Advantages of Low Pressure Carburising Technology in Manufacturing of Auto components

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With the many advances that have taken place to improve quality of the auto components, it is only logical that heat treat services would have to evolve itself to meet the increasing demands of precision auto parts. Low pressure technology which also referred as Vacuum Carburising has already become a preferred case hardening process over the conventional gas carburising processes in Europe and North America. Driven by cost savings in manufacturing of gears, shafts and spindles, the heat treatment process has gone into the focus of the manufacturers. The potential of savings in heat treatment cost is huge because the new technology allows shortening of the total process time compared to the conventional process. Quenching after low pressure carburising can either be followed with high pressure gas or oil as quench media. Selection of the quench medial is generally decided based on the part sizes and steel grades. The advantages of vacuum technology are in particular: the absence of surface oxidation, the cold wall technology, the gas quenching technology, Oil Quenching technology, the reduced logistics, flexible reaction on the needs of production and the control of distortion. Vacuum furnaces are flexible in their reaction to the production requirements. Only with these types of heat treatment furnaces it is possible to switch them off after use and save
immediately energy and costs.

Introduction

LPC is a case hardening process which is performed in a pressure of only a few (5 to 15) mbar in a protective atmosphere and in temperature range of 870 to 1050 °C. In most of the case temperature is maintain between 920 to 980 °C. In most applications acetylene is used as carburising gas carbon source. Case hardening essentially consists of three steps. First, the parts are austenitized, then carburized, and Once the required carbon profile is reached, they are quenched. Required surface microstructure in case harden layer of case hardened parts are martensite with maximum of 15-20% retained austenite LPC is usually combined with High Press-ure Gas Quenching (HPGQ) and Oil quenching. During HPGQ the load is quenched using an inert gas-stream. Usually nitrogen or helium are used as quench gas. In LPC with oil quench process parts are quench in special oil's designed for vacuum furnaces.00

Process

Figure 1 depicts a typical carbon profile, and Fig. 2 shows a typical hardness profile after a case hardening process. In this example, the surface hardness is 750 HV and the case-hardening depth (CHD) is 0.95 mm (0.03 in.). The common definition of case-hardening depth is the distance from the
surface in which the hardness is still above the hardness limit of 550 HV(50 HRC). Process cycle for low pressure carburising is shown schematic drawing in fig 3. After loading the parts , vacuum is created in chamber.

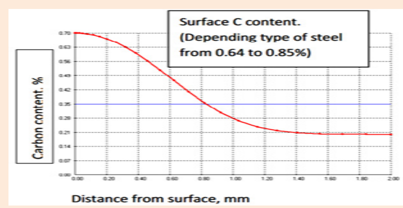


Fig. 1: Example of C profile after case hardening

Initially parts are heated under convective operation with help of nitrogen at 1.5 bar. Convective heating offers faster ramp rate and also homogenous along load, compared to vacuum heating. After reaching to a temperature of 750°C, Parts are further heated in under vacuum condition till the carburising temperature is reached. Carburising takes place by introduction of acetylene C_2H_2 in to furnace chamber. Acetylene act as source of carbon in carburising process.

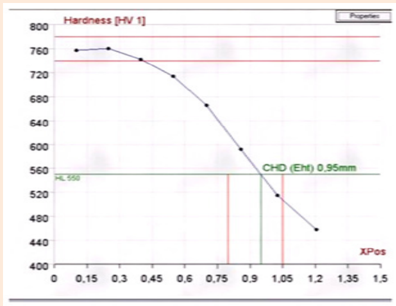


Fig. 2: Hardness profile after case hardening

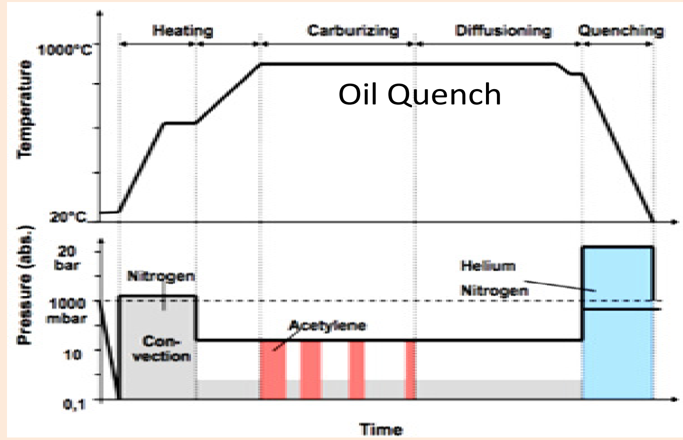


Fig. 3: Low Pressure Carburising Process Cycle

This carburising gas starts to dissociates at 500°C and as the temperature increases the dissociation occurs at faster rate forming atomic C. This carbon further gets deposited on the surface of the parts and C concentration rises on the surface within very short interval of time. Flow of acetylene in to the chamber is interrupted as soon as the C content reaches to the saturation level of the steel being used. Subsequently this results in to the high mass flow of carbon from surface to interior. Above process steps are referred as boost and diffusion steps of low pressure carburising cycle.

These steps are further repeated -Fig 4 till the required carbon profile is reached in the steel. After completion of all boost steps , final diffusion time is given for achieving required surface carbon content. The high Carbon yield from Acetylene Gas and fast mass transfer of carbon during carburising leads to the saving of almost 30% of process time compared to conventional process.

As soon as the required carbon profile has been achieved, parts are then further quench in either gas or oil media.

Low pressure Carburising at High temperatures

Low pressure carburising equipment's are based on cold wall technologies, i.e. the vessel is manufactured with a double wall jacketed steel structure, Furnace walls will be continuously cooled with flow of water and the hot zone is insulated with graphite plates.

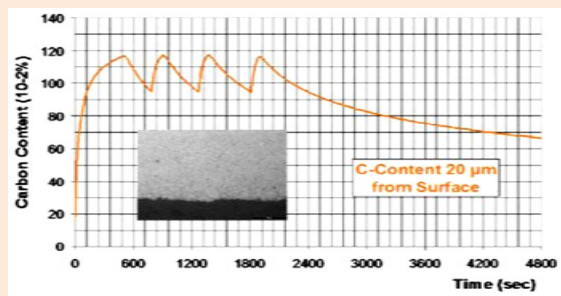


Fig. 4: Carbon Diffusion during LPC

Therefore, from the technical point of view, higher process temperatures can be used in Low pressure carburising furnaces. Conventional carburising furnace eg SQF, Pit Type furnace with its insulation systems can go maximum 910-930°C. As shown in Table 1 , With Low pressure carburising substantial amount of time can be saved compared conventional gas carburising due to high mass transfer of carbon from surface. This effect can be further enhance by increasing temperature for carburising. With higher carburising temperature leads to faster diffusion of Carbon in to the steel, thus carburising time is reduced significantly. This can be seen from Fig 4, carburising time reduces drastically as the temperature is increased.

Comparison of Carburising Process Time

Below Table 1 compares the process times of both technologies at a carburising temperature of 930C. Charging, heating and quench times vary slightly. Time savings clearly become evident in the carburising and diffusion time. The example in Table 1 shows a 20MnCr5 with a CHD of 0.8 mm (0.35%C). Carburising with the conventional technology takes 180 min, low pressure carburising only takes 140 min, 40 min less, or 30% (based on the carburising cycle).

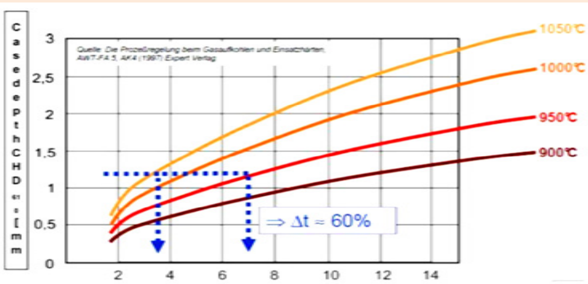


Fig 4. Carburising time (hr)

Table 1
Vacuum Carburising compared to Gas Carburising for CHD 0.8 mm -20MnCr5

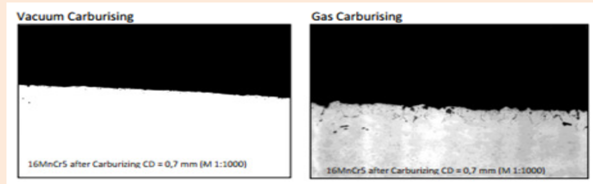
Process Step	Vacuum Furnace 930˚C min	Gas Furnace 930˚C min	Vacuum Furnace 960˚C min
Loading	5	5	5
heat-up to	90	90	90
carburizing and diffusion	140	180	90
Decrease temp. to core hard temperature	45	60	45
Quenching	15	20	15
Unloading	5	5	5
Total – Floor to Floor	300	360	250
Process Time Reduction-%	60- 17%		110 – 31%

Considering above the total time savings of 60 minute -17% in floor to floor operation represent a great potential. This is further increased to 110 minute -31% with carburising temp of 960˚C

Advantages of Low Pressure Carburising

Following are the various advantages /benefits of vacuum carburising over conventional gas carburising techniques

- Uniform case depth
- Surface free from intergrannular oxidation and surface oxidations
- Environmentally friendly process .
- No fire /flame hazards.
- Shorter process cycle time thus lower production costs.
- Better control on distortion
- Enhancing Energy efficiency.



Microphotograph shown above indicates the surface of steel parts after both Low pressure carburising and Gas carburising. It clearly shows that surface after LPC process is completely free from any intergranular oxidation compared to conventional gas carburising. This further affect in reduced surface hardness, low impact and fatigue properties of parts.

Applications

Various Automobile components can be case hardened through Low pressure carburising technologies for case depth ranging from 0.3 to 2.5 mm. Available Furnace technology for this process are Vacuum Chamber Furnace with High Pressure Gas Quenching and Double chamber Vacuum Oil Quench Furnaces for low alloy steel parts

References

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