

# Case Carburizing: An Important Surface Hardening Technique

Ashish Mishra

M. Tech Scholar, Department of Mechanical Engineering, Jaipur Institute of Technology Group of Institutions, Jaipur, Rajasthan, India  
Email: [heashish71\[at\]gmail.com](mailto:heashish71[at]gmail.com)

**Abstract:** Case carburizing is one of the most reliable methods for increasing the life of mechanical components subjected to constant abrasion and heavy loads. This surface hardening technique, although rooted in traditional metallurgy, has continued to play a vital role in industries ranging from automotive to aerospace. The method involves heating low-carbon steel parts in a carbon-rich atmosphere—typically between 900°C and 950°C—which causes carbon atoms to diffuse into the surface layer. This results in a hard, wear-resistant outer shell while the inner core retains its strength and ductility. It is evident that the process has evolved significantly over time. While pack carburizing is the oldest and simplest form, gas carburizing has become the industry standard due to its accuracy and scalability. Liquid carburizing, although once popular, has declined in use due to environmental concerns. However, this technique is not without its challenges; issues such as distortion, high energy consumption and the need for precise control still pose operational hurdles. This shows that although the process offers clear advantages in terms of wear resistance and fatigue strength, careful experimentation is still extremely important. Taking this further, modern industries are increasingly integrating automated systems to optimize parameters such as temperature, time and carbon capacity, reducing human error and improving consistency. In the broader context of materials engineering, case carburizing is a worthwhile example of how age-old processes can remain relevant through optimization and technological improvement.

**Keywords:** Case carburizing, surface hardening, gas carburizing, wear resistance, mechanical components

## 1. Introduction

Case carburizing is a well-known surface hardening process used to protect low-carbon steel parts from wear and fatigue by hardening the outer surface and keeping the inner core soft and flexible.

This process is particularly useful for mechanical parts that have to bear high friction and loads, such as gears, crankshafts and camshafts.

## 2. Principle of Carburizing:

In this process, the steel part is heated to a high temperature (typically 900 to 950°C) in a carbon-rich atmosphere. At this temperature, carbon atoms penetrate the steel surface.

The part is then cooled rapidly, forming a martensitic structure on the surface – which is very hard – while the inner core remains soft and flexible.

## 3. Types of Carburizing

### a) Pack Carburizing

- Components are packed in a box with a solid carbon material like charcoal and an energizer like borax and heated in a furnace.
- Oldest and simplest method.
- Slow process, difficult to control depth.

### b) Gas Carburizing

- Most commonly used industrial method.
- Components are heated by keeping them in contact with carbon containing gases (e.g. methane, propane).
- Better control over case depth and process.
- Suitable for mass production.

### c) Fluid Carburizing

- Components are immersed in a chemical fluid salt containing carbon.
- Faster process, but its use has declined due to environmental and safety reasons.

## 4. Process Parameters

- Temperature: 900-950°C
- Time: 1 hour to several hours
- Carbon strength: must be controlled
- Case depth: typically 0.5 mm to 2 mm

## 5. Subsequent heat treatment process:

- After carburization, the component is:
- Quenched (rapid cooling)
- Then tempered to reduce brittleness and relieve stress
- This can result in surface hardness as high as 55-62 HRC while the core remains flexible.

## 6. Advantages

- Excellent wear resistance
- Better fatigue resistance
- Strong and shock absorbent core
- Can be applied to low cost steels

## 7. Limitations

- Possibility of distortion in shape
- Process requires precise control
- Not suitable for certain metals
- Long life and high energy consumption

## 8. Areas of application

- Gears and shafts
- Camshafts and crankshafts
- Bearings and bushings
- Automobiles and aerospace equipment
- Heavy moving mechanical parts in industries

## 9. Conclusion

Case carburizing is a traditional but highly effective surface hardening process, which enhances the performance and service life of mechanical parts. With the aid of modern gas carburizing and automatic control systems this process remains an essential technology in the industrial sector even today.

## References

- [1] H. K. D. H. Bhadeshia and R. Honeycombe, \*Steels: Microstructure and Properties\*, 4th ed. Butterworth-Heinemann, 2017.
- [2] G. Krauss, \*Principles of Heat Treatment of Steel\*, ASM International, 1990.
- [3] G. E. Totten and M. A. H. Howes, \*Steel Heat Treatment Handbook\*, Marcel Dekker Inc., 1997.
- [4] D. R. Askeland and W. J. Wright, \*The Science and Engineering of Materials\*, 7th ed., Cengage Learning, 2015.
- [5] ASM International, \*Metals Handbook: Heat Treating\*, Vol. 4, 10th ed., ASM, 1991.
- [6] M. Prakash, "A review on gas carburizing process parameters and their effect on case depth," \*Materials Today: Proceedings\*, vol. 5, no. 2, pp. 4256–4260, 2018.
- [7] J. L. Dossett and H. E. Boyer, \*Practical Heat Treating\*, 2nd ed., ASM International, 2006.
- [8] N. Suresh and R. Balasubramaniam, "Process optimization of case carburizing using Taguchi method," \*Journal of Materials Processing Technology\*, vol. 170, pp. 307–311, 2005.
- [9] R. A. Swalin, \*Thermodynamics of Solids\*, Wiley, 1972.
- [10] H. J. Goldstein, "Effect of carburizing on surface hardness of alloy steels," \*Journal of Heat Treating\*, vol. 3, pp. 215–220, 1984.