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TECHNICAL JOURNAL 2022

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Association of Indian Forging Industry

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ASSOCIATION OF INDIAN FORGING INDUSTRY

Regd off: 101/112 Nyati Millennium, Off. Nagar Road,
Viman Nagar (Near Datta Mandir) Pune – 411014, INDIA
Telephone: +91-20-2663 4099/ +91-20-2663 4451 / +91-9322450873

WEBSITE:

www.indianforging.org

Foreword

To the reader of the journal,

Over the years, your Association has been publishing technical articles in its quarterly in-house magazine, Focus. And I am pleased to inform you that we have compiled a journal of all the technical articles that have been issued since 2019.

The Technical Journal 2022 is our minuscule effort to present our members with articles related to technological development under a single cover. The journal would also be available in the Publications Section on our official website-www.indianforging.org.

It is my sincere hope that this journal assists you in acquiring new Knowledge.

Thanking you,
On behalf of the Association of Indian Forging Industry
Trupti Vedpathak
Senior Manager

Contents

Development of Hot Forging Machinery Under the Industrialized Large-Scale Production Mode

By Mr. Jagen Zhong, China Forging Machinery Co., Ltd., China

Abstract: This paper expounds the development and trend of hot forging industry under the industrialized large-scale production mode, and it introduces the structural properties and process characteristics of several typical hot forging machinery, to clarify that various typical hot forging machinery have different adaptability under the industrialized large-scale production mode, which depend on the process characteristics.

Keywords: industrialized large-scale production, hot forging machinery, process characteristics, adaptability

1. The Development of Hot Forging Industry

With the development of economic globalization and industrialization, social large-scale production features gradually appear and the labor division is more and more detailed. Also, in order to realize scale management, industry producing mode gradually transfers from multi-kinds and small batch mode to single characteristic parts specialization mass production. Hot forging industry is no exception, in order to facilitate the realization of automation and intelligent production, some hot forging process special for parts (such as auto connecting rods, crankshaft, rocker arms, steer knuckle, hand tools, Mg-Al alloy and Ti alloy forgings) are gradually realized intensive, large-scale, professional production. Hot forging industry enterprises also gradually elongate its production chain from single forgings production, to realize specialized mass production from single forging parts to finished parts, even to assembly.

Forging machine is to meet the needs of process, and corresponding various types of hot forging equipment will be accompanied by the transformation of industrial production model and each play a different role.

2. Types and Performance Characteristics of Hot Forging Equipment

2.1. Die Forging Hammer

The die forging hammer is a kind of equipment using the kinetic energy accumulated by the working part (falling part or the movable part) to strike the forgings in the down stroke to obtain plastic deformation of the forgings, which has been playing an important role in the forging production. The emergence of CNC fully hydraulic die forging hammers has revived the forging hammer in the development of modern forging industry. Such kind of hammer is to give full play to the traditional forging hammer flexible, rapid deforming, comprehensive use of hydraulic, electrical and other modern transmission, control technology, not only has a simple and reliable structure, but also has a very thoughtful operation monitoring system, fault diagnosis system, energy automatic control system and program control system, which is the modern precision forging equipment with high-efficiency, energy-saving, environmental protection requirements, highly accurate, high reliability, cost-effective features and a wide range of adaptability in present forging industry.

2.2. Hot Die Forging Press

Hot die forging press is a kind of plastic forming equipment using the mechanical transmission, with same principle as general press to have flywheel and brake clutch for its transmission mechanism. Such press adopts the thick crankshaft, short crankshaft support distance, lower the frame height, large the frame section, short but thick connecting rod, the high rigidity mold height adjustment mechanism, to get the high overall rigidity and precision. Its slides stroke times can be 35-110 tims/ min. it is with the upper and lower automatic ejecting device to reduce the forging removing angle to be 2° or even lower, which can short die contacting time to improve die life.

2.3. Upsetting Machine

The upsetting machine is a kind of press, which is with two sliders (main slider and clamping slider), so it has two vertical die parting surfaces. It can be for forgings with long bar and also for continual forging for long billet. As there are two die parting surfaces, it can forge that parts with groove and concave holes, and the forgings shape is near to the parts required.

2.4. Screw Press

According to its driving mode, the screw presses can be divided into friction screw press, hydraulic screw press, electric screw press and clutch-operated high-energy screw press. Their common feature is to reserve the sufficient energy by the flywheel in the external force driven, and then through the screw to the slider to forge the blank. So, it is with the working performance of forging hammer and forging press. As there is no fixed down limit point, whether the working load or thermal expansion of the frame elastic deformation, it can forge the qualified forgings.

2.5. Hydraulic Press

The hydraulic press makes the workpiece deformation through its hydraulic static pressure, which is the basic difference with other forging equipment. So, it can get large working pressure and working stroke to press large workpiece or longer, higher workpiece. Such hydraulic press structure is simple and maximum loading is limited, so the die can be easily protected. Easy speeding adjusting is especially suitable for isothermal and super-plastic die forging. It can realize automation by its PLC. It is working smoothly, with small impacting and vibration, lower noise.

item	CNC fully hydraulic forging hammer	Hot die forging press	Screw press	High-speed servo hydraulic press
Working principle	energy limit	stroke limit	energy limit	loading limit
Load Properties	quasi-dynamic	quasi-static	quasi-dynamic	static
Deforming force control	on the amount of deformation	nominal pressure	on the amount of deformation	pressure controllable
speed of working stroke	≤6	0.06-0.2	0.6-1.2	0.01-0.3
max. speed without loading	6	1.5	0.6-1.2	1
Forging strain rate	≧10	1-5	2-10	0.01-0.06
Die contacting time	not controllable (subtle)	not controllable (milliseconds)	not controllable (milliseconds)	controllable (seconds)
Working frequency	≤100	40-75	15-20	≤20
Working stroke control	not controllable	not controllable	not controllable	controllable
Pressure holding control	not controllable	not controllable	not controllable	controllable
Working accuracy	good	good	normal	better
Anti-eccentric loading capacity	strong	strong	normal	normal
Die contacting impact	biggest	smaller	smaller	smaller (soft-contacting)
Die working space	small	small	small	big
Die heating online	no	no	no	OK
Ejector in upper die	no	OK	OK	OK
automation	very difficult	OK	OK	OK
Multi-kinds adaptability	excellent	poor	normal	normal
Non-ferrous alloy forging	not suitable	normal	normal	excellent
Machine weight index	1	3	1.5	1
Notable shortcomings	vibration, noise	complex structure and highest purchasing cost	poor anti-eccentric and lower frequency	poor anti-eccentric and lower frequency

4. Adaptability and Development Trend of Several Die Forging Equipment under the Industrialized Large-scale Production Mode The basic selection principle of hot forging equipment: equipment using characteristics (or parameters) must meet the process requirements and environmental protection requirements of die forgings, as far as possible to meet the requirements of automation, intelligent, and minimize production costs.

4.1. Forging Hammer

The outstanding advantage of forging hammer is the high striking speed, the high frequency, and the strong process adaptability, so the die contact time is short, especially suitable for the forgings requiring high-speed deformation to fill the die. The forging hammer can be multi-cavity forging, no needing pre-forging machine, simple and flexible operation, strong adaptability, suitable for multi-piece with one die process. On normal condition, there should be worker to operate, small machine can forge large parts. In order to improve the efficiency, the gripper will be used to shift the forgings between steps for small die forging hammer. Because upper die is difficult to set on the top die, and striking vibration, the general manipulator is very difficult to adapt.

The forging hammer is the forming equipment with the best performance price ratio, especially for large die forgings, the advantages of forging hammer is very obvious. One 800kJ hammer is equivalent to 40,000 ton die forging press, which cost is one-third of the press. The more than 400kJ large tonnage hammers are using compressed air driving on considering economy and reliability. Large-tonnage hammer user loaders or heavy-duty robots to grasp the workpiece, without considering gripper operation.

The forging hammer in the industrial production model, relying on its technological characteristics more suitable for multi-kind, small batches of thin and complex parts of the production, it is difficult to achieve automated production.

4.2. Hot Die Forging Press

The hot die forging press has high overall rigidity, the strong anti-deflection capacity of the slider, so the forgings have high dimensional precision, good surface quality and small machining allowance, which are mainly used for precision forging, hot extrusion and forging trimming process. The crank press stroke and pressure cannot be arbitrarily adjusted, not suitable for drawings long, rolling and the other billet distributing. In addition, the crank press has the characteristics of static pressure, which can forge some deformation rate sensitive low-plasticity materials. It has automatic ejecting device to realize automation. It is with high rigidity, and the precision of forgings is guaranteed, so it is suitable for single kind and large batches production. But the process characteristic is not suitable for the thin type and the complex part forging forming, so in normal condition, it is the big equipment to forge small workpiece.

4.3. Upsetting Machine

The working part of the upsetting machine is horizontal reciprocating moving, and the billet is placed horizontally during forging process, which length is not limited by the working space, so it is very suitable for the partial upsetting of the long rod forgings or forgings with holes. Forge die has two die paring surfaces, easy to remove forging from cavity, so it can forge the parts (with groove and concave on the two directions) that difficult to forge on the other machine. The upsetting machine is the most complex structure in the forging equipment, expensive, big investment, and needs to be equipped with special heating furnace for partial heating the billet.

The upsetting machine is with small die space and difficult to achieve automation. Relying on its process characteristics, it is generally applied to the semi-axis products of small batch production, which is poor adaptability to the industrialization of large-scale production mode.

4.5. Hydraulic Press

The hydraulic press deforms the workpiece by the hydraulic static pressure, with uniform deforming force and easy to obtain large working press and stroke. Due to the controllable working speed, it is especially suitable for isothermal forging, super-plastic die forging and non-ferrous alloy forgings sensitive to strain rate. With the increase of the output and variety of the lightweight forgings, the high-speed servo presses which are suitable for the light alloy hot die forging and isothermal forging will be developed.

The hydraulic die forging press trends:

(1). Increasing the speed without loading can improve its working frequency. CFM high-speed servo hydraulic die forging press speed without loading can be 1 m/s, but other general hydraulic press is not more than 0.3 m/s;

(2). Servo control the working speed to get wide adjustment of the forming speed;

(3). Soft die contacting is easy to use electric heating to keep the die temperature;

(4). On the basis of such high-speed servo hydraulic press, the special multi-direction forging or the compound forming press is researched for the Al-alloy deforming. The complex Al-alloy parts can be multi upsetting deforming on the condition of one die closing, to assure it deforming on the stress from three direction, which can reduce forming process and steps, also easy to be automatic during forgings, and easy to automatic loading and uploading billet and automatic die lubrication.

Under the industrialized production mode, the high-speed servo hydraulic machine developed by CFM will rely on its process characteristics, to apply more in the non-ferrous alloys and automatic production.

5. Conclusion

The die forging hammer, hot die forging press, upsetting machine, screw press and hydraulic press are the main and normal forging machines, which has their own structural performance characteristics and different adaptability. Under the industrial production mode, we should choose the most appropriate hot forging forming equipment, according to the characteristics of the forming parts, following the process-oriented principle, comprehensive consideration of specialization, batch, automation, low cost and environmental factors.

Application and Development of Isothermal Forging Technology and Equipment Technology

By Mr. Will Tian, Tianjin Tianduan, China

Introduction

Isothermal forging is a die forging technology originally developed through the natural phenomenon of super plasticity of materials, so it is also called super plasticity isothermal forging. It means that while forging materials with superplastic deformation characteristics, the alloy is firstly hot deformed (extruded, rolled or forged) near the normal recrystallization temperature to obtain ultra-fine grain structure; then secondly, at the superplastic deformation temperature of the alloy, and in the die which has the same temperature as the billet, die forged into the desired shape at a very slow speed. Superplastic isothermal forging makes the material in the superplastic deformation state during the forging process, which effectively improves the deformation performance of the material. Therefore, some materials that cannot be deformed by conventional hot forging method can be processed. At the same time, near net forming or net shaping of complex shape and structure forgings can be realized, so superplastic isothermal forging can be called near net forging process.

Isothermal forging is to heat the forging die to the same temperature as the billet for deformation. Even in the process of deformation of the forging billet at low deformation speed and long holding time, the temperature change can be lowest. Therefore, isothermal forging gradually goes beyond the traditional category of superplastic isothermal forging in practical applications, not only to pursue the development of material superplasticity, but also to use the forging process of forging billet to have a stable temperature field distribution, to ensure good deformation properties of materials and forming properties of forging billet. Generally speaking, isothermal forging refers to a forging process in which the forging die and billet are heated to basically the same temperature, and the forging is formed at a relatively slow deformation rate (or strain rate).

With the development of modern aerospace technology, the materials used are becoming more and more resistant to high temperature and difficult to deform. Superplastic isothermal forging is one of the most reliable key technologies for the production of new powder metallurgy superalloy turbine discs, TiAl and other intermetallic compound blades. In addition, the material has the best forming performance in superplastic forming because the material in each part of the workpiece is in or near the superplastic state. Superplastic forming can produce complex shape parts which need multi-processes to be formed or can not be formed at one time. It can also realize the integral forming of multiple parts at one time, which can reduce the processing allowance and realize near-net forming of components. Therefore, superplastic forming is of great significance to the forming of complex components of Difficult-to-deform materials in aerospace and other fields.

1. Technical advantages of isothermal forging.

Isothermal forging heats the die to the same or near temperature as the forging deformation. Lower strain rate is adopted to keep the forging temperature constant for a longer deformation time, which effectively improves the hot working performance of the material. Compared with conventional die forging, its technical advantages are mainly embodied in the following aspects:

- **Improving the Forgeability of Materials:**

Magnesium alloys, titanium alloys, nickel-based superalloys, intermetallics, ceramics and other refractory materials are very sensitive to deformation speed and temperature, the range of forgeable temperature is very narrow, and the hot working performance is poor. Therefore, when conventional hot forging is adopted, there are problems such as high deformation resistance, high forging load, multiple forging and easy cracking.

The increase of deformation speed and the decrease of deformation temperature will seriously affect the deformation properties of materials and the quality of forgings. Isothermal forging keeps the temperature constant during the material deformation process, and adopts very slow deformation speed, which effectively improves the hot working plasticity of the material itself. It can realize the forging of the material which is difficult to deform by conventional hot forging method and improve the Forgeability of the material.

- **Reducing Forming Load of Forgings:**

Forming load of forgings is related to material, deformation temperature, deformation rate and lubrication. During isothermal forging, the material's deformation resistance is very low under superplastic condition, which is only one-tenth to several-tenth of that of common die forging; the temperature of isothermal forging die is the same as that of billet, so that the workpiece will not have temperature drop when it touches the die; at the same time, the friction between the workpiece and the die can be reduced into the lowest by good lubrication conditions. Combining the above factors, the deformation force required for isothermal forging is usually only 10-20% of that for conventional hot forging. Therefore, large and super-large precision forgings can be forged on isothermal forging equipment with smaller tonnage.

- **Improving the Utilization Rate of Forging Materials:**

By heating the die to the same temperature as the forging billet, the isothermal forging process keeps the forging temperature constant and reduces the strain rate, especially by making full use of the Superplasticity of the alloy, which effectively improves the hot working performance and metal fluidity of the material. When designing forgings, isothermal forging forgings can have smaller transition roundness, drawing inclination and surface processing allowance than conventional hot forgings. According to statistics, the consumption of metal materials in superplastic die forging is reduced by more than half compared with conventional die forging. Figure 2 shows the contours of isothermal forging nickel-base superalloy disc and conventional hot forging.

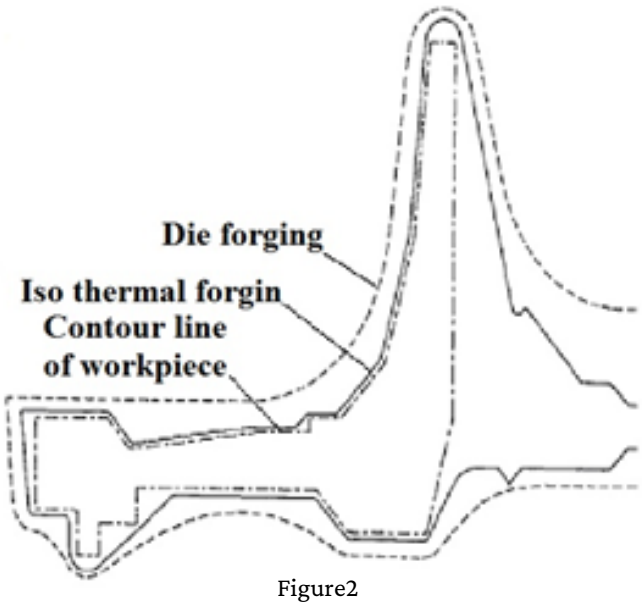


Figure2

Contour comparison between isothermal forging and conventional forging of Superalloy disc forgings

（4）Realization of Short Process Forging:

Die temperature of conventional forging is low, the cold die effect of forging process makes the temperature of billet cooled under malleable temperature before full of cavity, the billet must be re-heated and re-forged, so many times of reheating and re-reheating can fill the die cavity. Due to the difficulty of metal flow, in order to reasonably distribute metal flow and deformation, it is generally necessary to have multiple sets of dies and multi-heat pre-forging.

In isothermal forging process, the billet will not cool, especially when the material enters the superplastic state, the one-time deformation can be very large. The billet with simple shape can be used, and no more than one set of dies need to be heated. One die can forge complex forgings at one time, thus realizing short-process forging. Fig. 3 is an isothermal forging disc of titanium alloy with a profile size of 500-560mm. The disc-shaped billet is forged by one-time forging. The processing allowance of one side is 1.5mm on the dimension of ultrasonic flaw detection.

Improving Uniformity of Metallurgical Quality of Forgings:

Isothermal forging reduces or even eliminates the temperature drop caused by contacting the cold die during billet forging process. Low deformation speed and long holding time can be used to realize slow speed deformation. Temperatures in all parts of forging during isothermal forging process are basically the same. After superplastic forming, the metal grains are still equiaxed and the forgings are uniform. The yield strength, fatigue property and stress corrosion resistance of forgings are improved remarkably by homogeneous fine grain structure and isotropy. Therefore, the metallurgical quality of isothermal forging forgings is more uniform than that of ordinary forgings and the microstructure and mechanical properties of isothermal forgings are better than those of ordinary forgings.

2. Development of Isothermal Forging Equipment Technology

Isothermal forging generally requires lower deformation speed. The forging equipment is mainly hydraulic press. In order to meet the special technological requirements of isothermal forging, the isothermal forging hydraulic press should not only have the basic characteristics of ordinary hydraulic press, but also meet the following requirements:

(1) It can adjust speed and control strain rate: the speed of general hydraulic press is about 10-30 mm/s when working and it can not achieve quantitative control; while isothermal forging press requires that the speed of slow working can be accurately controlled. It is generally required that the micro-speed adjustment range of the equipment can reach 1-0.001 mm/s, and the strain rate should be accurately controlled in the range of 10-4-10-1/s. In some cases, isothermal forging process also requires the equipment to keep pressure at a certain pressure level.

2) Ejection device: Isothermal forging is the precise forming of forgings under the condition of slow deformation. The size and shape of isothermal forgings are closer to the parts, the die angle of forgings is small, and the shape of forgings is complex. Therefore, the phenomenon of "sticking die" appears after isothermal forgings are formed. Isothermal die forgings usually need special ejection device. For the forgings with complex cavity structure on the upper and lower ends, there are also two ejection systems.

3) To meet the special requirements of heating and protection of isothermal forging dies: because isothermal forging requires continuous heating of dies during forging process, corresponding die heating system should be equipped; in order to prevent heat transfer from dies to hydraulic press, cooling system or heat insulation device of dies should also be equipped; therefore, isothermal forging hydraulic press should not only be equipped with cooling system of dies but also with heat insulation device. It meets the requirements of closing height and space dimension of worktable when forging specific workpiece, and also meets the requirements of installation and disassembly of dies, heating devices and insulation devices.

When using refractory metal alloy TZM as die material, it must be used under the protection of vacuum or inert gas. It is necessary to set up a special closed vacuum or inert gas protected die heating furnace and an automatic manipulator which can operate continuously.

3. Research Progress of Isothermal Forging Technology of Tianduan

Aiming at the rapid development of hydraulic press and equipment for isothermal forging, 250 MN (maximum working capacity 300 MN) put into production in 2018 is the largest special hydraulic press for isothermal forging in the world, and 200 MN produced by Shanxi Hongyuan Aeronautical Forging Co., Ltd. in 2014 is the second largest isothermal forging hydraulic press in China

In terms of the performance of hydraulic press, the control level of low-speed stability in the current speed control index of hydraulic press can reach 0.02mm/s. It not only has the function of speed curve following control, but also has the function of strain curve following control. The fluctuation can be basically controlled in the range of 5%. The similar products in Germany are about 0.01 mm/s. In the aspect of precision control, with the help of leveling technology and slide, the precise positioning control technology of worktable can achieve the accuracy of less than 1mm from the shape control of the workpiece, and can also realize the leveling without loss of tonnage. The leveling accuracy of the equipment can reach 0.1mm/m, and that of the similar equipment in Germany is 0.25mm/m.

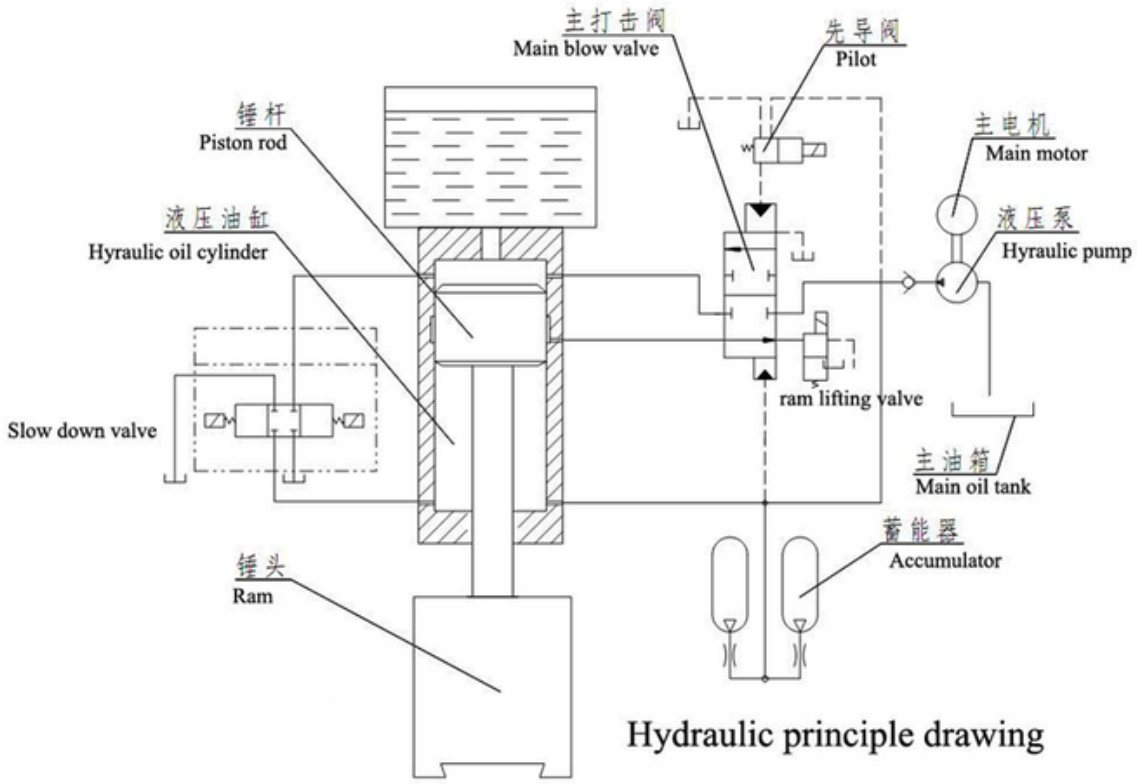
Introduction of CNC Fully Hydraulic Closed Die Forging Hammer

Anyang Forging Press Numerical Control Equipment Co., Ltd

With the development of automobile, aerospace and other modern industry, more and more precision forgings are required in the market, the quality requirement of forgings is also becoming higher and higher . How to maximize the precision forgings requirements for equipment design and development applied to products is the key point both users and manufacturers should consider. CNC fully hydraulic closed die forging hammer can highly satisfy the requirements of precision closed die forgings.

I. Working principle and features of CNC hammer

1. Working principle



Oil pump – accumulator as drive, constant pressure oil is always connected with lower chamber of main cylinder, upper chamber of main cylinder is independently controlled by hydraulic system.

When inlet valve of upper chamber (also called hitting valve) is open, pressure oil from oil pump, accumulator and bottom chamber will flow into upper chamber, then piston (connected with ram) is accelerated downwards and makes blow.

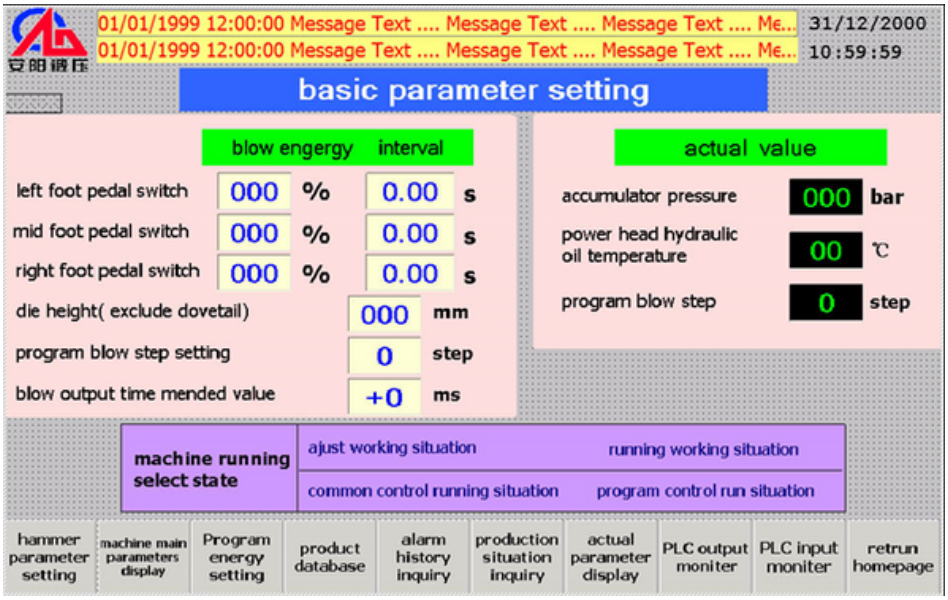
Once pressure of upper chamber is released, piston will be returned immediately.

Precise control of blow energy is realized by numerical control system through controlling closed time of hitting valve.

2. Features of CNC hammer

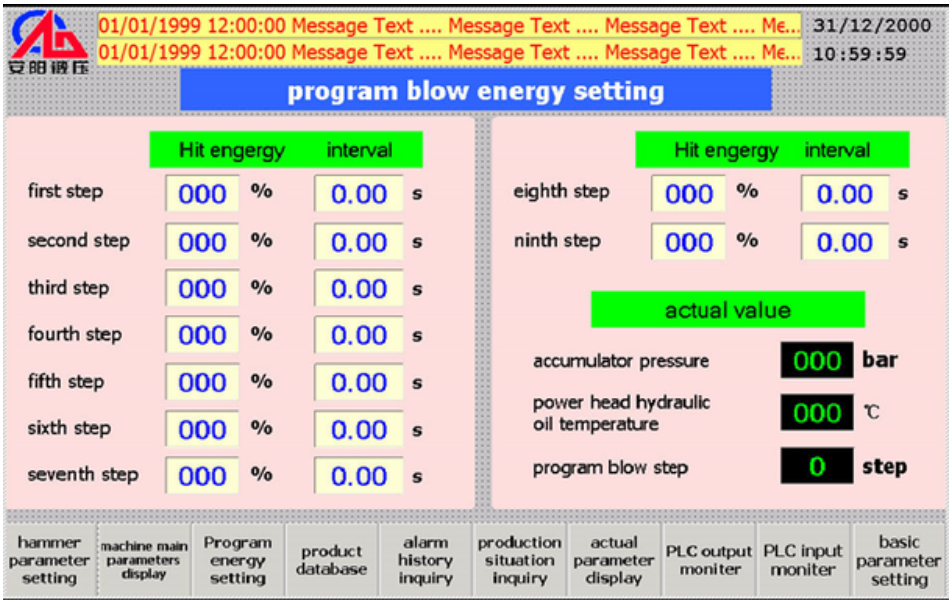
(1) Blow energy can be accurately controlled.

Blow energy can be adjusted by 1% or more increments between 1-100%; Blow energy can be controlled at ±1.5%. If input different die height, the system can automatically adjust parameters to assure energy's identity and accuracy.



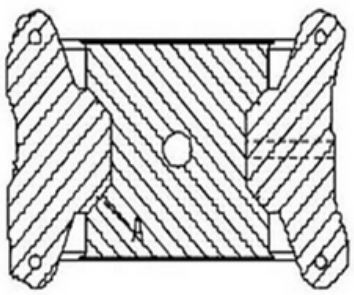
(2) Blow procedure can be controlled by digitization

Blow step can be set as per the customers requirement. Forging process parameters can be set as per requirement . It can save hundreds of forging craftwork programs, and it is compatible with all kinds of forgings craftwork library.



(3) Forging precision is high

Hammer frame use single piece steel casting “U” shape frame. It adopts “X” shape guide rails, clearance of guide rails is small which ensures the guide precision of ram, so it can realize precision close die forging.



(4) Blow frequency is high

With big ram and short stroke structure, and hydraulic double-acting drive, very high blow frequency is achieved while ensuring enough energy. Practice proves it can make 30% more production than ordinary hammers.

(5) Die life can be greatly increased.

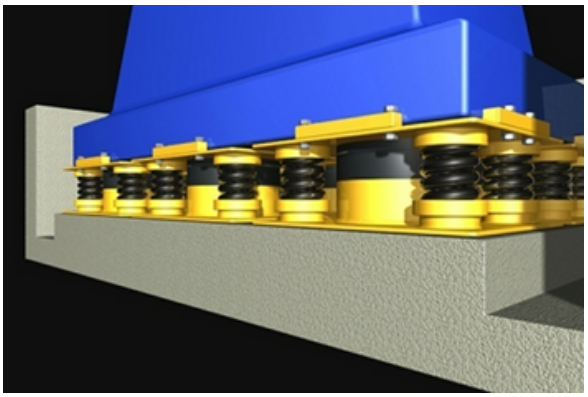
Blow speed is fast, forming and cold hitting time is short, this decreases thermal stress of dies;blow energy is accurately controlled, blow energy only works on forgings , no excess energy working on dies; Die life is about two times of ordinary hammer.

(6) Material using rate is high

CNC forging hammer single side guide rail clearance can be adjusted to be around 0.15mm, Top die and bottom die mismatch less ,the forging precision is high and forging flash is small , the material utilization is high.

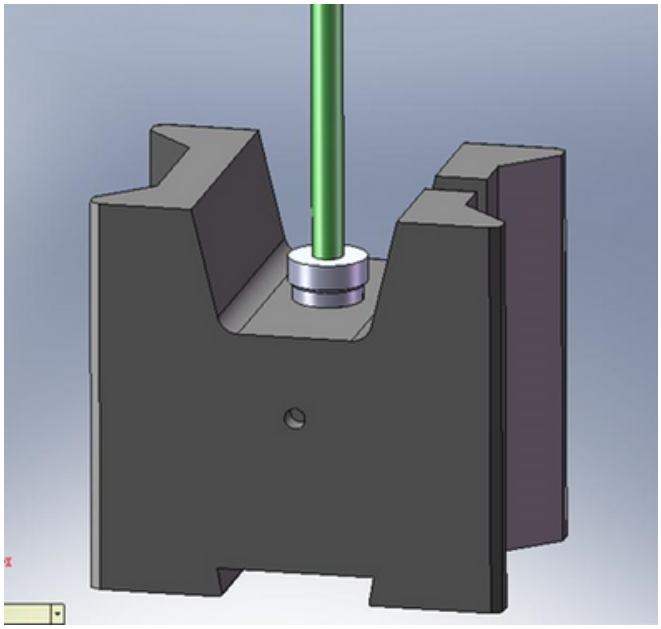
(7) Low noisy and low vibration

“U” shape solid casting frame produces lower hitting noise than box type and arch column frame.Adopting vibration isolation device can reduce 90% vibration.



(8) Hammer rod life is long

Adopting thin hammer rod, the hammer rod and hammer tup forming elastic buffering structure, making hammer rod from wear part to long time use parts.



(9) System running is safe and reliable

Adopt plug-in sensor to monitor oil temperature changing and overall process PID (cycle control) for adjustment in order to assure system running is safe and reliable; Adopt safety valve, after lifting ram to the top point, safety pin can eject out to avoid hammer head falling suddenly; Adopt long piston structure ,use more sealing rings and use Germany sealing rings on piston make the sealing very reliable;

(10) Automatic timing lubrication device

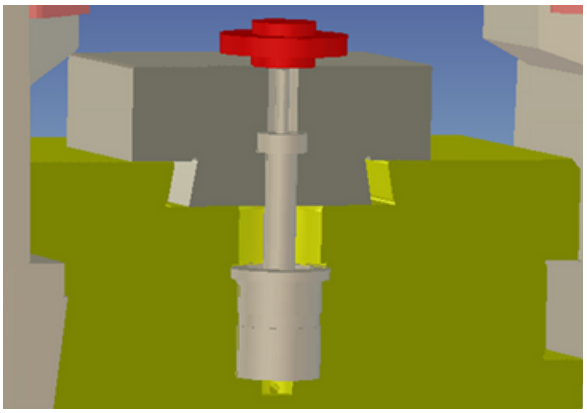
Through PLC control, guide rail lubrication pump can do timing lubrication, long time or short time can be adjusted. Also lubrication can be done manually.

(11) Dies can be changed and adjusted safely, easily and quickly

The hammer has slow up and slow down action, which can stop at any position, this makes it very safely, easily and quickly to change dies . Because the upper die and lower die adopt double wedge structure, which can adjust dies to left and right align, aligning key can adjust dies' front and back to satisfy all kinds of adjustments.

(12) Hydraulic Ejector

With ejector, deep cavity forging can be done on CNC hammer, meanwhile it can reduce the angle of die pull out, increase material use efficiency and reduce machining cost.



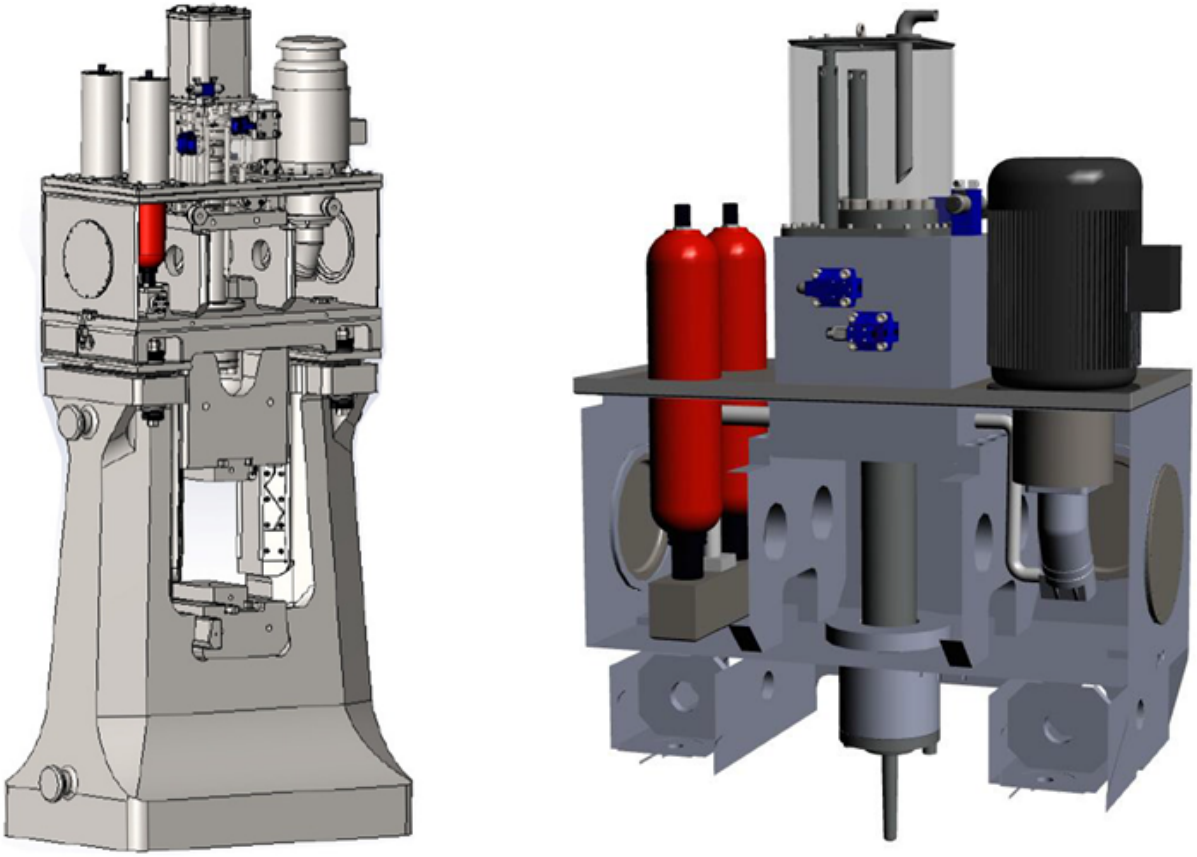
(13) Convenient machine maintenance

Remote program adjustment, running condition and fault monitoring can be carried out via internet.

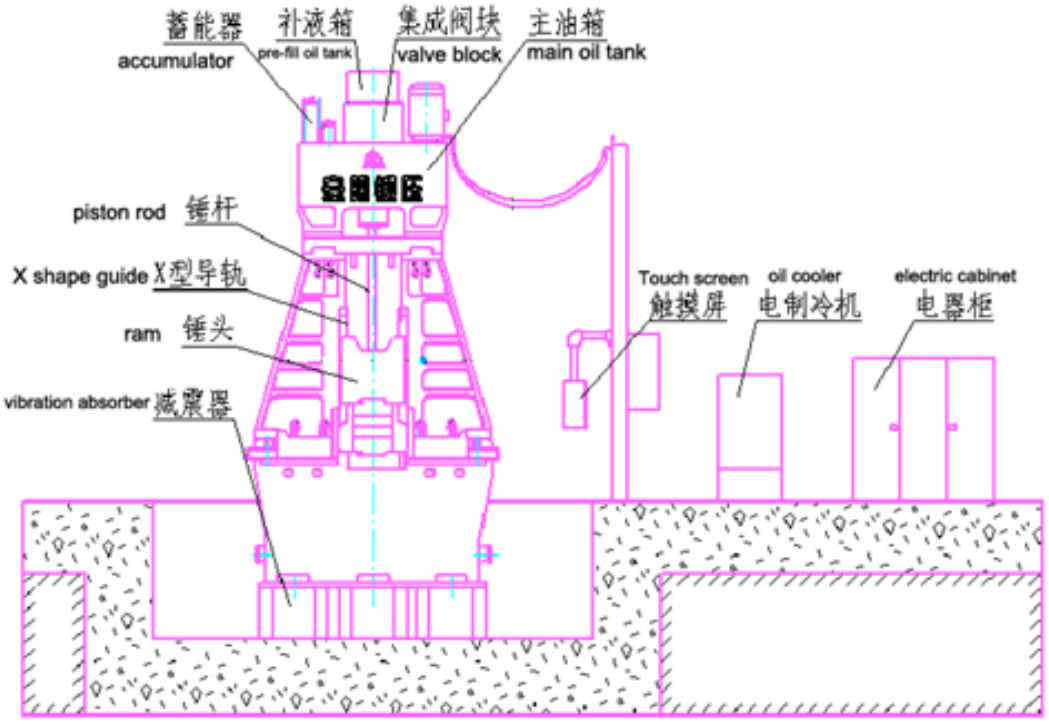
(14) Easy to realize automation production

Blow procedure and energy can be achieved by numerical control, this makes a good base for robot to put on and lay off materials automatically, and automatic product line can be achieved easily.

Structure of CNC hydraulic closed die forging hammer



Modernization of pneumatic or steam closed die forging hammer to be CNC hammer



The prospect of CNC hammer and its automatic production line

Among existing closed die forging hammers in the world, more than 80% are traditional closed die forging hammers . The traditional steam or pneumatic forging hammer energy efficiency is less than 2%, The blow energy of the traditional forging hammers are uncontrollable, forging production entirely by manual operation, the forging accuracy is greatly affected by the skill of forging workers. The working intensity of the workers is very big and die life is very low.

Now more and more forging companies are interested in using CNC hammer and its automatic production lines. Step by step the old forging hammer lines will be replaced with this CNC hammer forging lines.CNC closed die forging hammer has the advantages of good repeat accuracy, high die match precision, high speed, high efficiency, programme control of hit energy and processes, it is already widely accepted by the worldwide forging companies. CNC fully hydraulic closed die forging hammer and its automatic production line is the inevitable trend in forging industry, the future forging production mode will have a tremendous change.

The Right Drive Unit Every Time

By Mr. Martin Scholles, SMS group GmbH, Germany

SMS group has set itself the goal of creating competitive advantages for its customers with innovative ideas. To this end, new drive concepts are being implemented for closed-die forging presses and ring rolling machines. These can also be transferred to other plants and equipment.

For years now, the demands paced on suppliers to the automotive industry have been heading in one direction only: Up; stricter emission standards, increasing performance requirements, and higher expectations in terms of driving comfort are making life difficult for manufacturers – and are also having an impact on business in upstream sectors. Musashi Europe is facing this challenge head on. For almost 100 years, the company has been supplying components for driveline and chassis technology. At its plant in Bockenau, Germany, Musashi soon plans to manufacture large, rotationally symmetric forgings on a new press that utilizes an innovative drive concept. A concept that was designed and built by plant engineering specialist SMS group.

Low speed, great effect

The first new press of this kind went on stream in 2015. The machine, which was actually developed for test purposes at the time, quickly found a buyer. Its energy consumption – which is easily confirmed after more than 25 million strokes – is around 20 percent lower than comparable conventional presses. To exploit potential like this to its full, SMS group started looking at new drive system options. This led to the idea of utilizing torque motors. A characteristic feature of torque motors is their very high torque at relatively low rotational speed. Used in the right application, they replace a conventional servo motor and its complex reducing gear.

"Our customers in the automotive supply sector are under tremendous cost pressure", explains Martin Scholles, Project Manager for Sales Closed-die Forging Presses at SMS group in Mönchengladbach. "They have to demonstrate savings on an ongoing basis – in most cases these can be between two and three percent every year." At the same time, however, their expenditure is increasing – for wages and energy, for example. That is why automotive suppliers are under particular pressure to reduce costs.

Caption: The first MT 630 eccentric press with MEERtorque® drive unit at SONA BLW Präzisionsschmiede GmbH, Germany

Concentrated knowledge

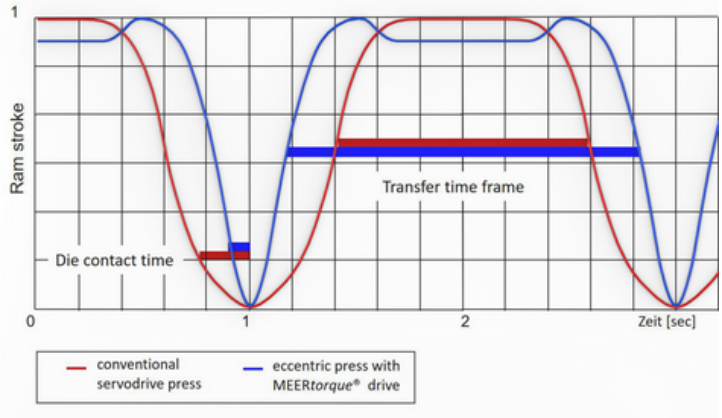
At SMS group, sales, technology, and design experts pooled their knowledge to find solutions to the problem and gain a vital edge over the competition. And it worked. “No one else has this torque drive for presses”, adds Scholles proudly.

At the first glance, the drivetrain of the press looks alike the drivetrain of a conventional press with a clutch and a flywheel. The special feature of the system is its type of acceleration. Instead of accelerating with the conventional friction clutch, it uses a torque drive, which is attached directly to the eccentric shaft. As soon as the shaft reaches the same speed as the flywheel, the clutch is engaged without any friction losses.

The energy provided by the flywheel can then be used for the required forming work. After forging the clutch is released again. To decelerate the drivetrain, the torque motor is switched to generator mode. The energy is either fed back to the power supply net or charges the flywheel to bring it back up to speed. “In conventional presses, this energy would be lost but our press can use it again. In this way, we are now one step closer to perpetual motion,” says Scholles.

The flywheel itself is also accelerated, maintained at speed and decelerated by a torque motor. This concept allows a swift startup and stop of the flywheel witch saves precious time when interventions at the tools are needed.

“The drive also separates motion sequences that, in the past, were necessarily performed in direct succession”, remarks Scholles. “This gives us a greater degree of freedom, from which the customer can benefit.” The time windows for transfers, for example, are longer as a result.



Caption: Distance-time graph at 30 strokes/min – Compared to conventional servo presses, the MEERtorque® drive system enables shorter pressure dwell times and longer transfer time windows

SMS group stands by flywheel concept

With the new press type, SMS group is standing by the design variant with built-in flywheel. "We firmly believe that this is still the most efficient way of providing energy", says Scholles. By contrast, the servo presses offered by our competitors have no flywheels. Their energy input, which can be in the megawatt range, needs to be supplied from the mains. This results in voltage peaks and in higher energy consumption costs with rival products. “Our system has also peaks, but they stay within the intermediate circuit of the inverter. It has no exceptional external impact, i.e. on the mains."

The idea for this "unconventional servo press" was born in 2014. With this machine, the goal – as well as improving efficiency – was to make it more maintenance-friendly and so reduce costs for the customer even further. According to Scholles, this works because the rate of wear is far lower with this system. Whole assemblies are no longer required, like the operating brake, for example; only the motor is used for braking. In addition, the clutch can be sized smaller shows virtually no wear, as the clutch is engaged when the eccentric shaft and flywheel are running at synchronous speed. Due to the use of the torque motors, all these advantages can be achieved while avoiding complex gearsets.

Electrohydraulic drives for ring rolling machines

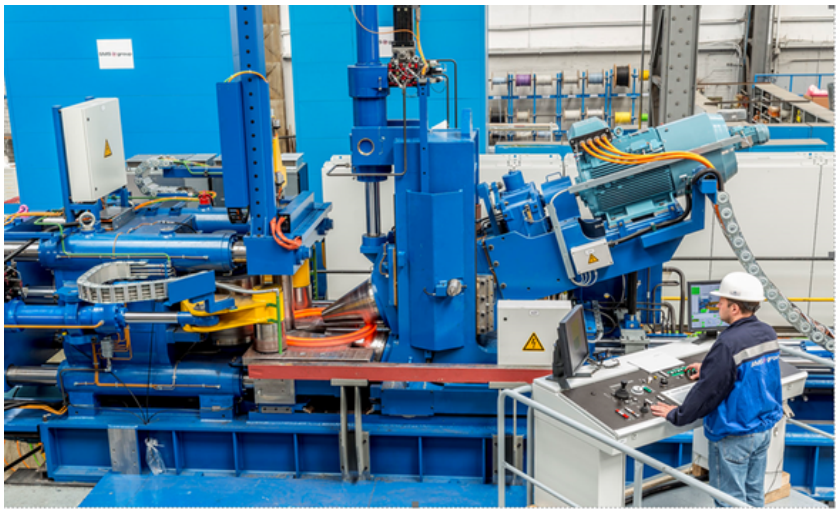
The new concept pays off in many respects at once. As a result, it meets the objective SMS group set itself – to work with customers to find the most cost-effective solution for manufacturing the products they want. "We are always thinking about what we can change to create unique selling points that bring benefits to our customers", adds Martin Gellhaus, who is in charge of sales for ring and wheel rolling plants at SMS group. He prides himself on a new development for ring rolling machines that has been on the market since 2016. Up to now, machines with a rolling force of 100, 200, and 1000 tons were sold.

What drove this development was the desire to reduce energy consumption, especially as the machines are at a standstill for up to half the time during the ring rolling process – either because they are being loaded or unloaded, or because the operator has to wait until the workpieces have been heated. So, to reduce energy losses resulting from these relatively high dead cycle times, experts at SMS group came up with the idea of using electrohydraulic direct drives. "Our colleagues in the specialist departments have very wide-ranging knowledge of electrical and hydraulic systems", explains Gellhaus. "So for them the obvious questions was: Why not use the drives that work well in other areas for ring rolling machines too?"

Precisely controlled movements

With the electrohydraulic direct drive, a motor drives a pump, and this is converted into a movement in a hydraulic cylinder. If the speed of the pump is reduced, energy consumption and noise emission levels also drop significantly at the same time. In the case of ring rolling machines, these drives are mounted directly on the rolling axes. This means that they can be controlled extremely precisely – without the movement losing any of its force. When the axes are stationary, the pump is decelerated, at which point the motor does not consume any energy.

Therefore, the drive power required is around 25 to 40 percent lower. The noise level is also reduced by about 15 percent. Another major advantage of the concept known as RAW EH is the lower investment and operating costs compared to conventional ring rolling machines. As the central hydraulic system is no longer required, a room does not have to be built specifically for it, as was usually the case up to now. The costly and labor-intensive pipework is also no longer needed. The volume of hydraulic oil can be reduced by 90 percent. In addition, there is no danger of environmental pollution from escaping oil. This concept incorporates the expertise accumulated with over 500 ring rolling machines that have been built to date. The experience gained with the electrohydraulic compact drives shows just how well the position and force of the axes can be controlled. The reduced number of components means the system is highly robust and barely susceptible to faults.



Caption: The hot commissioning of the RAW ecompact® was performed in-house at SMS group: this reduces installation work in the customer's plant.

The RAW ecompact® series was developed for newcomers to ring rolling as well as for job shops. It is available in five sizes – from 63 to 125 tons of rolling force. The RAW ecompact® boasts SMS group's Ecoplants plants label, which the company awards to efficient plant solutions.

Transferable concept

These innovations do not signify any major change for either SMS group engineers or customers. "Nothing is different for the operating personnel – the look and feel of the machine are still the same. We have to train the maintenance personnel, but that's also the case with conventional drive units", explains Martin Gellhaus.

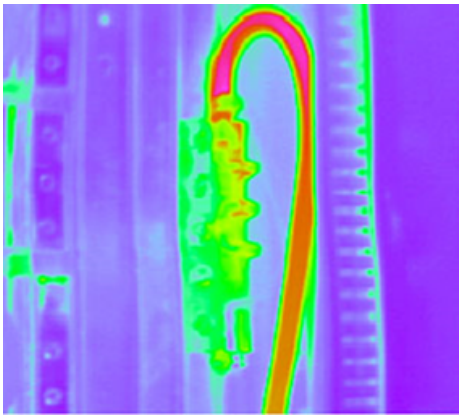
"In terms of the mechanical equipment, other cylinder types that are installed differently in the machine are used", he says in reference to his own team's work. "But those are typical modifications, which are an engineer's daily bread."

Gellhaus can well imagine fitting electrohydraulic drives in other products – like wheel blank presses, for example. "With wheel blank or dishing and piercing presses, we could apply the same principle we introduced for our ring blank presses", he continues. In 2014, SMS group developed a concept for utilizing speed-controlled axial piston pumps in a 2000-ton ring blank press. Each cylinder drive train consists of four motors. What's special about this principle is that the power supply for the actual forging process is separated – in this case from the power used for lifting and lowering. The cylinder surface areas can be adjusted by means of valves: the cylinder surfaces are large during forging, which produces high forces at low press speeds. During rapid traversing movements – i.e. lifting and lowering – small surface areas bring about small forces and high speeds. The movement of the press is reversed by switching the rotational direction of the servo drives.
This allows energy to be used efficiently here too. As well as applying the power-on-demand principle, the potential energy of the moving mass during lowering is converted into electrical braking energy, just like the decompression energy and the elastic spring energy of the press frame in an unloaded state. This energy is saved in the converter's intermediate circuit and fed back into the mains.

Introduction of Power Supply and System Maintenance Cost Effective Preventive Maintenance

By Mr. Joe Stambaugh, Ajax TOCCO Magnethermic Corp., Ohio

Preventive Maintenance Keeps Induction Systems In Peak Condition



Thermal image indicating hot-water path in a component caused by reduced flow

Maintenance of induction equipment can easily be ignored by assuming that everything is fine as long as the equipment is operating. Ignoring original equipment manufacturers' (OEM) recommended maintenance schedules can create problems that are not apparent from just looking at the system. It has long been understood that as much as 90% of induction-system problems are water related. High-conductivity water usually is the culprit that causes cooling system erosion due to electrolysis. This reaction causes the erosion of vital copper components resulting in the collection of contaminating material, which reduces water flow. Lower water flow allows the system devices that are being cooled to overheat and fail prematurely. This is most common in water-cooling systems where high electrical potentials are present, such as silicon-carbide rectifier (SCR) and diode heat sinks and chokes (reactors). Use of lake, well and city tap water to cool an induction power supply can reduce the service life of an induction system by 30 to 50%.

Electrolysis causes erosion, resulting in a hose leak failure

Water-cooling systems

These usually are closed-loop systems that cool the power supply, capacitor (or heat station), water-cooled leads and bus, and the induction coils. It is important to remember that about 90% of the problems with induction systems are water related. This also is the most neglected item in induction, causing the most down time and damage. The following preventative maintenance will minimize water-related problems in an induction system.

Daily. Check the level of the water in the cooling system and top it off if necessary using only approved high-quality water. Never use well water, city tap water and high-conductivity water in the system as these will damage the system in a matter of weeks due to erosion or corrosion. OEMs recommend different types and qualities of water and additives (ethylene glycol, for example). Distilled, deionized (DI) and reverse osmosis (RO) are approved types of water, but usually require a glycol addition.

The glycol addition prevents the water from freezing and serves as a buffer to corrosion. A 30 to 40% ethylene glycol (uninhibited type) addition should prevent freezing in severe cold weather conditions, even during power outages. Glycol also prevents the water from becoming too aggressive to the materials in the system components. DI water by itself usually is too low in electrical conductivity (< 1 Kmho/cm) and is called "hungry." Always add glycol to plain DI water.

Every three months. Check the conductivity of the recirculating water using a hand-held conductivity meter. When the conductivity reaches or exceeds the OEM-recommended threshold, drain, flush and refill, then drain and refill the system again. Purge the system to remove trapped air. (See OEM manual for recommended cleaning and flushing practices.) Damage caused by poor water quality and system charging can result in tens of thousands of dollars in repair costs. Some power supplies have replaceable targets (anodes), which should be checked and replaced if necessary.

An example of the cooling water specification for recirculating water used to cool induction power supplies that do not use targets is 15 ppm total water hardness (CaCO3), 25 ppm total dissolved solids, 20 - 70 Kmho/cm conductivity, 10 ppm maximum suspended solids and 7.0 - 7.5 pH. An example of the cooling water specification for recirculating water used in an induction power supply that has replaceable targets is 100 ppm total water hardness (CaCO3), 200 ppm total dissolved solids, 50 - 300 Kmho/cm conductivity, 10 ppm maximum suspended solids and 7.0 - 7.5 pH.

Every spring. For maximum cooling efficiency, all cooling water systems should be drained and flushed with fresh clean water for a few hours, drained again, then recharged. Also, clean the "Y" strainers in the system at this time. Remove a few hoses during draining and cleaning, especially where hoses are looped, and inspect for erosion and deposits on the copper fittings and inside the hoses at both ends. Clean hoses indicate good system maintenance. The presence of corrosion and deposits indicates the need for more frequent conductivity testing, flushing and cleaning. Corrosion usually is due to water solutions that have degraded, allowing the conductivity to rise.

Spring and fall. If necessary, adjust the temperature control sensor for the recirculating water-cooling system to prevent condensation from forming. The water-cooling controls usually have an adjustable set point connected to a solenoid valve that controls the temperature of the cooling water. In winter conditions, cooling water generally is controlled to operate at a temperature of about 75F (24C). Summer conditions often require a higher temperature (about 85F, or 30C) to operate above the higher dew point (higher summer humidity) and prevent damage caused by condensation. The presence of condensation in the power system can create destructive paths around high-voltage components.

Every other year in the spring. Remove the water to water heat exchangers for both the water-cooling system and the quench system. Use a solution of humidifier cleaner and a low-pressure pump to circulate the fluid through both paths of the heat exchanger to remove calcium scale build-up, which can restore full cooling efficiency of the heat exchanger. This requires using a small valve to regulate flow and some hoses for connection. Pumping for two hours usually is sufficient. However, the heat exchanger and the humidifier cleaning fluid may need to be replaced if there is a large amount of calcium inside. This cleaning method is preferred because the humidifier cleaner is user friendly and nontoxic

Collector bus shows signs of heating and possible condensation; bus section at lower right shows signs of overheating

Cooling towers

Cooling towers are designed to remove heat from water and dissipate the heat into the atmosphere. Two common types are dry towers and evaporative towers.

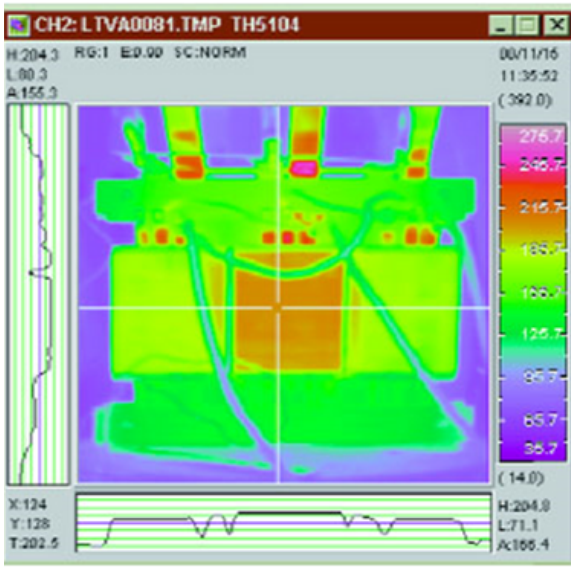
Dry tower systems consist of a motor and pump with an expansion tank and tower, which is made up of cooling tubes, fins and fans. They are low maintenance systems compared with evaporative systems, but lack the cooling capabilities of the latter. Yearly maintenance of a dry tower requires the following:

- Drain the water in the spring, flush with clean water and recharge with a 30 - 40% ethylene glycol-water solution (depending on geographic location) to prevent damage due to corrosion and freezing
- Remove dirt from the surface area of the cooling fins using a high-pressure power washer to restore the tower to maximum cooling efficiency
- Lubricate the pump and motor as required and check seals and gaskets for leaks
- Lubricate the fan bearings and bushings as required

Evaporative tower systems, consisting of a recirculating pump, heater, sump pump, fans and cooling fins, require more maintenance than dry types. Yearly maintenance is the same as for dry tower systems plus the following:

- Lubricate the pump(s), motor, bearing and bushings
- Check seals and gaskets for leaks.
- Remove dirt that has accumulated in the sump pump and reservoir.
- Check to ensure that the sump pump heater is functioning properly. This is very important because the heater prevents freezing of the sump pump water during winter operation.

Suggested water quality requirements for both dry and evaporative cooling towers are 100 ppm total water hardness ($CaCO_3$), 200 ppm total dissolved solids, 20 - 300 Kmho/cm, 10 ppm suspended solids and 7.0 - 7.5 pH.



Infrared image of a transformer shows the center winding being hotter the outer windings

Power supplies and heat stations

The power supply and heat station, which are the most expensive parts of a production induction heating system, are the most likely to be ignored. Maintenance requirements and frequency schedules are given below.

Daily inspection:

• Inspect inside the cabinet for water leaks, drips and condensation. This must be done with the cooling pump on, at the beginning of the shift after the unit has been idle all night, and again at the end of the shift while the system is warm. If tightening a hose clamp cannot stop a leak, replace the hose. Never reduce the length of a hose; some hose connections have a specified length and may have loops to prevent electrical conduction and subsequent electrolysis of the copper tube at the end of high-voltage dc potentials.

• Test the ground leak detector; see the OEM manual for details.

Monthly inspection:

- Check for loose connections of all ribbon connectors and wires on terminals.
- Tighten loose connection using only a screwdriver; never overtighten.
- Visually inspect for overheating (discoloration) of bus connections, SCRs, diodes and other components including transformer and capacitor connections, and tighten using appropriate tools. Do not over- torque SCRs. If the system has mechanical contactors, inspect the contact pads and springs and adjust or replace worn components.

Yearly inspection:

- Test all door interlocks. Check the OEM manual as each manufacture has its own requirements for this very important safety test.
- Inspect the power supply and heat station using infrared thermal imaging, which identifies hot spots and provides information that can be used to identify potential problems during operation.
- Check power-supply battery backups used for logic memory; some batteries require replacement annually, while others have a five-year life. Check the OEM manual.
- Check water-cooling hoses. Hoses become brittle and are susceptible to leaks and complete failure. Depend-ing on many factors, such as ambient heat and humidity, water-cooling hoses may need replacement every five to ten years. Use only the same type of nonconductive hose as originally supplied, and never shorten the length of any hose when replacing it.
- Wipe the inside of the power supply and heat station interior using plain hot water and detergent to remove any loose dirt. Allow the unit to dry before starting it. Rust spots on the floor of the cabinet should be removed by sanding and painted using white enamel, which makes it easier to detect leaks later. Never operate the system with the doors open and never use cooling fans to cool the inside (to prevent the unit from overheating during extreme hot weather). This practice allows a large amount of dirt to get into the unit, which is not easily removed.

Every five years: Replace all door gasket material to keep a good seal and to keep dirt out.

• accessible. Bolts and washers on the bus and coil connections should only be nonmagnetic stainless steel or silicon bronze. Never use carbon-steel washers and bolts. Hardware should include a flat washer, lock washer and a bolt long enough to engage at least three full threads. The recommended torque for a 0.375 in. (10 mm) brass bolt is 23 to 25 lbf ft (31 to 34 N ?m), 45 to 50 lbf ft (61 to 68 N ?m) for stainless steel and 40 to 45 lbf ft (54 to 61 N ?m) for silicon bronze. Use of plain brass hardware should be avoided. Follow the manufacturer's recommended torque specifications. Do not overtighten

Forging coils and water-cooled skid rails

Coils used to heat a workpiece for forging either are lined with cast refractory or have a ceramic liner. The following maintenance should be performed on a daily basis:

• Blow all loose scale out of the coil opening and check coil connections for tightness, daily. If scale is not removed, it builds up inside the coil and works its way into microcracks until it contacts the copper surface, which causes overheating and arcing, and results in coil failure. Wear safety goggles when using compressed air.

• Inspect the exit end of the coil where the highest temperature occurs. Patch as needed to eliminate direct exposure to heat radiation from the part and to reduce the chance of arcing. Remove loose scale and refractory that is cracked or contaminated by grease and oil. Rough up any area that has a glassy appearance using a file. After installing the patch, use a heat lamp for several hours to cure the refractory.

Follow the OEM casting and patching procedures. Flush the copper tubing using humidifier cleaner as described earlier. Never use refractory that is out of date. Refractory and the water used to mix it should be used at the same specified temperature. Premix an entire bag to get even consistency. Reseal partially used bags in an airtight container to keep out moisture. Cover freshly poured refractory using plastic to allow moisture to weep (usually overnight is sufficient), then dry in an oven at progressively higher temperature per refractory instructions. If an oven is not available, leave the plastic in place an extra day, remove and let air cure for 12 hours, then apply the heat lamp.

Every week, inspect water-cooled rails for wear and inspect water-cooled leads for wear and connection tightness. Replace rails as needed. The OEM should recoat (hardface) the rails. The supplier often can rebuild defective leads at a lower cost than purchasing new leads.

Air and hydraulic components

Air-operated doors, workpiece locating centers and solenoid quench valves (easily forgotten parts of a system) and hydraulic devices require regular maintenance. The filter, lubrication and regulator (FLR) should be maintained per the OEM manual. Excessive water in the compressed air can cause rust and other corrosion and premature wear of pistons and delicate seals. Some downstream components, such as cylinders and actuators, are sealed for life. Excessive seal failures usually are due to improper lubrication of the FLR. Some FLRs have a filter or water collection bowl, which requires regular draining. Failure to drain collected water can affect air-cylinder and solenoid performance and reduce their service life.

PLC and PC controls

Changes made to recipe programs should be backed up on floppy disc to ensure that all recipe data is current. Follow OEM manual recommendations for back-up battery replacement, and back up all data on disc before changing the battery. Inspect fuses for overheating and arcing on a yearly basis. If a computer is used for controls, defrag the hard drive and empty the wastebasket at least once per year.

Check door safety latches for proper function yearly. Wipe the interior using hot water and fan dry before operation. Keep water off vital components. Control boards should be cleaned using an electrical cleaner. A clean, dry paintbrush also works well to remove dirt from fragile components.

This information is not intended to replace OEM equipment manuals, which usually cover induction heating equipment maintenance, but to provide easy-to-use checklists for regular system maintenance.

OPTICAL PYROMETER MAINTENANCE

1) Check that Pyrometer is NOT Overheated

Like any electronic device, a pyrometer cannot operate properly over a certain temperature limit. For most sensors we recommend operating under 140°F/60°C. Above this ambient temperature limit, the circuit boards inside the pyrometer start to act funny. Pyrometers exposed to ambient temperatures above this limit will start to drift out of calibration and can produce errors in temperature reading.

Keeping pyrometers at a cool temperature can extend the life of a pyrometer and decrease the intervals between calibrations. Some pyrometers include a temperature strip that indicates if the pyrometer has been exposed to high ambient temperatures. We generally recommend that if the ambient temperature is above 120°F/50°C, then active cooling should be applied to a camera style pyrometer, or consider using a fiber optic pyrometer (400°F/200°C ambient limit)

2) Make Sure the Pyrometer Lens is Clean

Just like eye glasses, a pyrometer works best when the lens is clean. Dirty lenses on your eyeglasses will leave you with blurry or unclear images. Similarly, a dirty pyrometer lens on a single-wavelength pyrometer will lead to some fuzzy temperature readings. A dirty pyrometer lens blocks infrared energy from reaching the pyrometer and will lead to lower measured temperatures. For accurate temperature readings, it is essential to check the pyrometer lens and to clean it if there is any dirt/debris/dust/oil/crude built up on the lens. Similarly, if you are viewing a target through a window, you want to make sure the window is also clean as this will have the same effect as a dirty lens. Cleaning a pyrometer lens is rather simple: take a soft cloth or a Q-tip and wipe it clean using any alcohol based cleaner. One simple way to help prevent lens contamination is by using an Air Purge connected to a clean/filtered air supply.

For real nasty environments and applications where dirty optics are unavoidable, dual-wavelength pyrometers might be worth considering. Dual-wavelength pyrometers report a temperature based on the ratio of infrared energy at two separate wavelengths. Assuming the dirt and debris affects both wavelengths equally, the ratio between the two wavelengths stays the same and therefore the temperature stays the same – essentially unaffected by the dirty optics. Obviously, if there is an inch thick layer of crud on the lens no infrared energy can get through and the pyrometer won't be able to make a reading. But, dual-wavelength pyrometers can better tolerate dirty optics compared with single-wavelength sensors.

3) Verify the Alignment of the Pyrometer

While it may be an easy step to overlook, it is always important to verify that the pyrometer is aimed at your target. Pyrometers can be accidently bumped, moved, misaligned, or reinstalled improperly so it is always a good practice to verify alignment. A pyrometer is an optical device so it only can see what is in its field of view. If you can see a physical obstruction between the pyrometer and the target, you can be sure that the pyrometer will see that too if it is in its field of view. For single-wavelength sensors, alignment is critical as the pyrometer takes an average temperature of whatever it sees in its field of view. Therefor a single-wavelength pyrometer needs a full field of view of the target to make an accurate measurement, so as not to average in other non-target temperatures. A dual-wavelength pyrometer can tolerate a partially filled field of view so dual-wavelength pyrometers are ideal for smaller or wandering targets as they can better tolerate misalignment.

There are several different methods of aiming pyrometers: line-of-sight, through the lens visual aiming, laser aiming, and aim light. With the line of sight pyrometer you simply point and shoot the pyrometer in the direction of your target and eyeball it to get an idea of where the pyrometer is aimed. Through the lens aiming provides you with a "bulls-eye" target to show you where the pyrometer is aimed. Laser aiming provides you with a laser dot in the center of the sensor's field of view. The aim light is for fiber optic pyrometers and outlines the field of view of the fiber optic unit.

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Reducing Cost of Coolants, Lubricants and Quenchants by Automatic Proportioning with Water

By Mr. Srikar Shenoy, Steel Plant Specialities, India

Huge losses due to improper mixing of coolants / quenchants / lubricants with water are experienced throughout industries. These include coolant spillage losses of up to 5%, high evaporation losses of coolants from sump, failure of heat treated parts due to improper quenchant mixing, low die life or excessive lubricant consumption in hot forging, die casting operations and low tool life in CNC/ VMC operations due to improper coolant mixing with water.

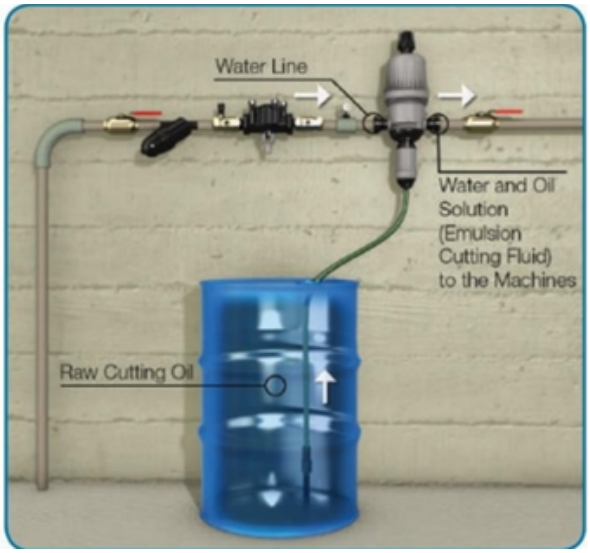
Manual mixing methods followed in the industry are always subjected to human error. Maintaining consistent, correct dilution ratio of concentrates with water is a challenge faced by metal-forming industry.

Steel Plant Specialities LLP, Mumbai, offers Accurate Proportioner for correct mixing of coolants / lubricants / quenchants with water, consistently and automatically. Mixing in correct dilution ratios with water enables a number of benefits in important operations like:

. CNC / VMC operations: Correct mix of cnc coolant with water enables reduced evaporation losses, increased sump life of coolant, preventing bad odour from sump and increased tool life due to better lubricity

. Polymer quenching: Correct mix of polymer quenchant with water enables uniform heat treatment of parts at all locations of quenching tank and desired heat treatment characteristics of induction hardened parts

Hot forging and die casting lubrication: Correct mix of die lubricants with water enable optimal die life and ease of operations, without job sticking



Accurate Proportioner automatically pulls pre-set quantity of coolant directly from coolant drum. It emulsifies (mixes) the coolant thoroughly with water and delivers the diluted solution through the outlet.

The Accurate Proportioner operates only on water connection. No electricity connection and no complex softwares or settings are required. As it works on water pressure, the proportion will always be accurate, as per the inlet of water quantity.

Difference in water inlet water pressure will not affect accuracy of proportioner. Capacity of Accurate Proportioner is up to 350 litres per hour (concentrate + water)

Can Forge Shops be Clean and Hygienic?

By Mr. Srikar Shenoy, Steel Plant Specialities, India

Most forge shop owners understand and appreciate the need for maintaining cleanliness in their production zones. Having a clean and healthy workshop is a major milestone when it comes to running a successful business. However, most business owners take notice of cleanliness issues only when they get completely out of hand.

Audits like OHSAS, ISO 14001, ISO/TS 16949, 5S and many others lay down stringent rules for maintaining cleanliness in production areas too. A number of overseas customers and reputed Indian automotive manufacturers conduct their audits with very high importance to cleanliness in forge shops.

Hence, it is imperative to regularly clean and maintain forge shops, heat treat shops, machine shops and assembly areas to ensure that your employees are happy, healthy and productive while it also leaves a good impression on existing and potential customers.

Challenges faced by a forging organization in maintaining cleanliness:

Forge shops are pre-disposed to being dirty owing to factors such as use of various oils for fuel, machinery lubrication, rust prevention etc, use of graphite as die lubricants, oil leakages during production and maintenance. Almost each area of a forge shop presents its own challenge in maintaining cleanliness. Some of these are:

Forging presses: Oil and grease used for centralized lubrication eventually spills on and around the forging machinery. Graphite based lubricants used for dies create black deposits on dies, presses, forge shop floors and nearby locations. Maintenance of forging presses require degreasing of parts, which is sometimes done in kerosene or thinner based products. This is not advisable due to various reasons.

Die shops face cleanliness issues due to handling and storing dirty dies covered in dense oil and graphite. Cleaning of dies consumes time and efforts. Sometimes, dies are stored with layers of oil and graphite present on them due to previous production run. This also dirties floors and nearby areas.

CNC/ VMCs develop oil stains over a period of time due to the coolants being used. These stains cannot be removed easily. Tramp oil getting leaked from centralized lubrication areas increase the dirtiness in machine shops.

Small forged parts are often moved in plastic bins that gather oil and dirt over a period of time. Due to oils, metallic burs get stuck in plastic bins. Such metallic bur creates scratch marks and damages forgings that are carried in such dirty bins.

Areas that are used for applying rust-preventive on forgings are also prone to oil spillages and become very dirty and oily over a period of time.

To add to all the above problems of cleanliness, the tyres of forklifts gather oil and graphite and deposit them all over the area during movement.

Most problems of cleanliness in forging organisations are due to oils and graphite.

Typically, cleaning is done by the use of kerosene, thinner, saw dust, acids and chemicals. Such strong chemicals may be fast-cleaning, however, they are neither safe nor eco-friendly nor economical. In many cases, acids and such chemicals erode the lustrous paint finish of expensive machinery like presses and CNCs. If not used very carefully, kerosene, thinners and solvent based cleaners pose fire hazards or skin hazard to workmen's hands.

To solve these problems of dirty machinery and shop floors, M/s. Steel Plant Specialities LLP, Mumbai, have developed an eco-friendly solution in the form of O-CLEAN3 water-based oil-cleaning liquid that has proven to be effective and safe in each of the mentioned challenging areas.

It is important to know the working and method of operation of any cleaning product to enable appropriate cleaning. Oils are made up of hydrocarbons. When O-CLEAN3 is applied to oily machinery or surfaces, it breaks the bond between hydrogen and carbon, thereby eliminating the 'greasiness' or 'oiliness' in oils. Once the oiliness is eliminated, the surface can be easily cleaned with water.

Time duration to be allowed after application of O-CLEAN3 is crucial. In the case of metallic surfaces, a reaction time of 30 minutes to 45 minutes is sufficient. After such time, the oily surface can be cleaned off effortlessly. In the case of concrete floors that have a tendency to absorb oil, it is advisable to apply O-CLEAN3 and leave it on overnight to achieve a clean surface next day. In many cases, repeated applications are necessary to thoroughly clean such surfaces where oil has seeped in since many months or years. Once cleaned, it becomes very easy to maintain the surfaces oil-free by regular use of O-CLEAN3. Being eco-friendly, O-CLEAN3 is safe and comforting to use even as hand-wash for workmen's oily hands.

Prior to epoxy coating of floors, to ensure long life of epoxy coating, it is very important to remove all oils that may have seeped in the floor. In such cases too, O-CLEAN3 and its customized variants have proven highly effective in cleaning oily floors for surface preparation prior to epoxy coating.

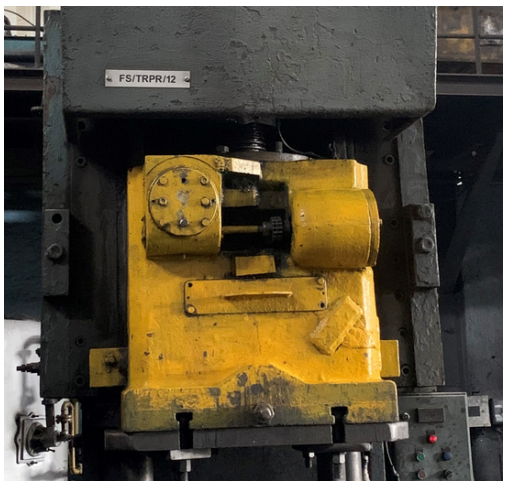
Documented demos of effective cleaning are carried out in forge shops in following areas: Forging machinery cleaning | Die cleaning | CNC cleaning | Bin cleaning | Floor cleaning

Methodology:

a. O-CLEAN3 eco-friendly oil cleaning liquid was applied on the oily machinery and floors. After 30 minutes, it was simply wiped off with wet cloth and water.
b. Oily, dirty forging dies were dipped in O-CLEAN3 for 30 minutes.

Photographs of the demos in various applications are provided below. Images on left are before cleaning. Images on right are after the use of O-CLEAN3 and effortless cleaning.

Dirty, oily forging machinery.



Cleaned in minutes with O-CLEAN3, effectively & effortlessly

Dirty, oily dies.

Dipped in O-CLEAN3,wiped

Observations:

• A 30 minutes soaking in O-CLEAN3 has given all above results. Efforts required to clean oily surfaces are substantially reduced by the use of O-CLEAN3. For better results, soaking time may be increased. Initial repeated cleaning and planned frequent application of O-CLEAN3 on cleaned surfaces will enable in maintaining oil-free, clean machinery, CNCs and shop floors.

• In the case of die cleaning, slight agitation in the dipping tank will give much better results. Heating of dipping tank up to 80 deg. C., will also give much better results. Both these techniques, agitation and heating of the liquid, may be tried out individually and collectively to evaluate results.

Summary:

By the use of O-CLEAN3 eco-friendly, water-based cleaning liquid, the forging industry can achieve oil-free, clean and hygienic forge shops.

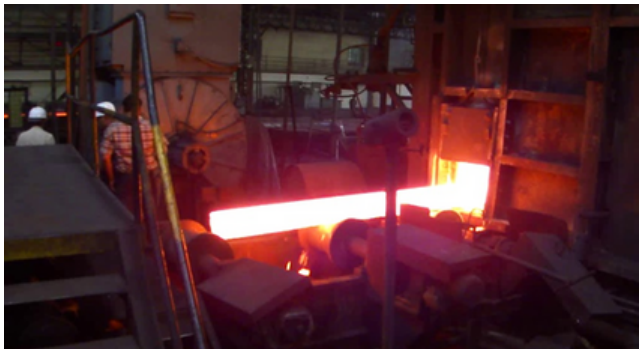
Reducing Fuel Consumption And Maintenance Cost in Furnace Operations

By S. P. Shenoy, Steel Plant Specialities, India

Abstract

This presentation shows how significant savings in fuel consumption and reduced maintenance downtime can be achieved in furnace operations by adapting a technique developed by an Indian company. The technique is now popularly implemented in furnaces like BRFs (billet re-heating furnaces) and heat-treatment furnaces. The process involves improving thermal shock cracking resistance, emissivity enhancement and increased corrosion resistance of refractory lining.

Hot forging is a process of heating ingots or billets and forming them into automotive or engineering parts. Most of the forged parts are heat treated Hot rolling too involves plastic deformation of heated metals and alloys into flat products (plates) or long products (wire rods, angles, channels, I sections, TMT bars, etc.). Some of the hot rolled products are heat treated.



In these important metal forming operations, fuel for the reheating furnaces and heat treatment furnaces and refractory are the major costs. Popular fuels are furnace oil, pulverized coal or gas. Electricity is used as fuel in the automotive parts heat treatment industry. Refractory lining consists of alumina bricks.

Any process or technique to reduce costs of fuel and refractory brick lining will automatically improve the profitability of the hot forming organisation. This article introduces a practical method of achieving these results. The technique is popularly used in hot rolling, hot forging and heat treatment industries. It can be implemented in all types of organisations, big and small.

Refractory plays a major role in the fuel consumption and also in the maintenance of the furnace. Hence, it is important to know the problems of refractories.

The following problems are encountered in the case of refractories:

a) Thermal shock cracking:

Thermal shock is caused by the exposure of refractory lining to rapid heating and cooling conditions which cause temperature gradients within the refractory
bricks. Such gradients, in the case of uneven cooling or heating, may cause
cracking. Thermal shock is unavoidable in furnace operation, however much care may be taken. Thermal shock cracks cause energy leaks through them. This loss may be as high as 33% of the total energy consumption. Thermal shock cracks lead to ‘spalling’ and reduced refractory lining life.

b) High thermal conductivity:

Conductivity of alumina bricks increases as refractory lining wears out over time. This leads to increased furnace outer shell temperature over a period of time. Reduction in thermal conductivity will lead to retention of heat within the furnace.

c) Low Emissivity:

Refractory lining has a low emissivity of 0.2 and hence hampers furnace efficiency. Improving the emissivity value to 0.5 or more will prevent heat absorption by the refractory lining, leading to fuel saving. However, it is difficult to measure emissivity. Measuring thermal conductivity is easier.

d) Corrosive Action:

Furnace oil contains sulphur dioxide and vanadium pentoxide. These compounds corrode the refractory lining. This is one of the reasons why burner blocks wear out much faster.

e) Vicious sand blasting effect:

The flame impinging on the refractory lining has a vicious effect of sand blasting. Combined with the corrosive effect, the flame damages the refractory lining and reduces its life span.

f) Carbon deposit on the burner blocks:

Unburnt carbon deposits on the burner blocks, and over a period of time, sufficient carbon build up takes place. Due to this build up, the flame geometry is impaired and heating efficiency is lowered. This problem is more pronounced when the fuel used is furnace oil. The operators try to remove these deposits by inserting metal rods from outside the furnace, near the burner, thereby damaging the burner block.

Effects observed in furnaces due to refractory problems:

Owing to problems mentioned above, a number of adverse effects are observed in the furnace. These are:

1. Increased fuel consumption: It is observed that fuel consumption increases for achieving the same temperature and heating efficiency, after a time gap of say, six months, from the date of relining the furnace refractory. This is due to energy leaks from cracks due to thermal shocks and wearing out of the refractory lining.

2. Increased furnace outer shell temperature: Conductivity of refractory lining and thermal shock cracking together contribute to increased temperature of the furnace outer shell, over a period of time.

3.Formation of 'hot spots' on furnace outer shell: In some cases, only selective areas of the refractory get highly damaged from inside the furnace. As a result, the outer shell becomes very hot and at times, red hot. These are called hot spots.

4.Rejections due to chipping of refractory lining and roof damage: Due to thermal shocks, the refractory lining begins to chip off or spall and fall off. This falling of refractory pieces may cause rejections of materials being heated or heat treated in furnace. Examples: Ceramic tiles and ceramic items being heated in furnaces get immediately rejected even if small refractory pieces fall on them. Refractory pieces may cause rejection of automotive parts that are being heat treated in a highly controlled environment.

5. Non-uniformity of temperature leading to uneven heat treatment: In highly controlled heat treatment operations (like those in sealed quench furnaces), non-uniformity of heat by a few degrees leads to uneven heat treatment and the desired characteristics of parts are not achieved. This may lead to rejections.

6. Furnace downtime for refractory repair or re-lining: For repair of refractory or for its relining due to damage, unplanned furnace shut down has to be implemented. This results in loss of production time and loss of energy in cooling and re-heating the furnace.

An effective solution:

Steel Plant Specialties LLP, a Mumbai based firm, has developed a unique solution to overcome all the above problems. The entire refractory lining of the reheating furnace is coated with a special ESPON coating. This coating contains zircon, proprietary additives and binders, developed over many years of research. The coating was tested in reputed laboratories and then implemented on industry scale in the year 2005. Since then it has undergone a number of upgrades to make it the best version available today.

ESPON refractory coating is in the paste form. It can withstand heat up to 1900 deg. C. After attaining temperature of 200 deg. C, the coating is slightly plastic in nature, thereby preventing cracks due to thermal shocks.

ESPON coating has very low thermal conductivity. It reflects the heat back into the furnace.

As per lab test reports: A single coating of ESPON on refractory has shown to reduce thermal conductivity by approximately 14%. If two sides of refractory bricks are coated with ESPON, the thermal conductivity is further reduced substantially by up to 35%. The two sides of refractory bricks to be coated are hot face (side facing the heat inside the furnace) and the opposite side. However, it may not be practical to coat two sides of refractory bricks. Hence, the furnace shell is coated from inside, before laying the refractory lining. After laying refractory lining, the hot face of bricks is coated with ESPON.

The coating procedure includes surface preparation, primer coating and final coating with ESPON, complete drying of coating and slow furnace firing. Step-by-step training is provided to re-lining team by experienced technicians of SPS. Videos for each of these steps are also provided.

Some successful case studies of ESPON refractory coating in billet re-heating furnaces and heat treatment furnaces are presented below:

1. ESPON refractory coating in continuous carburizing furnace: Reduced outer shell temperature and reduced fuel consumption.

In this organization which is one of the top 3 Indian tractor and passenger car manufacturers, the continuous carburizing heat treatment furnace relining was due. They were referred by their associates to try out ESPON refractory coating. Maximum temperature in continuous carburizing furnaces is 925 deg. C.

After coating the continuous carburizing furnace with ESPON refractory coating, the following results were recorded:

. Furnace skin temperature reduced by up to 15 deg. C. average. (Temperature readings of 5 locations on each furnace wall were taken)

. Saving of 12% in fuel consumption was recorded.

. **ROI of ESPON coating is 1 month only**, as certified in writing by this esteemed tractor and passenger car maker.

2. ESPON refractory coating in sealed quench furnaces: Reduced outer shell temperature and increased uniformity of heat within furnace.

In the heat treatment of automotive parts, uniformity of heat throughout the furnace is very important to achieve desired metallurgical characteristics in the parts being heat treated. Maximum temperature in sealed quench furnaces is 900 deg. C.

In two esteemed Indian organizations manufacturing bearings and gears, very similar problems were faced: Temperature variation of more than 9 deg. C., in various zones of their sealed quench furnaces. Skin temperature of furnaces was much higher.

Both sealed quench furnaces were coated with ESPON refractory coating. The following results were recorded:

. Uniformity of heat increased from +/- 12 deg. C. to +/- 8 deg. C.
. Furnace skin temperature reduced by up to 15 deg. C. Fuel saving of 5% up to 9% is achieved.

3. ESPON refractory coating on billet re-heating furnace in a hot rolling mill: Saving fuel and saving time to achieve heating temperature.

A hot rolling mill producing 200 tons per day of structural steel has achieved significant savings in oil consumption.

The reheating furnace is put off at 06.00 p.m. daily.

Before use of coating: To achieve the working temperature of 1150 deg.C, furnace is fired at 02.00 a.m. At this time, furnace temperature is 300 to 400 deg.C. Billet heating temperature of 1150 deg. C. is achieved at 05.00 a.m.

After use of ESPON refractory coating in furnace: To achieve billet heating temperature of 1150 deg. C. at 05.00 a.m., the same furnace is fired at 03.00 a.m. At this time, furnace temperature is around 700 deg. C due to heat retention.

Saving: 1 hour of fuel consumption and time for achieving desired temperature.

Explanation: When the refractory lining is coated with ESPON, emissivity of refractory lining is increased and thermal conductivity is reduced. As a result, heat is retained within the furnace for a longer period of time, even after switching off the furnace.

Monetary savings in this case:
In one hour, 600 litres of oil are saved daily.
In six months, oil saving is 90,000 litres. (600 ltrs x 25 days x 6 months)
At Rs.31/- per litre, value of fuel saving in six months: Rs. 27,90,000/-
Cost of coating material : Rs. 3,60,000/-
Net saving in six months: Rs. 24,30,000/-

4. ESPON refractory coating in ingot soaking pit furnace in a steel making company: Save fuel and reduce outer shell temperature.

Temperature inside ingot soaking pit reaches up to 1300 deg. C. In this case, the outer shell temperature of the ingot soaking pit was as high as 130 deg. C. Workmen found it difficult to operate nearby the furnace due to high temperature.

The use of ESPON refractory coating sealed off all gaps and cracks in the refractory lining and enabled retention of heat within the furnace. As a result, furnace outer shell temperature reduced by 20 deg. C.

When outer shell temperature is reduced, it is a sure indication of fuel saving due to reduced conductivity of heat through refractory lining. In this case, more than 5% of fuel was saved owing to increased heat retention in furnace.

5. ESPON refractory coating in billet re-heating furnace of a rolling mill: Increased refractory lining life and reduced fuel consumption.

In a billet re-heating furnace of a TMT bars rolling mill, ESPON refractory coating was used with the aim of reducing furnace maintenance downtime.

Before coating: Re-lining of this furnace was carried out once every 12 months due to regular wear out of refractory. Occasional shutdowns once every few months were required to carry out 'patch work' or repair of refractory.

After ESPON refractory coating: Refractory lining life increased from 12 months to 21 months. Fuel saving of 5% was recorded. Unplanned furnace shutdown was prevented.

6. ESPON refractory coating in annealing furnace used for heat treatment of cold-rolled coils: Substantial savings in fuel consumption. ROI= 1 month!

In this Organisation, annealing furnaces designed and supplied by Andritz, Germany, are used. Temperature is 1250 deg.C. The fuel efficiency and refractory lining life are excellent. Furnace outer shell temperature is steadily maintained at 45 deg.C. There are no problems faced in this furnace.

The only aim of using ESPON refractory coating in this furnace was to further reduce fuel consumption. Thermographic analysis was carried out before and after use of ESPON coating. Fuel consumption is recorded accurately as the furnaces have inbuilt software to monitor fuel efficiency.

After application of **ESPON** refractory coating in this already highly fuel efficient furnace, a further reduction in fuel consumption by 1% was recorded.

Even with a 1% reduction in fuel consumption, the Return on Investment **(ROI) was 1 month only!**

Owing to the excellent results, this organization has given a 'blanket approval' for use of ESPON refractory coating in all the furnaces.

SUMMARY

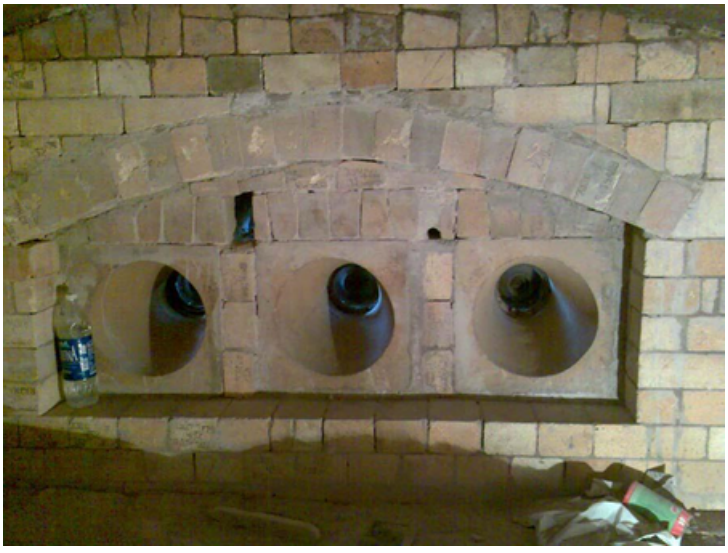
1. Use of a special ESPON refractory coating holds high promises to any forge shop or heat treatment unit or hot rolling mill that is interested in reducing fuel consumption and increasing refractory lining life.

2. This technique is a proven method of achieving savings by reducing fuel consumption and reducing furnace maintenance issues.

PHOTOS

Refractory lining before coating

Burner blocks before coating



Refractory lining after coating with ESPON

Burner blocks after coating with ESPON

Cost Reduction in Hot Forging by the Use of Environment Friendly, Graphite-Free Water-Soluble Die Lubricants.

By S. P. Shenoy, Steel Plant Specialities

Hot forging involves controlled plastic deformation of heated metals and alloys into desired useful shapes. It is a noble metal craft. Modern civilization cannot survive without hot forging. At the same time, without suitable forging die lubricant, economical and effective closed-die forging operation is not possible. In the case of closed die forging, cost of die amounts to 10% to 15% of the total forging cost. Any improvement in the forging die life would automatically result in improved productivity and profitability of the forge shop.

The following factors contribute to ensuring maximum life of a forging die:

1. Correct die material.
2. Correct die design, especially proper draft, corner radius and fillet.
3. Appropriate heat treatment of forging die. Use of protective anti-scale coating to prevent scaling on critical surface areas of die. Nitriding of forging die.
4. Reduction of friction during hot forging by the use of polished dies and suitable die lubricant.
5. Correct method of application of die lubricant at appropriate intervals.

REQUIREMENTS OF A GOOD HOT FORGING DIE LUBRICANT:

Basic function of any lubricant is to reduce friction between two surfaces and reduce wear. In the case of forging, a good hot forging die lubricant must have the properties listed below:

1. Minimize friction between the workpiece and the forging die: Table 1 provides a comparison of coefficient of friction for various types of lubricants used in hot forging.

Table-I : Coefficient of friction for various die lubricants:

Sr. No.	Lubricant	μ
1.	DRY (No Lubricant)	0.33 0.35 0.35
2.	Furnace Oil	0.10 0.18 0.12
3.	Graphite in machine oil	0.065 0.09 0.09
4.	Graphite in water	0.11 0.10 0.13
5.	Saw Dust	0.13 0.16 0.17

Ref.: Dr. A. S. Deshpande, IIT, Mumbai, India.

2. Reduce forging load: Fig 1 shows reduced forging load by use of graphite-in-oil-based die lubricant

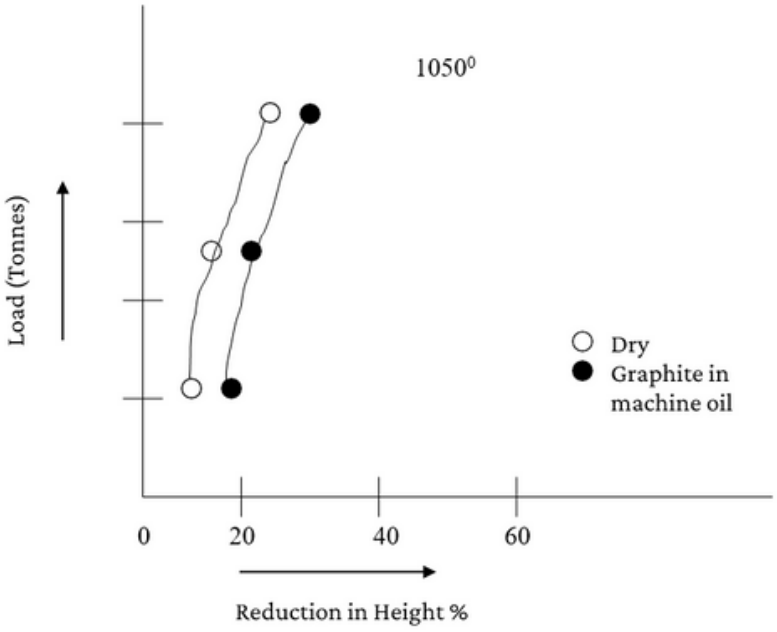


Fig 1: Reduced forging load by using oil lubricant.
Ref.: Dr A. S. Deshpande, IIT, Mumbai, India.

3. Enable uniform metal flow to fill the die cavity: Especially in the case of critical forgings with low degrees of draft radius, die lubricants play an important role in enabling uniform metal flow such that it correctly fills the die cavity.

4. Function as a parting compound: Forging dies with low degree of draft radius usually face problems of job-sticking in the die. Special additives in the forging lubricant must ensure a mild gas generation to aid the ejection of the forging from the die after the part has been forged. However, the lubricant must neither cause an explosive effect nor generate smoke.

5. Serve as a barrier to heat transfer: Thereby maintaining the correct die temperature. The die should not gain excess heat due to continuous contact with hot billets as this will lead to faster die wear and cracking. At the same time, the die should not be subjected to rapid cooling due to excess lubrication as this will lead to die chilling effect. Forging lubricant must help in maintaining the correct die temperature by acting as a barrier to heat transfer from hot billet to forging die.

6. **Prevent build up in the die cavity** due to deposit of lubricant residue in the die and cause problems such as forging underfill.

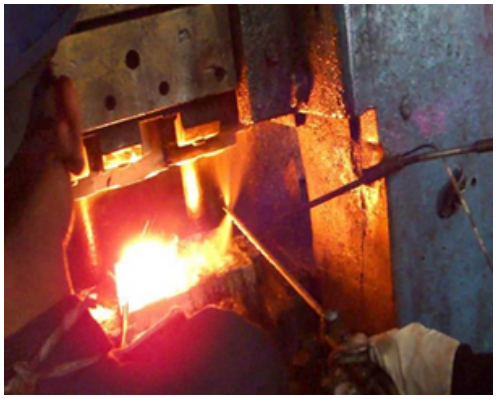
7. Lubricant must be **readily removable** from the workpiece.

8. Avoid 'explosion' during forging due to rapid phase change. Sawdust, when used as a lubricant in hot forging, is known to cause a loud explosion with sparks and thus release the forging from the die. Modern lubricants can achieve the same effect without the explosion and hazard.

9. The forging die lubricant must be **eco-friendly.** Preferably, bio- degradable lubricants must be used. Use of polluting oils and additions like graphite in lubricants cause much damage to the environment due to smoke and dirtying the forge shop floor and surroundings.

10. The hot forging lubricant must be **economical** and justify its use.

METHOD OF APPLICATION OF HOT FORGING DIE LUBRICANT



Lubricant is either sprayed automatically, manually or swabbed onto the hot dies. Adjacent image shows lubricant being sprayed manually with a double- action spraygun on the forging die.

Many installations use automatic sprays that are timed with the stroke of the forging press. Deeper cavity dies may require the use of a supplemental spray to ensure coverage throughout the die surface and cavity.

The correct amount of lubricant provides an optimum film in the die cavity to aid metal flow and to curtail heat transfer from the workpiece to the die. Excess lubricant is wasteful, dirties the area and the workpiece and pollutes the atmosphere. Excess forging lubricant may also leave residue into the dies to cause problems like forging 'underfill' and 'lap'.

Lubricant cost is less than 2% of the forging cost. Yet, use of improper lubricant can upset the forging production by way of low die life, rejections, rework, reduced productivity and customer dissatisfaction due to delayed deliveries.

TYPES OF HOT FORGING DIE LUBRICANTS:

Table-II gives various types of lubricants used in hot forging.

Table II: TYPES OF FORGING DIE LUBRICANTS

Sr. No.	Lubricant	Advantages	Disadvantages
1.	Furnace Oil	• The cheapest. (Costliest??) • No purchase hassles.	• Carcinogenic. • Low die life. • Dirties the die and surrounding. • Highly polluting.
2.	Special oil + graphite	• Improves die life.	• Some amount of gentle smoke is emitted.
3.	Only oil, without graphite.	• Suitable for brass.	• Not suitable for steel.
4.	Water + Common Salt	• Apparently economical	• Corrosive
5.	Water + Saw Dust.	• Economical	• Explosion due to rapid phase change. • Unsafe.
6.	Water + Graphite	• Improves die life. • No smoke. • Eco-friendly.	• Graphite particles fly off and damage the electrical systems. • Graphite particles accumulate on shop floor. • Risk of slipping.
7.	Water + Soluble Lubricant	• Easy to use. • No particulate settling. • Improved die life. • Improved productivity • Non-polluting. • Most eco-friendly.	• Not adequate for very large forgings.

Owing to development of a range of water based lubricants, polluting oils and sawdust have been largely replaced by graphite lubricants.

In the case of graphite containing lubricants, purity, particle size and special additives in the lubricant are important factors. Graphite based lubricant is popular throughout the world due to low cost. Although smoke pollution is absent during its use, certain problems are being faced by modern forging press operators. First, the graphite particles fly off and damage the electrical system. Secondly, graphite particles accumulate on shop floor and pose the risk of slipping to the people moving around. Hygiene factors such as release of particulate matter in air, release of carbon monoxide and sulfur in air are hazards that prevail during use of graphite based die lubricants.

Owing to these factors, environment friendly graphite-free, water soluble lubricants are gaining due importance compared to graphite based lubricants. Due to complete solubility in water, problem of settling of graphite is absent in the case of graphite-free die lubricants. Mild to nil agitation during use is adequate. Continuous stirring may not be necessary.

Thickness of film formation on forging die is controlled by varying the dilution ratio of forging lubricant with water. In the case of graphite-free forging lubricants, hazards like suspended particulate matter in air, release of carbon monoxide and sulfur are substantially reduced. Bio-degradable phosphate esters, soaps and organic substances contribute towards the development of eco-friendly lubricants.

These special additives also possess superior lubrication characteristics compared to graphite. Hence, in the case of small to medium sized forgings weighing up to 12 kgs., graphite-free, water soluble die lubricants have proven to perform either at par or better than graphite based die lubricants. Cost of die lubrication is proven to considerably reduce by switching over to graphiteless, water soluble die lubricants in such forgings. This is due to benefits like increased die life, reduced need for constant die grinding due to reduced die wear by the use of graphiteless die lubricants. It may be added that maintenance downtime of die lubrication systems by clogging of spray nozzles, deposition of graphite inside tanks, inside spray pumps and inside automated lubricant delivery pipes is eliminated by the use of graphite-free die lubricants.

INDUSTRIAL CASE STUDIES OF COST REDUCTION AND PRODUCTIVITY INCREASE DUE TO THE USE OF GRAPHITELESS, ENVIRONMENT FRIENDLY WATER SOLUBLE DIE LUBRICANTS

Graphiteless, water soluble forging die lubricants have played a crucial role in increasing die life and increasing productivity, especially in the case of
small to medium sized forgings. Productivity improvement, die life improvement and cost benefits analysis of graphiteless, water soluble die lubricant as compared to graphite based and other popular lubricants are given in following **Comparison Case Studies.**

Comparison Case Study I: Productivity Improvement due to reduced die grinding time by switching over to graphiteless, water soluble lubricant.

Sr. No.	Particulars	Graphite Based Lubricant	Graphiteless Lubricant
1.	Forging Equipment	1000 Ton Press	
2.	Product	Forging Sleeve 	
3.	Dilution Ratio	1: 10	1: 10
4.	Time Loss Due to Die Grinding at Each Shift	1.5 hours	NIL
5.	Production in 3 shifts	7000	9000
6.	Productivity Improvement	--	**22%**

Comparison Case Study II: Die life increase by switching over to graphiteless, water soluble die lubricant from conventional oil.

Sr. No.	Particulars	Conventional Oil	Graphite-less Lubricant
1.	Forging Equipment	1000 Ton Press	
2.	Product	Companion Flange 	
3.	Die Life	4500	6000 **(33% improvement)**
4.	Method of application	Manual swabbing	Manual spraying
5.	Pollution	Obnoxious, carcinogenic smoke.	Zero pollution. Clean environment.

Comparison Case Study III: Die Life and Cost benefit analysis of graphiteless water soluble die lubricant compared to conventional oil.

Sr. No.	Particulars	Conventional Oil	Graphite-less Lubricant ESPON
1.	Forging Equipment	1600 Ton Press	
2.	Product	Input Shaft (Indica motor car) 	
3.	Die Life	5000	7000 **(40% improvement)**
4.	Price	Rs. 24/- per litre	Rs.12/- per litre of solution prepared by mixing paste with water (1:10)
5.	Method of application	Manual swabbing	Manual spraying
6.	Pollution	Obnoxious, carcinogenic smoke.	Zero pollution. Clean environment.

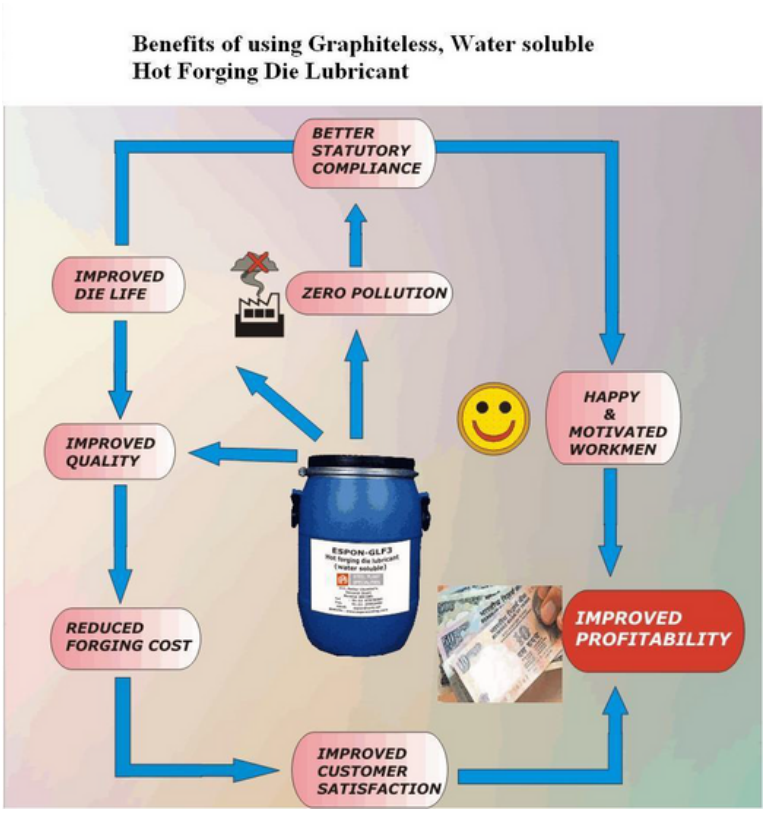
Comparison Case Study IV : Cost Saving due to graphiteless, water soluble forging lubricant.

Sr. No.	Particulars	Graphite Based Imported Lubricant	Graphiteless Indian Lubricant ESPON
1.	Forging Equipment	1000 T Press	
2.	Product	Two-Wheeler Crank Shaft 	
3.	Total Production	100 Tons	
4.	Consumption of lubricant per 100 tons	400 kgs.	
5.	Lubricant cost per kg.	180/-	117/-
6.	Total cost of lubricant per 100 tons	Rs. 72,000/-	Rs. 46,800/-
7.	Saving per 100 tons	--	Rs. 25,200/-

Note: Consumption per ton of graphite-free die lubricant has remained same as that of graphite based lubricant. Cost reduction is achieved due to lower cost per unit of graphiteless die lubricant.

Figure-2 explains how solving a problem (pollution control) simultaneously gives other benefits like cost reduction and improved customer satisfaction.

Figure 2: Benefits of a water soluble, graphiteless hot forging lubricant:



EXACTLY HOW ENVIRONMENT FRIENDLY ARE GRAPHITE-FREE DIE LUBRICANTS?

An independent government approved laboratory has conducted tests to monitor 'Work-Zone Air Quality' in a forge shop using graphite based lubricant on one press and graphite-free die lubricant on a similar press located away from the first press. Air sample in the work-zone of each press was monitored over period of time. The analysis of average of air quality readings when using graphite based lubricant compared to that of graphiteless, water soluble lubricant is given in the following Comparison Case Study V.

Comparison Case Study V: Forge Shop (Work Zone) Air Quality Monitoring Readings Report;
Graphite based lubricant compared to graphiteless, water soluble forging die lubricant.

Sr. No.	Parameters	Factories Act 1948 Standards	Units	With Graphite	Without Graphite
1.	Suspended Particulate Matter	N/S	$\mu g/m^3$	509	362 **(29% Less)**
2.	Sulfur Dioxide	≤ 5000	$\mu g/m^3$	33.60	32
3.	Oxides of Nitrogen	≤ 6000	$\mu g/m^3$	42.50	41.00
4.	Carbon Monoxide	≤ 50	ppm	8	3 **(63% Less)**

Tested by: MITCON Consultancy Services Ltd., Pune, Maharashtra, India.

It is evident that benefits like reduced 'Suspended Particulate Matter' and substantially reduced 'Carbon Monoxide Emission' are enabled by the use of graphiteless, water soluble die lubricant. These factors lead to hygienic working condition in forge shops as opposed to highly polluted surroundings and slippery black forge shop floor. Utilization of carbon would be eliminated in the case of graphite-free, water soluble hot forging die lubricants. This fact may be harnessed to possibly claim carbon credits by Organizations that are switching over from oil based or graphite based lubricants to graphiteless forging die lubricants. However, this is yet to be explored by the forging industry at large.

SEEING IS BELEIVING

Comparison Video Links: Polluting oils against graphiteless, water soluble, environment friendly die lubricants.

Sr. No.	Forging Operation details	Video links *(To view videos, please click on links or copy and paste them in your web browser.)*	QR CODE *(To view videos, please Scan on your smart device.)*
1. A.	Use of polluting oils as die lubricant in Press Forging operation:	http://bit.ly/oildielube	
1. B.	Use of environment friendly, water-based die lubricant in same Press Forging operation:	http://bit.ly/ESPON-DEL3	
2. A.	Heavy pollution (smoke and flames) due to oil lubricant in Hammer Forging:	http://bit.ly/hammeroil	
2. B.	Zero pollution by switching over to environment friendly hot forging die lubricant in same Hammer Forging operation:	http://bit.ly/hammerdielube	

HOW TO SELECT THE RIGHT TYPE OF HOT FORGING DIE LUBRICANT?

Selection of right type of hot forging die lubricant is carried out based on parameters like depth of die cavity, size and complexity of the forging, method of dispensing the lubricant onto the die, time required to complete one forging part, commitment to cost reduction and pollution control. Though the best method of determining an appropriate lubricant and the dilution ratio of die lubricant to water is by field trials, general guidelines for selecting die lubricants for a range of forgings are provided in the **'Table of Guidelines for Selecting Correct Hot Forging Die Lubricant'.**

SUMMARY:

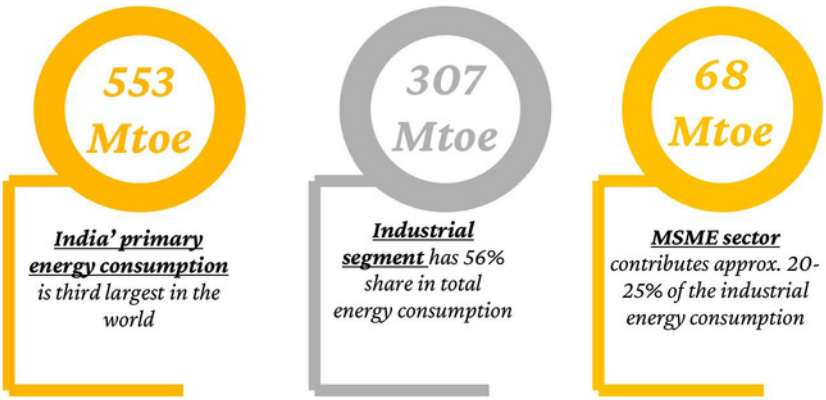
1. Use of right type of die lubricant and correct method of dispensing the lubricant is a decisive factor in the success of closed-die forging.
2. Specially developed graphiteless, water soluble hot forging die lubricants hold promises of significant contribution towards hot forging cost reduction and progress towards environment friendly forging operation. Such lubricants are proven to be effective in forgings weighing up to 12 kgs. For heavy and complex forgings, graphite-free, water soluble lubricants may be used by calibrating the dilution ratio of die lubricant to water and lubricant application technique to suit the forging process.

Energy Efficiency Potential in Indian MSME Sector: Focus on Forging

By Hitesh Asnani, E Nand Gopal, Amit Seth, and Jayakrishnan P Nair, PWC, India

Introduction

With a total primary energy consumption of 553 Million Tonnes of Oil Equivalent (MTOE), India is the third largest energy consumer in the world after United States of America and China. The Industrial segment has been contributing to the bulk of the energy consumption in the country (~56%). Among this large share, MSME sector contributes about 25% of overall industrial energy consumption, estimated at 68 Mtoe. This immense quantum of energy consumed by the MSME sector signifies the immense potential for energy conservation across the sector. This improvement is also driven by several factors including the high cost of input energy in processes, a high share of the manufacturing cost, increased competitiveness and the introduction of new and efficient technologies.



The MSMEs in India can be segregated into over 20 energy intensive industry sectors, such as foundry, forging, textile, ceramics, refractory, glass, dairy, etc. The industries in the MSME sector generally exist as clusters across different geographical locations of the country. The MSMEs, across these sectors and clusters exhibit several commonalities, such as technology use, production process & capacities, and operating practices.

Bureau of Energy Efficiency (BEE) is an agency of Government of India, under the Ministry of Power, entrusted with development of programs which will increase the conservation and efficient use of energy in India. As per BEE's UNNATEE (UNlocking NATional Energy Efficiency Potential) report, industrial sector including MSMEs, will contribute an estimated 40-50% the of the energy savings. Large industries have access to adequate resources and strong technical teams to support energy efficiency (EE) interventions as compared to MSME sector. These factors help them to access technology upgradation opportunities comparatively more easily than the MSMEs, where resources, technical capabilities and access to finance are limited.

Energy consumption of the Indian MSME sector is estimated to increase to 500% in the next decade (by year 2031). To realize the energy saving potential at MSMEs, an investment of ~12.3 Bn USD is required in next 14 years as per UNNATEE report.

An initiative by Bureau of Energy Efficiency: Energy and Resource Mapping of MSME Clusters (Forging Sector)

To tap the above-mentioned energy efficiency potential and in its endeavour to accelerate uptake of energy efficiency in the MSME sector, BEE had initiated an SME programme during the year 2009. Energy Efficiency in the MSME sector has also remained on the programme agenda of several institutes and development agencies, including World Bank, UNIDO, UNDP, TERI and GiZ etc. for a significant time now.

While these programmatic interventions have made an impact, they were focused on preparation of cluster manuals, awareness creation, technical support, energy auditing activities. These programmes did not comprehensively cover the policy and implementation aspects with a focus on specific sectors like Forging. The reach of interventions has been limited to a select few MSME clusters.

Hence, a need arises for a comprehensive exercise for establishing actual energy consumption by the most energy intensive industrial MSME sectors including Forging. BEE's Energy and Resource Mapping study aims to identify the present scenario of the forging sector in terms of energy consumption, as well as readiness of the sector in adopting EE solutions.

The exercise primarily focuses on estimating the energy consumption, production processes adopted, technology vintage in major Forging clusters and the current energy efficiency scenario of the sector. Findings of this study will further assist BEE to formulate conducive policies and prepare actionable implementation plan for pacing up the EE initiatives in the MSME Forging clusters across India.

To conduct this study, several initiatives are being planned for the forging sector which will directly and indirectly benefit the industry stakeholders:

- Detailed Energy Studies in 50 forging units covering 5 forging clusters including Pune, Ludhiana, Bengaluru, Chennai, and Delhi NCR
- Analyze the specific energy consumption and highlight energy benchmarks for the sector
- Map the readiness and needs of the Forging sector
- Develop an EE policy and technology implementation roadmap

BEE has hired the Consulting Services of PwC for carrying out this study for Forging MSME sector. The proposed study is expected to expedite the implementation of energy efficiency technologies in Forging clusters across India. Some of the anticipated environmental, economic and social benefits for the sector are shown below.

Environmental Benefits	Economic Benefits	Social Benefits
• Improved energy security • Lower dependence on imported fuels • Contribution towards climate change mitigation • Better work environment	• Reduced operating (energy) cost for industries • Improved competitiveness nationally and internationally • Increased investments in state-of-art technologies	• Skill enhancement of industry personnel • Cluster friendly policies • Improved living standards • Quality product and service

Need of Energy Conservation in Forging MSME Sector:

Forging sector in India is considered as the backbone of the manufacturing value chain and caters to various industries such as automobile, machinery, agriculture, engines, aerospace etc. Auto sector is the major consumer of forging products accounting for over 58% of the total forging production.

Indian forging industry has gradually evolved from being a labor-intensive industry to a more capital-intensive industry, with high capital investments in plant and machinery. Forging is an energy intensive process, where energy is mainly consumed for metal re-heating and heat treatment processes.

Metal heating operations contribute to 60-90% (depending upon the type of furnace and metal being processed) of the total energy consumption, while 10-15% of the total energy is consumed in metal forming operations (motors and compressors). Machining & finishing processes (motor driven), and auxiliaries supporting the entire forging process (pump sets, cooling tower, compressed air, blowers etc.) consume about 10-15% of the total energy.

Project team has reviewed the various sector specific documents, cluster reports, past project reports etc. to review the trends of the energy consumption in the forging sector. Based on this secondary research, and discussions with Industry Associations, and technology providers, project team has summarized the energy consumption pattern covering different processes across different clusters as presented in the following table:

Major Processes	Type of energy usage	Major equipment	% Energy consumption
Metal Heating	Oil, Electricity, Gas	Heating Furnaces, Heat treatment furnaces (Induction, Oil/Gas fired furnaces)	60-90%
Heat treatment			
Metal Forming Process	Electricity	Compressed air driven Presses, motor operated hammers and presses, Hydraulic hammers and presses (Drives -Motor / Pneumatic / Hydraulic)	10-15%
Finishing and Machining	Electricity	Drives -Motor / Pneumatic / Hydraulic), Lighting, pumps, Short blasting machines, CNC machines	10-15%
Auxiliaries			

Importance of BEE's Energy mapping study for Forging MSME sector

According to Association of Indian forging industry (AIFI), the Indian forging industry consists of 83% small & very small industries whilst 9% consists of medium ones and large industries constitute the remaining 8%.

Most of the MSMEs still use the conventional heating furnaces and technologies. Even with several MSMEs beginning to use efficient technologies such as induction billet heating, there is a significant scope of improvement in terms of efficient use of the energy such as control of the metal heating temperature, operation optimization, efficient compressed air system, and recovery of the waste heat etc.

Detailed energy audits and regular energy monitoring can highlight the potential opportunities for energy conservation in various process areas. This will not only help in reducing the carbon emissions and conserving natural resources like electricity, oil, water, etc., in the forging industry but will also result in better productivity, increased quality and healthier workplace environment. The proposed study is expected to expedite the implementation of energy efficiency technologies in Forging MSME Clusters.

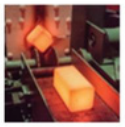
BEE will improve its understanding of the sector level challenges, which will further help in developing measures with high correlation to industry needs and identify the financing & capacity building needs of the cluster to encourage the adoption of efficient technologies.

Energy efficient solutions and benchmarks relevant to the Forging Sector

The energy performance of forging unit can be benchmarked by comparing its specific energy consumption (SEC). The SEC is the overall energy consumption per tonne of forged product, which can be further broken down into energy consumption per tonne in forging furnace and energy consumption per tonne in auxiliary.

Generally, the SEC of the best operating forging industry with induction billet heating and induction hardening furnaces varies in the range of 900-1200 kWh per tonne of production. Based on the PwC analysis from past forging projects with mix of induction and oil/gas fired furnaces - best SEC was 1072 kWh per tonne and median value of 1760 kWh per tonne and average value of 1885 kWh per tonne.

The SEC Benchmarks of Equipment and processes in forging Industry are presented in table. In addition, the table provides details of major area of improvement required to meet the benchmark values.

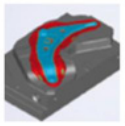


Replacement of FO fired furnace with IBH

Application of veneering module to heating furnace

Use of IoT based real time energy optimization

Industry 4.0 Productivity Enhance. Predictive Maint.



Use of Simulation for process and energy optimization

SEC Benchmarks of Equipment and processes in forging Industry

Particulars	Units	Forging Industry SEC range	Best	Median	Major Area of Improvement Required to meet the Benchmark values
Metal heating furnaces					
Induction Billet heater	kWh/tonne	330-450	330	390	Inadequate coil size, Metal temperature control
Gas fired box type furnace	kg/tonne	80-120	60	110	Excess air control, waste heat recovery, Adequate insulation, Reduction in incomplete combustion
Oil fired box type furnace	kg/tonne	100-150	90	120	
Heat treatment furnaces					
Box type	kgoe1/tonne	70-90			Excess air control, waste heat recovery, Adequate insulation, Reduction in incomplete combustion of fuel
Travelling grate furnace	kgoe/tonne	80-100			
Revolving furnaces	kgoe/tonne	100-150			
Auxiliaries					
Screw Air compressors (Pressure 7 bar)	kW/cfm	0.15 - 0.2	0.15	0.17	Optimal Pressure setting, Reduction in pressure loss in piping, friction less piping and fittings, Sequential control of the compressors, VSD, IE4 / Permanent motors / Synchronous motor drives
Reciprocating Air compressors (Pressure 7 bar)	kW/cfm	0.2 - 0.25	0.2	0.23	Technology shift to screw compressors with integrated control systems

[1] kg of Oil equivalent

Particulars	Units	Forging Industry SEC range	Best	Median	Major Area of Improvement Required to meet the Benchmark values
Air leakages	%	15 - 35%	10%	20%	Arresting leaks at bends and joints, use of leakage proof fittings, valves etc.
Pump set (efficiency) up to 10 kW	%	30 - 70%	80%	60%	Selection of adequate pump with appropriate flow and head, Proper maintenance
Motors and Drives	Class	80 - 96%	96%	85%	IE4/ Permanent Magnet, Replacement of rewound motor
Lighting	Lumen/watt	80 - 135	135	100	Use of higher efficient Star rated LEDs, use of adequate lux level in different areas

The EE interventions to achieve the best SEC benchmark can be either categorized as best operating practices, retrofits and complete revamp of equipment, system or process. Typical EE interventions are presented in table.

Revamps	Retrofits	Operating practices
Replacement of box type furnace with Induction billet heater	Inverter for air compressor	Optimization of air compressor operation
Replacement of reciprocating/screw air compressor with Internal Permanent Magnet Type screw air compressor	Insulation improvement through veneering and ceramic coating in furnaces	Proper damper control for excess air optimization
Replacement of inefficient pumps with high efficiency vertical centrifugal pumps	Proper burner assembly for gas fired furnace	Management of cooling water
Replacement of blower with adequate pressure and flow	Installation of recuperator, recuperative and regenerative burners, for billet reheating and heat treatment furnaces	Periodic repair of insulation

The case studies from the past interventions under BEE programs for EE improvement in forging units is presented next.

Conversion of conventional furnaces to IBH

IBH is most efficient technology for the metal heating and meting; electromagnetic energy is used for the heating the metal to the desired temperature. IBH is positioned as the cleanest technology for metal heating free from the emissions, use of the IBH also helps in the reduction of the metal loss in form of scale.

L- FO-fired furnace; R- Induction billet heater

Conversion of conventional furnaces to IBH

Installing IBH in place of Oil-fired furnace

Description	Major Advantages	Average Payback Period
Use of IBH for metal heating	• Precision temperature control • Reduction in scale loss, scale loss in range of 1-2% only, less as compared with oil and gas fired furnaces • Lower emissions and Cleaner workspace	~ 18-30 months

Team has also carried out the literature review to analyze the trends of the energy consumption benchmarks and best operating practices for the prominent equipment and processes in the sector.

Equipment	Best Operating Practices	Parameters to be monitored	SEC/Efficiency range

Fuel Fired Furnaces	• Maintain the appropriate air fuel ratio
	  ○ Liquid fuel: 1.15 - 1.20
	  ○ Gaseous fuel: 1.12 - 1.15
	• Maintain the appropriate surface temperature
		• Fuel flow rate (liter/hour)
		• Material flow rate (tonne/hour)
		• Fuel gas temperature
		• Surface temperature of furnace
		• Temperature of hot metal
			• 70-100 liter per tonne

	○ Ceiling – 110-120 ºC ○ Side wall – 85-100 ºC • Flue gas exit temperature: 250 -300 ºC	• Air fuel ratio	
Induction furnaces	• Use appropriate coil size for the job • Maintain the furnace surface temperature 70-90 ºC	• Temperature of the hot metal • Cooling of the coil • Power consumption by furnace (kWh/hour) • Material flow rate (tonne /hour) • Surface temperature of furnace	• 400-500 kWh/tonne