resistance to fatigue, improves machinability, reduces the tendency for hot tearing and helps to disperse microporosity.

This treatment is best carried out by chemical additions, which form fresh titanium diboride particles within the melt. A tablet addition with NUCLEAN* 70 SS or NUCLEAN 100 SP will have this effect but best of all a cleaning and grain refining flux, COVERAL MTS 1582 applied
through a MTS 1500 metal treatment station, will give excellent grain refinement, remove oxides and inclusions while ensuring that a very dry dross is generated thereby reducing metal loss.

Melt cleaning and hydrogen control can best be done simultaneously and the traditional method is to add a granular flux COVERAL GR 6512 to the surface of the ladle and then to carry out rotary degassing with a pumping graphite FDU XSR rotor or a GBF rotor.

The stirring action of the rotor will activate the COVERAL GR 6512 and create an exothermic reaction while the finely dispersed inert gas bubbles will help oxides to float to the surface to be collected in the dross. After several minutes of treatment the melt is cleaner and lower in hydrogen content.

A more modern version of this melt treatment is with MTS 1500 technology using a more powerful MTS FDR rotor. In the early stages of the rotary degassing treatment the baffle plate rises from the melt and a vortex is formed. A specially developed cleaning flux, COVERAL MTS 1565, is then added into the vortex. The flux is taken down to the lower parts of the ladle where it can react with the bulk of the melt and after less than 60 seconds the baffle plate moves back into the melt and the vortex disappears.

Normal rotary degassing then continues but because the flux is low in the melt a much more effective cleaning process follows. The MTS 1500 process will therefore remove more oxides than FDU alone.

However for the most effective and automated treatment the COVERAL MTS 1565 flux can be replaced by COVERAL MTS 1582, which when added using the MTS 1500 unit, will offer hydrogen control, melt cleaning and grain refinement as well as generating a dry dross low in aluminium, as shown in fig.6, all in one automated treatment.

To monitor the effectiveness of the modification and grain refinement treatments a cooling curve can be plotted using THERMATEST* equipment. As well as producing a cooling curve, where the undercooling of the liquidus and solidus can be observed, the software also calculates a eutectic structure index; where 5 is the maximum reading and a grain index, with 9 being the maximum reading. Thermal analysis is a very effective way of checking that each melt has been correctly treated.

As shrinkage is such a common issue in aluminium wheels it is sometimes advisable not to reduce the hydrogen content of the melt to the lowest possible level. The overall treatment time must be maintained because of the need to clean the alloy and so shortening the degassing is not an option. It is therefore beneficial to degas to a low level and then to reintroduce a small amount of hydrogen at the end of the treatment. To retain the advantage of automation and consistency it is possible to programme the FDU, GBF or MTS 1500 unit to make a late addition of Argon-H2 gas for just a few tens of seconds at the end of the treatment. This will adjust the hydrogen content to an acceptable level, which will not create porosity but will control the level of shrinkage found in the final casting.

The use of a programmable MTS 1500 treatment to clean, grain refine and control the hydrogen content of the melt gives the foundry excellent process control and repeatability.

MELT TRANSFER
After treatment the melt is poured into the low-pressure furnace, ready for production. This is another critical stage of the process as turbulent filling of the lowpressure furnace can result in oxide creation and an increase in hydrogen content. A specially designed INSURAL 140 pouring basin to suit the particular lowpressure furnace can help to control the filling process.

LOW-PRESSURE DIECASTING FURNACE
As these furnaces can be in service for up to seven years it is vital to select a refractory which will avoid oxide and corundum growth. ALUGARD A 95 has been used for several years in these types of furnace and will avoid many of the problems that can be experienced where furnaces run in production for long periods of time. When ALUGARD A 95 is installed in front of a highly insulating backing system then external steel shell temperatures can be as low as 65°C, reflecting a very energy efficient system.

As an alternative to casting the lining in the furnace body it is possible to install a pre-cast and pre-fired shape in INSURAL 270. This option offers a very fast reline and guarantees that all combined moisture has been removed before installation begins. A furnace relined with the INSURAL 270 system can therefore be put immediately into service after relining, without the need for additional drying and firing.
For the furnace roof, an insulating lining is appropriate and LITEWATE* 80 AL is an ideal material for this application. The low-pressure furnace is heated by electric radiant glow-bars in the roof and their service life can be extended by covering them with a highly conductive protection tube. ISO-PRIME heater protection tubes ensure good heat transfer from electrical element to the furnace atmosphere while protecting the element from mechanical damage, metal splashing and chemical attack during general use or metal treatment and furnace cleaning. They will extend the life of the heater elements, reducing the running costs of the furnace.

For accurate temperature control, a thermocouple sheath with high conductivity is required and ISO-PRIME thermocouple sheaths are well proven in the specific application of a pressurised furnace. Again fast response will result in more accurate temperature control and less variation on casting temperatures.

To have accurate control of the filling process and to retain pressure for effective feeding during solidification a pressure tight LPS tube is essential. Two materials are offered for this application - ZYAROCK* and ZYACAST* - both based on fused silica and being well proven in these applications. These LPS tubes can be supplied with a SEDEX* or STELEX* ZR foam filter installed in the bottom to prevent oxide inclusions entering the tube from the furnace floor.

**CASTING**

Above the LPS tube there is the opportunity to apply highly insulating ceramic inserts and INSURAL 140 is an ideal material for these applications. The use of these inserts allows the foundry to increase the amount of water cooling in the die, thus extracting heat from the casting while retaining heat in the feed areas. Casting quality is therefore improved while cycle time is kept short to improve productivity.

To improve metal flow and trap oxide inclusions, a filter can be positioned in the upper bush. Foam filters are the most effective at flow control and SIVEX* FC filters are lightweight and can be remelted from the carrot.

The die itself must be coated to control the thermal balance, ensuring good filling while also controlling heat loss during the feeding cycle. The aesthetic quality of the casting is also defined by the surface finish on the main face of the wheel and so a smooth coating is used on the front face, DYCOTE* 39. For an extended service life DYCOTE 3900 or DYCOTE 3950 can be used. For the side and top cores a more insulating coating is required and this can be DYCOTE 34. As service life of the coating is important to retain the insulating properties for a longer period, a primer coating - DYCOTE DR 87 - can first be applied to the die with the other DYCOTEs applied on top.

To ensure that the DYCOTE used is correctly prepared a special mixer - DYCOTE CARRY and MIX - is offered. This mixer will also maintain the quality of the coating during standing.

**CONCLUSIONS**

The important attributes of the low-pressure diecasting process are:

- Productivity
- Energy usage
- Metal yield

The important attributes of the casting itself are:

- Surface finish
- Mechanical properties
- Soundness
- Pressure tightness
- Freedom from oxides and porosity
- Machinability

The products listed in this article form a valuable group for the low-pressure wheel producer and when used together will have a positive impact on the quality and performance of the castings as well as the commercial success of the foundry. Research and development projects are now underway to add further elements to this range and to increase the end-to-end value offered to the industry.

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Important: Appropriate Personal Protective Equipment (PPE) must be worn by anyone in proximity to molten metal.
Ever seen Grass cutting the Steel?
Not only that it is possible, the same is experienced by those who have used the Grass Chopper commonly known as “Toka”. It is one of the high in-demand products of Pakistan and is manufactured from sand casting. The commonly used Toka in Pakistan and India is a state of the art engineering design. However, the primitive manufacturing technology combined with the non-adherence to the basic Quality manufacturing procedures while Machining and Assembling Processes result in a massively "Mis-Aligned Machiner" which is "Forced" to be rotated under high inertia by using a heavily over-rated electric motor. The resultant is a very quick wear of its gears and start of a chain reaction of changing the components and so on...
So is the case with almost every Agricultural Implement and Machinery. From the metallurgical problems of as simple a part as a 'Till' (or "phallee") to the fancy-fabricated Harvesters and Wheat Threshers, all items are being produced in Pakistan without any Design Analysis and Due Engineering Calculations. One finds it quite interesting to see that the prime factor in selecting a Wheat Thresher by its buyers is its weight. It is a general perspective that the heavier the thresher, better it would be. It is totally ignored that the real parameter to see in selection of such machinery is its production efficiency and its components' life viz-a-viz its fuel consumption and maintenance required. There are no Standard Procedures to qualify and grade any implement on the basis of its efficiency and manufacturing quality.
This results in massive wastages as follows:
- Poor Production processes result in huge production loss to the manufacturers.
- Lack of Quality Procedures result in poorly manufactured machinery, resulting in very high running costs.
- Low quality components result in lesser machinery life, resulting huge replacement costs.

It would not be surprising to estimate the above mentioned losses running in many billions of rupees annually.
Since 1980s, manufacturing has been totally revolutionized. The use of Computers in making of Drawings (Computer Aided Drawing or CAD), running the machines (Computer Aided Manufacturing or CAM), and Analyzing the Engineering Process and Designs (Computer Aided Design/Computer Aided Engineering or CAE) by Simulation is considered a norm in any modern industry. During past 30-years, the use of computers has not only increased the efficiency of the machines, but it has also allowed the engineers and researchers to go into the depth of the manufacturing processes and apply their minds to fine tune the procedures. Resulting in a better product!
Let us see what is a Modern Flow for Design and Manufacturing of any component:
**Step-1: Design of Part**
- Concepts Designing on Paper with hand.
- Conversion of hand sketch to a 3D-Model Drawing on Computer using any 3D Modeling Software like Solidworks etc.
- Design Analysis/Simulations of the Components (or complete machinery) on Computers by using any suitable/relevant software. For example for Foundry/Casting Procedures one may use ProCAST or MagmaSoft etc and for Stress Analysis or Motion Studies one can use Solidworks etc.
- Design Analysis is an iterative process, and in case of not achieving desired results, the Part/Machine's design can be altered on Computers.
- Upon achieving desired results on computer Simulations for the whole machinery, one may proceed with the individual component’s manufacturing process optimization by the above mentioned software.
- One may spend some extra buck to get a pre-sample by using 3D Printing techniques. This step alone may save millions at the later stage. This helps in quickly making the component or machinery at this stage in Plastic or some Synthetic materials to ascertain the correctness of the component or fitting of the
components.
Do note that till this stage, everything is in the Digital format on Computers. But the thoroughly simulated and corrected design that we would have in the end of this stage will leave a little margin for Design errors once it is physically manufactured.

Stage-2: Manufacturing of Patterns / Dies / Molds and Machining
- The resultant of simulations and corrections of Stage-1 will be a verified CAD models in 3D format. These can easily be fed to CNC machines for making of the Casting patterns or Molds etc according to the procedure.

Stage-3: Production of Components
- The selection of right tooling, right machinery and process for production is critical of the Development Cycle. Computer Aided Engineering once again can save the design engineer from the hassles of doing repeated mistakes by carrying out all simulations of Machining processes on computers before selecting the machines. Today, one can easily run a tool-path simulation for all machining processes.
- For production process optimization, depending upon the volume or production and the desired precision tolerances, one may select the appropriate CNC or Special Purpose Machinery (SPM).
- There may be a possibility that in some large volume production cases, certain machining steps could be carried out by making a smart Machining fixture for a manual hand operated machine instead of using a CNC. A smart Design engineer or an experienced person can easily decide it.
- The use of computers in the supply chain management for the production process is a great help. Very complex decision making steps can be automated, like re-order levels of raw materials, stock positions in the inventory, wastage calculations, inward-outward flow control in the stores etc. Many ERP software tools are available for such purposes.

Stage-4: Quality Assurance and Process Optimization
- Proper use of modern portable gauges and portable CMM machines have eased out the life for quality inspectors. Now, with the help of 3D CAD drawings on computers, one can easily run a comparison of dimensions on a produced component with that of the original design in 3D model.
- Process optimization is a continuous process which must be going on forever. Effective use of Feedback Data, Strict eye on Production rejections and losses is very helpful in improving in the yield of production and saving that extra dime.
- Most importantly, if one look at the rejections and production losses of any metal working setup (especially production foundries), one will notice the exorbitant numbers of rejections due to wrong pattern design or wrong casting parameters. We have seen the casting rejections of high-production foundries to be anywhere from 10% to 40%. All these can easily be brought down by employing the Computer Aided Design Analysis Software.

Another Rapidly upcoming technology in the manufacturing is 3D Printing. In a very short span of 15-years, 3D-Printing has taken over the world. Explaining this technology require separate space, but it is envisaged that very soon, metal-components manufacturing/production will be done on 3D Printers instead of in foundries or castings!!! Do you hear the tolling bells?

It is pertinent to note that modern Computer Aided Tools are amply available in Pakistan, but due to non-patronizing by the manufacturers, the young technicians and engineers are forced to use Pirated Software. Due to same reason, the Manufacturers of the Software are turning away from promoting their products in Pakistan. There are a few Public-Sector organizations working in Pakistan to help the manufacturers in CAD/CAM sector, but these are not enough and these are not 'effectively affordable'. Today’s manufacturers must come up with the investment on the Computer Aided Techniques under the licensed regime and help themselves come at par with the modern world.

The Engineering Universities and Technical Colleges have already given enough introduction and knowledge to the young graduates to work under a Supervised Design Setups based on
CAD/CAM technologies. It is the duty of the Industrialists to provide grooming environment to these graduates and technicians and to give them right direction...and...take advantage out of the Technology! If properly driven, The advantages in terms of time-lead and effort saving will soon make you forget the cost incurred on the acquiring the technology.

Maj(r) M. Arfaeen Iqbal, is an Electrical Engineer and working as a Manufacturing Technologist since past many years. During 22 years of his professional career, he has done different postgraduate courses in Computer Aided Technologies from Pakistan and Abroad. Based in Lahore, he can be reached by email at arfaeen@gmail.com

**IMAGES FOR CAD and CAE**

- Design of Inspection fixture for Center Housing Casting
- Simulation of Heat Flow from the Heat-Exchanger
- Evaluating the Results of Casting Process Simulation
- Stress Analysis of a Connecting Rod in Design Phase
- Loading and Bending Stress Analysis of a Bracket
- Complex Component made by 3D Printing
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Top industry experts in tooling and patternmaking discuss common concerns related to the metalcasting industry and casting end-users.

Nearly infinite patterns and tooling have been produced for metalcasters over the years, yet certain topics seem to pop up time and again. Today, as hot subjects like additive manufacturing and decreased lead times aren’t far from the mouths of patternmakers, Modern Casting talked to three of the industry’s pattern and tooling experts about common concerns for metalcasting facilities and casting buyers. Here’s what we heard from John McIntyre, president, Anderson Global, Muskegon, Mich.; Brandon Lamoncha, sales manager, Humtown Products, Columbiana, Ohio; and Steve Murray, sales director, Hoosier Pattern, Decatur, Ind.

What should be a customer’s first step in locating a new source for tooling and patterns?

Lamoncha, Humtown Products: First of all, the customer needs to understand their needs. Are they making counterweights for the back of a forklift or highly engineered, complex cylinder heads that have geometrical tolerances down to a few thousandths? As the customer, you need to understand your needs first.

McIntyre, Anderson Global: They should look for expertise in the specific segment of castings they need. The toolmaker needs to have an extensive background in that particular type of casting, in that particular type of process, so they understand the processes that go into a quality casting. That way, they can design and build a tool that will give that metalcaster the biggest processing window possible.

Murray, Hoosier Pattern: Open mindedness is hard to gauge, but you need that to do new things in new and better ways. The mindset of “always doing something a certain way because you have always done it that way” is a death sentence. Also, it is not about being across town that is important. It is about being on top of the technology, methods and materials to get the job done in the most timely and cost-effective manner.

Have you noticed a specific trend in what metalcasters are demanding from you?

Murray, Hoosier Pattern: My customers are asking for solidification on demand, reverse engineering capabilities and laser scanning in the shop and at their facility. Oh, did I forget [they want it] faster? Always faster.

McIntyre, Anderson Global: Toolmakers need to have processes in place to compress the project into a shorter time period by streamlining design and build. This can be done a lot of ways, like through improved organization and better machinery.

Lamoncha, Humtown Products: Everything is trending toward CAD. Someone from a large
OEM asked me: Is it the drawing or the CAD model that we’re working toward? For the most part, I don’t even get drawings anymore. When my grandfather made patterns off a drawing, he had to have that interaction with the foundry. Now, it’s a little bit different. If they see an area that has to be chilled or might shrink, they’re going to deal with that immediately.

**How can a casting buyer determine a good pattern from a bad one? What are key things to look for to ensure quality?**

McIntyre, Anderson Global: Depending on the personality of the casting buyer, he can insist on dimensional certification and proof that proper materials and heat treatment were used.

Lamoncha, Humtown Products: We’ve gotten away from simple measurements and verniers. We just do a scan of our pattern with a laser. We do a comparison and send that along with the pattern. The proof’s in the pudding. Everybody knows the pattern is not going to be absolutely perfect. But if you show you’re within the tolerances, they know if there’s any variation in a casting, it most likely is an in-house problem.

**What missed opportunities/misconceptions do you see from customers?**

McIntyre, Anderson Global: Not asking to participate. Many times, metalcasters will want a tool—and they won’t explain whether the castings will be low volume or high volume or they won’t detail its key characteristics. If that information isn’t communicated, the customer will get a generic tool that wasn’t specifically made to help them reach the goals of the casting.

Murray, Hoosier Pattern: Mixing and matching materials and manufacturing methods to get the best fit for the specific need is OK. Pattern shops are here to help with questions on new technologies, methods and materials. Ask why we still do things such-and-such way. Explore your options.

Lamoncha, Humtown Products: When people think of a patternmaker, they imagine someone gluing wood segments together or using a lathe. These are great tools that obviously still have their place, but we have so much more to offer. Our advanced methods are just additional tools in the toolbox. We are much more dynamic than that. We want to utilize all the technologies available. We want to have a CNC tooling shop and an advanced manufacturing shop in addition to our traditional pattern shop.

**What should be the major considerations when choosing between offshore and domestic pattern suppliers?**

Murray, Hoosier Pattern: The same things you use to choose between domestic suppliers. We compete in a world marketplace today. You must be on your game to be competitive and have the services your customers require.

McIntyre, Anderson Global: Materials. For overseas pattern shops, labor is inexpensive, so they focus on saving in terms of materials, which can lead to cutting corners. Also, being in the same time zone where you are speaking the same language can reduce complications in communication.

Lamoncha, Humtown Products: The biggest consideration is time. I don’t think anyone can deal with the time lag [with overseas suppliers]. If there’s a revision or a change, it takes way too long to go back and forth. How have advancements in additive manufacturing affected your business?

Murray, Hoosier Pattern: It is not just another
tool in the toolbox. It is another drawer in your toolbox. We want to show customers where and when to apply the technology and guide the customer through that maze of technological hype versus reality. Yes, we can print a pattern or corebox for low volume production, but you have to do a cost-benefit reality check. It has to make sense dollar and cents-wise.

Lamoncha, Humtown Products: We want our customers to understand that advanced manufacturing isn’t only additive, but it’s a fundamental tool. It’s the ruler, the tape measure—something you’ll be using very frequently. But some people get enamored with one technology and won’t look elsewhere. By keeping an open mind, you will be able to get better castings at a much lower cost.

What’s one surprising way for metalcasters to utilize pattern shops to streamline the supply chain?

McIntyre, Anderson Global: Have the toolmaker visit your foundry, your core room, your molding line. Have them talk to in-house maintenance people to find out what problems they’ve had in the past, what problems they’ve had in the foundry, so the tooling shop can use that knowledge to produce a better tool.

Murray, Hoosier Pattern: Establish standard prices so you know what you are getting into before you do something. Things like re-rigging, remounting and core box maintenance should all be fairly predictable. Try to eliminate surprises in that regard.

Lamoncha, Humtown Products: In terms of the supply chain, you really have to look at a pattern shop like a partner and not just a supplier. In the end, the goal is to make the end customer happy. If a tool shows up and it’s not working as expected, it’s easy to start pointing fingers and that’s counterproductive.

What’s one common misconception you encounter regarding tooling ownership and/or storage?

Murray, Hoosier Pattern: Tools will last forever and storage is free. The truth is much different. Old wood patterns and coreboxes dry out and degrade. Iron will rust and corrode. Regarding storage, there is a cost to bring tooling out of storage after many years and getting it ready for production.

What’s one unexpected benefit for a metal casting facility to outsource its production of patterns and tooling?

Murray, Hoosier Pattern: Speed. If you can outsource a part when it makes sense, you can use the technologies offered by the pattern shop without owning the machinery.

Lamoncha, Humtown Products: You gain a lot of knowledge working with a pattern shop that builds tooling for all different industries. I’ve built 30-40 tools in the last few months in all different industries, so I have a different way of looking at a particular corebox or casting.
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- High Speed Continuous Casting Machines
- Coal based Rotary Kiln (Sponge Iron) Plant
- Coal based Tunnel Kiln (Sponge Iron) Plant
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Abstract:
Organic binders, baking and no bake, self-sets and gas curing types, have been introduced periodically by replacing inorganic binders like water glass (sodium silicate) & phosphates and cereals like starch, vegetable oils, molasses etc. to meet requirements of modern Foundries like high productivity, least possible cleaning operations, close dimensional accuracy and surface finish of castings with near perfection. Many of these binders have been phased out by newer ones providing overall advantages and demand for many are growing continuously. Some are not having much popularity but are being used in limited number of Foundries.

Co2 cured Phenolic, introduced in Foundries towards end of 20th century has started gaining popularity at beginning of 21st century in Foundries in India and subcontinent. Low energy consumption for making molds/cores by this process combined with fast productivity, clean working place environment, ease of knock out and excellent casting finish for ferrous and non ferrous metals are some of the features attracting Foundrymen to prefer this system over others.

This paper will deal with possible future of this comparatively new gas curing organic binder system with emphasis on its possible areas of application, alone or in combination with water glass system.

Introduction:
While discussing about possible areas of application of this modern gas cured binder system, we need to review about existing systems which can be substituted.

In automotive sector, repetitive thick sectioned cores like blocks and heads, once being produced by Hot box and Shell process, both heat curing, have largely been substituted by amine cured Cold box process (PUCB) over a period of time, mainly to save energy and faster productivity. However, whereas Hot box is almost nonexistent in Indian Foundries pouring ferrous metal, Shell process is still being used, particularly in areas like thin sectioned and rangy cores like water jacket, oil passage and molds for two wheeler cylinder assembly, molds and cores for cam shaft etc for variety of reasons like ease of ejection, unmatchable handling strength, unique collapsibility, near perfect dimensional accuracy of castings etc.

In automotive sector, it’s common practice to make molds by green sand and cores by Shell or PUCB mainly because of viable economy. With passage of time, more and more complicated cores are being converted from Shell to PUCB for obvious benefits using special sands like mix of silica and Chromite, Mullite etc. Whereas CO2 cured Phenolic can’t enter into area of Shell for automotive castings, it can partially substitute PUCB in many cases. One of the main reasons for this switch over is continuous increase in cost of PUCB making the new system, once costlier, becoming increasingly viable. The other being impact on environment, where it outplays PUCB.

It’s another area of application can be substitution of sodium Silicate, curing agent (CO2) remaining same. Sodium silicate or water glass system is probably first synthetic sand binder system introduced in foundries for making molds and cores. In spite of it’s several advantages over ancient binders like cereal binders, baking oils, green sand process etc, being inorganic in nature, de coring and poor surface finish of castings, requiring rework remains a problem. Thus, with introduction of organic sand binders from time to time, silicate has been continuously replaced by modern organic binders. CO2 cured Phenolic is seen as replacement of Sodium silicate system, which, being organic in nature, gives excellent collapsibility of core/mold assembly, post pouring of castings.

System in brief:
Like Sodium silicate, binder component is single part; a typical resole type Phenol Formaldehyde resin. CO2, in gaseous form is the curing agent. Thus, basically it is two component systems.
Resin properties:
Appearance : Yellow colored liquid
Viscosity : 40-60 secs (Ford cup no 4, 30 DC)
Water miscibility : Unlimited
Sp.gr : 1.28-1.32
PH : 14
Free Phenol : \( \leq 1\% \)
Free formaldehyde : \( \leq 0.1\% \)

Advantages offered
• Resin is water soluble
• Compatible with silica, zircon and Chromite sand
• Short curing cycle
• Good flow ability of mixed sand
• Unique storage stability of mixed sand - more than 4 hours
• Long shelf life of binder
• Molds/cores are resistant to atmospheric degradation
• Suitable for batch as well as continuous mixers
• Over gassing does not reduce strength of molds/cores
• Binder is non flammable
• N, S and P free system
• Suitable for Ferrous as well as non Ferrous metals
• Castings are usually free from veining and lustrous carbon defects
• Excellent post casting breakdown properties
• Excellent workplace environment
• Viable economy

Binder/CO2 demand
Usual binder demand is 2.5-3.0 % by weight of sand. CO2 demand is 0.5-2% by weight of sand.

Process and possible areas of application
Sand can be mixed in all types of mixers. Mixed sand can be used like sodium silicate mixed sand by passing CO2 through molds/cores through holes made.
Mixed sand can be stored safely up to 4 hours without deterioration of properties. If kept covered with wet jute bags, it has been found to remain usable up to 24 hrs.
Typical CO2 flow rate and pressure requirements are 5-20 lts/minute and 0.5-1 kg/sq cm respectively.
It can find four distinct areas of application, which is as follows:

a) Substitution of PUCB
Originally found to be costlier than PUCB because of higher binder demand, sharp increase in raw material prices for PUCB has made the new system competitive.
Practical example of producing cores for automotive castings in automatic core shooters with this new system in green sand molds ,although not common so far ,exists in India .Casting results are absolutely satisfactory ,surface finish being better than that obtained using PUCB. Working environment is much cleaner.

b) Substitution of Water glass process
Whereas process of application of both the processes are same, resin binder enjoys series of benefits over silicate. These are:
Increased Bench life of mixed sand
Better flow ability of mixed sand
Non reversal in strength on over gassing
Increased storage life of cores
Better casting finish
Better collapsibility- and many more

c) Substitution of so called beta set core
In foundries practicing so called alpha set mold/beta set core system ,core making can be replaced by this system producing cores of better quality without affecting reclaim ability by attrition, working environment being far better.

d) Hybrid system optimizing economy and casting quality
Molds with resin sand at facing and silicate at backing can be co cured by CO2. These molds when used with resin/CO2 cores ,produces casting offered by sophisticated organic binders with working environment matching silicate system.
Two halves of molds made with 3% CO2 cured Phenolic facing and 5.5% CO2 silicate sand

Core made with 3% CO2 cured Phenolic sand

Valve body casting (steel, WCB) using above mold/core assembly

Coating practice:
It has been found that castings of reasonably good quality can be obtained without application of refractory coatings using molds and cores made with this system. However, both water and thinner based coatings are compatible for the system.

Strength:
Typical dry compression (Kg/sq cm) of the system @3.0% binder level in crushed quartz of AFS 46.
Immediate after gassing : 8-9
1 hr. after gassing : 12-14
4 hrs : 14-16
24 hrs : 17-18

Compatibility with green sand:
There are practical examples in India where castings are being produced with green sand molds and CO2 cured Phenolic cores. Core sand on mixing with green sand does not poison bentonite.

Casting Quality:
Ferrous castings produced with this system have been found to be free from veining, lustrous carbon, hot tear and pinhole defects. Copper and aluminium alloys are successfully poured with this system.
**Environment:**
Mixing area is free from obnoxious fumes usually experienced with other organic binders. BTX emission in pouring area is much lesser compared to cases using most of the organic binders.

**Drawbacks:**
The system is not compatible with Olivine sand which is usually used in facing area of molds producing Mn steel castings.
When compared with PUCB, this system offers poor flow ability of mixed sand leading to comparatively porous cores.
Thin and rangy cores and molds like water jacket, oil passage, inlet exhaust port core, brake disc etc cannot be made of this system.

**Conclusion:**
One more gas curing system has been made available to Foundries in Indian subcontinent with existing PUCB. This system has got lots of positive features a good binder system should have. These include fast productivity of molds/cores as well as castings, excellent work place environment, suitable for pouring ferrous and non ferrous castings and favorable economy.
Few drawbacks are non compatibility with Olivine sand, poor flow ability of mixed sand and comparatively inferior handling strength compared to many organic binders.
Thus, with its strength and weakness, this binder system, considered to have combined benefits of organic and inorganic binders, is going to cement it's place in many of foundries in India and sub continent in years to come.
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Development of Compacted Graphite Cast Iron (CGI) in Ravi Autos

Prepared By: Ijaz Ali Behar (M.Sc Metallurgy & Materials Science)
M. Mubbashir Saeed (B.Sc Metallurgy & Materials Science)
Qaisar Nawaz (B.Sc Metallurgy & Materials Science)
Special Thanks: Mr. Pervaiz Mahmood (G.M. Foundry Ravi Autos)
Presented By: Ijaz Ali Behar (Manager Foundry Ravi Autos)

Introduction:
The shape of free carbon in the metal matrix determines the category of cast iron such as Grey iron, SG Iron or CG Iron. Shape of graphite in Compacted Graphite Irons is like a worm or stubby form with rounded edges. It is also known as vermicular graphite cast iron. The production method is similar as that of ductile iron. Some rare earth element and an alloying element such as titanium are required to minimize the formation of Spheroidal Graphite.

Mechanical properties of SG Iron depend on Nodularity and ferrite-pearlite content in the matrix. While the flake shape and flake size decides the mechanical properties in Grey Iron. In CG Iron, the vermicular or compacted shape of graphite makes it fall in-between GI or SG Iron.

The term "vermicular" is derived from the worm like shape of free graphite in matrix and is used to illustrate compacted graphite iron. Generally the term "compacted" is used to describe this kind of structure as it easy to understand.

Why Developed:
With the growing needs of Automobile amenities, it is required to upgrade automotive industry with the new and improved materials that can work more efficiently in severe conditions. CG Iron is the upcoming addition in automotive parts manufacturing industry as it has mechanical properties intermediate between gray iron and ductile iron.

Keeping in mind the international trends in material development and usage, it was observed that in Auto Industry the future of CGI is very bright, which is also evident from the table below.

Trends in United States Diesel Penetration Predictions for future.

<p>| Table: |</p>
<table>
<thead>
<tr>
<th>Sr. No.</th>
<th>Information Source</th>
<th>Penetration</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>International –Navistar</td>
<td>25%</td>
<td>2010</td>
</tr>
<tr>
<td>2</td>
<td>Bosch Automotive</td>
<td>20%</td>
<td>2014</td>
</tr>
<tr>
<td>3</td>
<td>British Petroleum BP</td>
<td>18%</td>
<td>2015</td>
</tr>
<tr>
<td>4</td>
<td>JD Power –LMC</td>
<td>16%</td>
<td>2015</td>
</tr>
<tr>
<td>5</td>
<td>United States EPA</td>
<td>40%</td>
<td>2020</td>
</tr>
</tbody>
</table>

Comparison:
Comparison of mechanical & physical properties between Grey, Compacted graphite & ductile irons.

<table>
<thead>
<tr>
<th>Properties at ambient temperature</th>
<th>Grey Cast Iron</th>
<th>Vermicular (Compacted Graphite) Cast Iron</th>
<th>Ductile (Spheroidal Graphite) Cast Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (MPa)</td>
<td>200 - 400</td>
<td>300 - 600</td>
<td>400 - 900</td>
</tr>
<tr>
<td>Yield strength (MPa)</td>
<td>150 - 200</td>
<td>200 - 400</td>
<td>250 - 600</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>&lt; 1</td>
<td>1 - 3</td>
<td>2 - 25</td>
</tr>
<tr>
<td>Hardness (HBW)</td>
<td>150 - 250</td>
<td>150 - 250</td>
<td>150 - 300</td>
</tr>
<tr>
<td>Fatigue strength (MPa)</td>
<td>75 - 150</td>
<td>130 - 200</td>
<td>200 - 300</td>
</tr>
<tr>
<td>Thermal conductivity (W/m.K)</td>
<td>40 - 50</td>
<td>35 - 45</td>
<td>30 - 35</td>
</tr>
<tr>
<td>Oxide Penetration</td>
<td>High</td>
<td>Intermediate</td>
<td>Low</td>
</tr>
</tbody>
</table>

Benefits:

CG Iron V/S Grey Iron
- The Strengths and Impact toughness of CG Iron are much higher than that of Grey Irons.
- Tensile strength of CG Iron is greater than Grey Iron.
- It has Damping properties like grey Iron
- The heat resistance fatigue performance is much higher for CG Iron than Grey Iron.
- Wear resistance of CG iron is more than grey Iron

CG Iron V/S Ductile Iron
- Hardness of CG iron is nearly equal to Ductile Iron.
- Its elongation is lower than Ductile Iron.
- CG iron has ductility as Ductile Iron.
- No Warpage due to heating/cooling over the time due to its matrix

Main Applications:
- The first commercial application for compacted graphite iron was for the Brake Discs for high speed rail Trains
- More recently compacted graphite iron has been used for Diesel Engine Blocks
- It is also used for Turbo Housings and Exhaust Manifolds.
- Fly Wheels of high efficiency cars.
Development at Ravi:

CG Iron can be produced by the following two methods.

First method is called under-treatment by magnesium (keeping in mind the ductile iron Mg treatment process) and second method is known as Mg + Ti treatment. Following is the brief description of these two techniques and discussion on the results of these techniques which were observed during production of CGI in Ravi Autos.

1. Under treatment method

Typically residual magnesium ranges from 0.035% to 0.065% in ductile iron, depending on the type of castings and section thickness of casting being made. In case of compacted graphite irons, the residual Magnesium ranges from 0.015% to 0.022%. This composition can be achieved using standard FeMgSi alloys. But practically this method is very difficult and requires strong control on the Mg treatment process. If Mg content is too high, it will result in high nodule count. Too low Mg will lead to the formation of flake structures, particularly in thicker sections. In castings of multiple section thicknesses, this method is practically impossible to control and is not widely used.

At Ravi Autos we tried with different Mg content in the melt to obtain compacted graphite structure, but it was partially successful, the main reason being inconsistency in CG structure.

The metal was tapped at temp varying from 1470 °C to 1500 °C. Metal behavior with respect to shrinkage was like Ductile Iron, as such the Gating System was designed accordingly. As in SG iron the metal was consumed in 5 minutes. In the initial days of this experiment we completed the pouring in min possible time so that Mg can retain in the metal composition and flake formation could be avoided. But it resulted in complete nodule formation. To avoid this we delayed pouring practice so that only required content of Mg could retain. But we could not get the desired consistency.

2. Magnesium plus titanium treatments

In this method the melt is prepared and magnesium treatment is performed similarly to that of Ductile Iron. The difference is low Mg content in the melt and addition of Titanium to the process. This Ti may be in the form of Fe-Ti or combined with Fe-Mg-Si. Typical range of residual Ti is 0.07% to 0.10%. Titanium is a flake promoter element and this method gives a wider production range than the Mg under-treatment method. That is why CG structures can be obtained in both thin and thicker sections.

The Titanium was added with a trace amount of Cerium Misch-metall. With this method the results attained were consistent having better control of CG Iron structure.

Tapping temperature was kept at 1480 °C. Pouring time range set at 4 to 4.5 minutes. Behavior of molten metal was same as in ductile iron. It was noted that loss of temperature in compacted graphite iron is a little less than ductile iron during poring practice.

Comparison Table & Micrograph Pictures

<table>
<thead>
<tr>
<th>Description</th>
<th>Under-treatment with Magnesium</th>
<th>Magnesium + Titanium treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Composition</td>
<td>C (%)</td>
<td>Mg (%)</td>
</tr>
<tr>
<td>Si (%)</td>
<td>2.18</td>
<td>2.19</td>
</tr>
<tr>
<td>Mg (%)</td>
<td>0.026</td>
<td>0.021</td>
</tr>
<tr>
<td>Ti (%)</td>
<td>0.044</td>
<td>0.061</td>
</tr>
<tr>
<td>Mechanical Properties</td>
<td>Hardness (HBW)</td>
<td>UTS (MPa)</td>
</tr>
<tr>
<td></td>
<td>212</td>
<td>484</td>
</tr>
<tr>
<td></td>
<td>187</td>
<td>483.1</td>
</tr>
</tbody>
</table>

Micrographs (Un-etched) (At 100x)

Cost Comparison Chart:

<table>
<thead>
<tr>
<th>Description</th>
<th>Gray Iron</th>
<th>Ductile Iron</th>
<th>Compacted Graphite Iron</th>
</tr>
</thead>
<tbody>
<tr>
<td>95-105 (PK,R)</td>
<td>115-125 (PK,R)</td>
<td>105-115 (PK,R)</td>
<td></td>
</tr>
</tbody>
</table>

References:

1. BCIRA Broadsheet 138: Principal Graphite forms in cast Irons.
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Preparing for the China moment
It would be fair to say Pakistan ranks as a dark horse within the Asia Pacific foundry network. While it may not place among the leading producers of casting nations around the world, with an approximate output of 350,000 annual tonnes, the country is slowly building momentum as a formidable manufacturer, learning lessons from its surrounding neighbours.

As it stands, the Pakistan industry comprises 1640 foundries operating in grey, SG iron, steel and non-ferrous castings, plus a marginal trade in aluminium die castings. Those parts span several different industries including automotive parts, tractors, sugar mill machinery parts, cement factory consumables, chemical factory consumables, agriculture implements, heavy industrial castings, pumps, valves electric motors and textile machinery, among other services.

The industry has already experienced progressive growth over the past five years thanks in part to strong exports to US, Germany, UK, Brazil, Netherlands, Japan, Afghanistan, France, Saudi Arabia, Italy, China and India, among others.

In the 2013-2014 financial year, the industry exported $263.1 million (US) worth of casting products, more than double that of the 2009-2010 financial year ($116.7 million), but down slightly against 2012-2013 and 2011-2012. Foundry products now account for 21 per cent of Pakistan's total engineering exports.

According to industry analyst and secretary, Abdul Rashid, Pakistan's low labour costs and manufacturing flexibility position the casting industry favourably for overseas investors and entrepreneurs.

"Pakistan still has huge growth potential," he said.

"During the past few years Pakistani foundries, which are mainly micro or SME (small to medium size) businesses, have started to modernise.

"A few high pressure moulding lines with higher levels of mechanisation have been established. Major foundries are owned by players in the auto parts sector. "Companies like Bolan Castings, KSB Pumps, Rastgar Engineering and MECAS continue foundry-related modernisation plans, but all supply into the local or global auto parts value chains. In each case the foundry is captive of its holding company or directly part of the process of manufacturing end products."

Add to that Pakistan's booming middle class, which is driving strong domestic growth, and the country's economics are growing at a decent rate. Even family-owned foundries are sitting comfortably, with steady demand despite little to no prospect of new work or investment.

Withstanding the positive sentiment, Pakistan still has key gains to make in its environmental and occupational health and safety practices from an industry perspective. However, unlike other surrounding Asia Pacific countries, foundries are yet to be grossly impacted by rising labour wages, which remain in moderation.

Automotive work drives outputs
The automotive sector is deeply ingrained in Pakistan's foundries. The industry has enjoyed favourable growth in the past three years, according to Rashid, as consumers increasingly take up personal transportation and foreign investors take advantage of Pakistan's favourable manufacturing conditions.

"Despite current economic situation, Pakistan is set to become a market for 115,882 cars in the year 2013-14 as compared to 106,968 in 2012-13," he said, adding, "and 691,037 motor cycles in the year 2013-2014 as compare to 710,553 in the year 2012-13.

"That's in addition to bus, truck and farm machinery sectors.

"Major multinationals in auto, engineering, food, pharmaceutical and cosmetics have already entrenched themselves here, with stellar results.

"To fulfil the future demands of casting in Pakistan as well as for export destinations, the Japanese and Chinese auto giants ... or their..."
overseas vendors may invest in the foundry sector in Pakistan in order to reap the profits of the rising demand in Pakistan.”

In addition, small export of raw castings continue to prop up the underlying automotive parts industry, as well as sugar cane machinery and parts, tractors and farm machinery.

**The next chapter for Pakistan**

Other than the automotive industry, there is another promising project building momentum in Pakistan, according to Rashid: the newly established China Pakistan Economic Corridor (CPEC), a planned infrastructure and logistics project which will join Western China to Pakistan through the Indian Ocean and the deep water Pakistani port of Gawadar.

"This project envisages 2200 kilometres of road and rail link between Kashgar, China and Gawadar, Pakistan, as well as an equally long oil pipeline," Rashid says.

"It plans to have 35 electricity production projects along the route of the CPEC, entailing huge works relating to hydroelectricity and its transmission to national grid. Even the national grid will be upgraded."

According to Rashid, the development punctuates an "economic revolution" going on in Pakistan. Indeed, there are approximately 9 million Pakistan residents that comprise the country's growing middle income population. As a result, the retail sector is enjoying unprecedented prosperity and car and motor cycle production is constantly gathering momentum towards full capacity.

The growth in demand for cars and other consumables has driven demand for underlying infrastructure such as roads and transport, which has in turn boosted urbanisation outside of the major metropolitan centres such as Lahore, Islamabad and Peshawar.

**Need for modernisation**

Amid the unprecedented growth, Pakistan's foundry industry has fallen behind in its environmental and efficiency practices. The industry's reluctance to adapt to Western standards is now to the detriment of prospective exports, according to Rashid.

"There is a lot of machinery like flour milling, steel re-rolling, oil expellers, agri rotavators, tillers, planters and threshers being manufactured," he said.

"Most of this lacks the quality and features which could make these machines fit for the global market. A vibrant machinery manufacturing sector can quickly drive up demand for castings."

That said, the casting industry in Pakistan finds itself at a stalemate with exports due to the fact that foundries require sustained income before they can invest in the latest techniques and practices.

Compared with neighbouring India, many Pakistani foundries are not as diverse and cannot offer the same manufacturing capacity. Research and interaction at a tertiary level is also behind compared with many western counterparts.

"It appears that the present players, family owned foundry and auto parts manufacturing companies do not have the drive to make bold, modern investments," Rashid said.

"It is most likely that some multinational like Suzuki, Toyota and Honda subsidiary may move in to meet the demand for castings from their engine machining lines and start a growth cycle for Pakistan’s foundry industry."

With relatively low labour costs, low completion times and construction costs for new casting facilities and low tooling costs and local development costs of auxiliary foundry equipment, the time has never been better for said investors to take advantage of Pakistan’s favourable trading environment.
KS&EW is the only shipyard and oldest heavy engineering establishment of Pakistan catering for shipbuilding, ship repair and general/heavy engineering. It had a country’s biggest foundry also catering the in-house and commercial needs of public/private sector. Nearly seven years ago, the then management decided to dismantle/dispose of the foundry being old and obsolete and primarily to vacate the site to give room for the mega project of Ship Lift and Transfer System speculating the future commercial needs of shipbuilding/repair and submarines construction.

Realizing the present size of sugar vendor industry being around Rs. 22 billion, and considering the past pivotal role of KS&EW in producing sugar rolls and allied production activities, present management took initiative to re-establish foundry on other available area of KSEW, afresh, to again make the presence eminent in foundry sector of the country and to boost production activities of its large machine shop.

Accordingly serious efforts have been made by all to revive this facility at Karachi Shipyard. A 10 ton/hour cupola furnace, 5 ton and 1.5 ton induction furnaces and 300 kg non ferrous gas/oil fired furnace have been installed. All the equipments including furnaces have been manufactured in Pakistan to promote local industry. Cupola furnace shell has been fabricated in our yard. By Grace of Allah new foundry has started functioning in June this year.

The first lot of 07 sugar rolls was handed over to M/S Naudero Sugar Mill, in a gracious ceremony on 05 August 2015, attended by various sugar mills owners, representative of Pakistan Foundry Association, other stake holders and KS&EW high officials. In addition to this second lot of 20 sugar rolls will also be completed and delivered to respective clients, very soon.

Rear Admiral Syed Hasan Nasir Shah HI(M), M.D. KS&EW, said in his welcome address that Karachi Shipyard & Engineering Works is pioneer in the construction of sugar mills on turn-key basis in Pakistan. Shipyard has also been supplying quality sugar rolls catering the seasonal demands of various sugar mills all over the country. To continue this endeavor a new foundry has been re-established having greater capacity cupola furnace of 10Ton/hour. He assured that as the tradition will continue to commit timely quality production in future, as well.
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