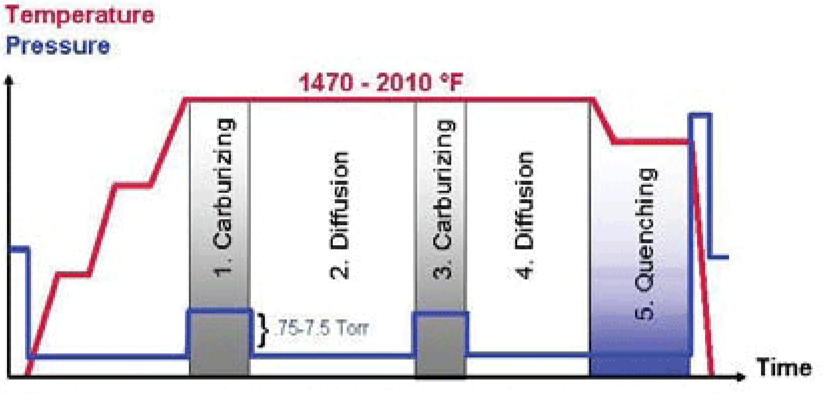
The AvaC™ Process

AvaC™ Process Description

AvaC™ is a proven process for vacuum carburizing with acetylene. One of the most important advantages of this process is high carbon availability, ensuring extremely homogenous carburizing even for complex geometries and very high load densities. The AvaC™ process involves alternate injection of acetylene (boost) and a neutral gas like Nitrogen for diffusion. During boost injection acetylene will only dissociate in contact with metallic surfaces thus allowing for uniform carburizing. At the same time it almost totally eliminates the soot and tar formation problem known to occur from propane.

As shown in Figure 1, once the carburizing temperature is reached, the first carburizing step is initiated by admitting acetylene into the furnace to pressures between 3 and 5 torr. Carbon transfer is so effective that the limit of carbon solubility in austenite is reached after only a few minutes. Therefore, the first carburizing step must be stopped after a relatively short time by interrupting the gas supply, and evacuating the furnace chamber. This initiates the second step or the first diffusion segment. The carbon transferred into the material and the surface carbon content decreases until it reaches the desired surface content. Depending on the material case depth specified, further carburizing and diffusion steps follow. Once the specified case depth is obtained, direct hardening usually involves reducing the load temperature and quenching the load, either in the same chamber or in a separate chamber.

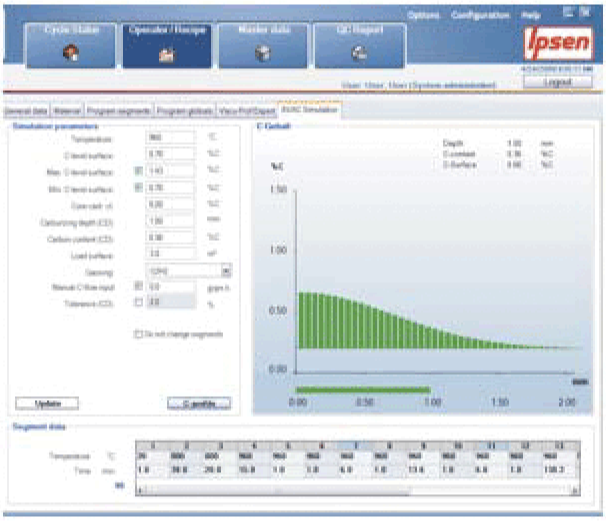
Figure 1: Typical cycle with temperature and pressure curve.



Controlling the AvaC™ Process

Control of the AvaC™ process is done via number of physical parameters which are temperature gas, gas flow, gas pressure and the number and duration of carburizing and diffusion steps. The number and duration of the carburizing and diffusion steps must be determined in order to meet the case depth specifications. A simulation program is used to keep pre-testing to a minimum. The module "AvaC-Simulation", illustrated in Figure 2, creates low pressure carburizing (AvaC™) cycle programs. The simulation program calculates carbon profiles dependent on the temperature, surface carbon content and case depth. The calculations are based on carbon transfer characteristics of acetylene gas.

Figure 2: AvaC™ Expert depicting AvaC™ Simulation model.

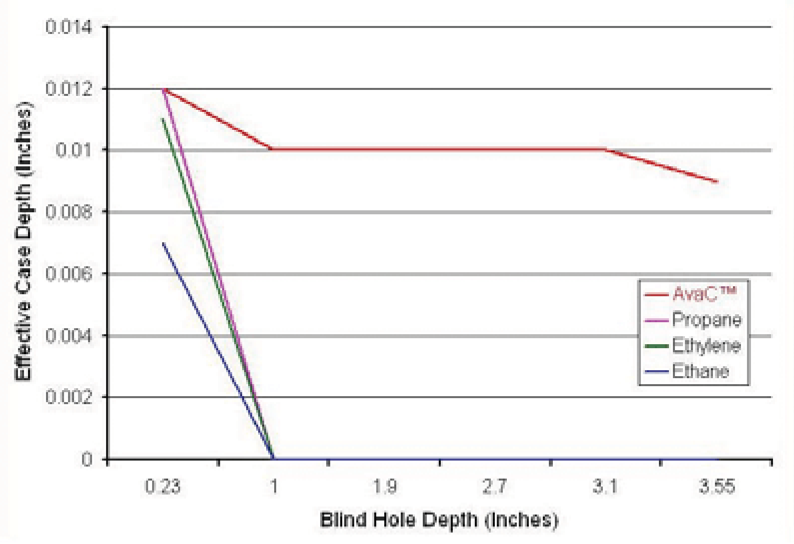


The most remarkable benefit to AvaC™ can be found when the different hydrocarbon gases for low-pressure carburizing are evaluated for their penetration power into small diameter, long, blind holes. This aspect has been investigated for samples with blind holes of 0.011" in diameter and 3.55" in length as shown in figure 3. The test cycle used in this case was a 10 minute pure boost carburizing at 1,650†F (3 torr pressure) and fast cooling in 2 bar nitrogen, followed by re-hardening from 1,580ºF, using a nitrogen quench at 5 bar. After sectioning the round bar sample of 5115 steel, the surface hardness was measured inside the blind hole, at various distances from the opening.

Figure 3: Example of Blind Hole

The results of these surface hardness measurements are shown in figure 4. This clearly indicates that the carburizing power of propane and ethylene is only sufficient to carburize the initial 0.23" of the blind hole. It was determined that the carburizing fell off rather significantly up to 1.00" hole depth. After 1.00" of hole depth the hole surface was completely un-carburized.

Figure 4: Surface Hardness Results



In contrast, vacuum carburizing with acetylene results in a complete carburizing effect along the whole length of the bore, fully to the bottom of the 3.55" blind hole. The acetylene has a totally different carburizing capability than that of propane or ethylene.

Another feature/benefit is becoming more relevant during industrial utilization of this new technology and the desire of industries to move toward more "green" technologies. Despite the high carbon availability and the greater carburizing capability of acetylene, no soot or tar is produced.

Examples of AvaC™ Vacuum Carburizing

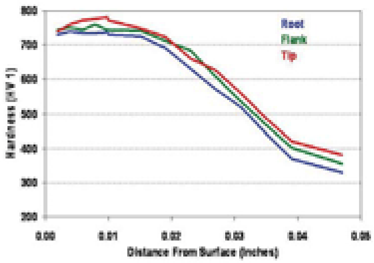
This new and cost effective technology AvaC™, is yielding totally unexpected and superior results, and is quickly being adopted across many industries.

The extreme uniformity of carburizing produced by acetylene carburizing of such components is shown. At the same time, the structure of the carburized case is totally free of any intergranular (internal) oxidation, as the only atmosphere which comes into contact with the nozzles during the carburizing process is the hydrocarbon acetylene.

A wide range of materials and processing techniques in vacuum carburizing can be seen in the following examples. These examples demonstrate the diversity of the process using vacuum carburizing techniques on small and large components. Additionally the examples selected had simple and complex geometry; were wrought and powder metal materials; parts with critical distortion concerns; requiring oil and high pressure gas quenching methods. Also considered were parts requiring dense loading arrangements; variations in section size; with shallow, medium, and deep case depth requirements. This variety underscores the type of products adaptable to the AvaC™ process in vacuum carburizing equipment.

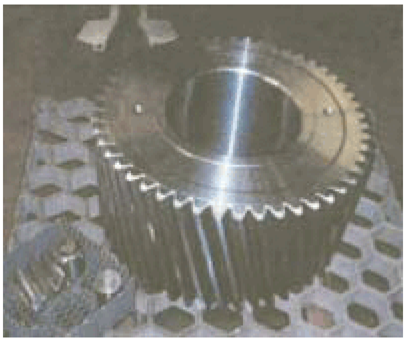
Avac™ Application Example 1 - Bevel Gears

Hardness Profile



Designation	Bevel Gear
No. of Parts	46
Load Weight	705 lbs.
Material	5115

AvaC™ Application Example 2 – Wind Turbine Gears

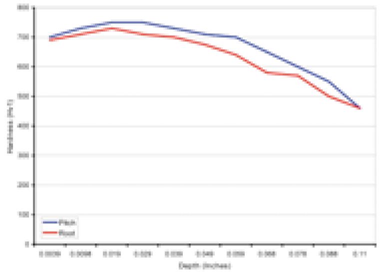


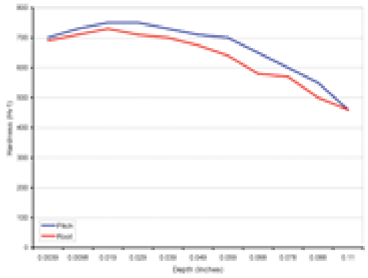
Designation	Turbine Gears
Material	18Cr Ni Mo7-6
ECD at 513 Hv 0.5	0.078 +/- 0.011”
Gross Load Weight	350 lbs
Carburizing Temperature	1,800ºF
Gas Quenching Pressure	15 Bar
Cycle Time	6 Hours

Hardness Profile

Wind Turbine Gears

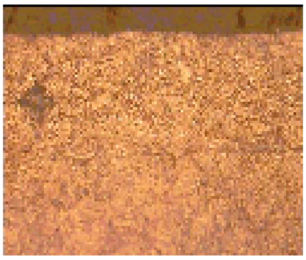
Carbon Profile

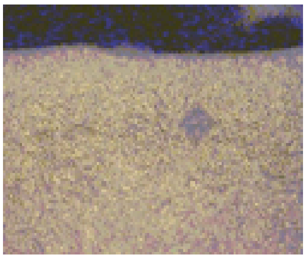




AvaC™ Application Example 3 – Aerospace Materials

SAE 9310	M50 NiL	Pyrowera X53
Carburizing Temp: 1750ºF	Carburizing Temp: 1750ºF	Carburizing Temp: 1700ºF
Cycle Time: 4 hrs. 25 min.	Cycle Time: 8 hrs. 40 min.	Cycle Time: 4 hrs. 25 min.
ECD@50 HRC: 0.037"-0.043"	ECD@50 HRC: 0.040"-0.055"	EC@50 HRC: 0.032"-0.035"



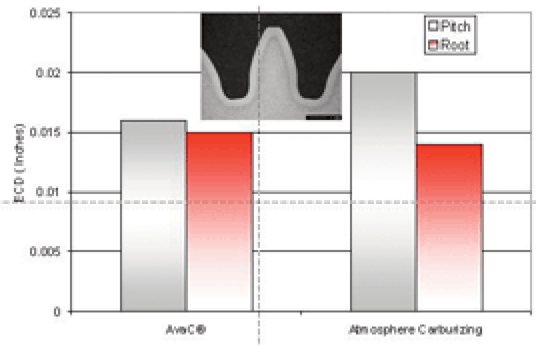


Nital Etched 500X

AvaC™ Process Advantage

One of the most important advantages of the AvaC™ process as illustrated in figure 5 is high carbon availability ensuring homogeneous carburizing even for complex geometries and very high load densities.

Figure 5: AvaC™ vs. Other Processes: Carburizing Homogeneity



Improved pitch to root case ratio of 70% for Atmosphere Carburizing as compared to 85%-90% with AvaC™

Other advantages include:

- Shorter process times due to high carbon flux, high carburizing temperature and elimination of furnace conditioning.
- Enhanced component quality due to elimination of internal oxidation and precise case uniformity.
- Carburizing of complex geometry and dense loads.
- Safe process due to the lack of flammable waste gases.
- High furnace availability/reliability due to elimination of soot or tar formation.
- Higher part-to-part, load-to-load repeatability over atmosphere technology.

AvaC™ Process Advantage Over Atmosphere Furnaces

The AvaC™ process provides the following features and benefits over conventional atmospheric furnaces:

- Better work environment with cold-wall design which provides lower shell temperature.
- No costly exhaust hoods or stacks required.
- Faster start-ups and shutdowns with no furnace idling over the weekends.
- No endothermic gas generators required.
- Gas quench furnaces require less floor space and no post washing to remove quench oils.
- No pits or special foundation requirements needed.

AvaC™ Furnace Configurations

The AvaC™ furnace can be provided in the following configurations and sizes.

Figure 6: Single Chamber Design

Single Chamber Work Space
24" W x 24" H x 36" L
36" W x 36" H x 48" L

Figure 7: Two Chamber Design: Oil and/or Gas

Two Chamber Work Space
24" W x 24" H x 36" L
36" W x 36" H x 48" L

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