

# GRADING THE STRENGTH OF STEEL

# Newly developed high-strength steel for car powertrain and transmission components includes three grades – knowing the difference will help you meet your quality goals.

By GREGORY VARTANOV

Vehicle manufacturers are faced with a difficult task of significantly improving fuel economy and safety while maintaining competitive position in the market. This can be accomplished, among other things, by using higher strength steel for car and truck. Newly developed high strength steel for car powertrain and transmission components (GEAR-Steel) can help accomplish just that. Replacing traditionally used carburized SAE 8620, 4320, and 9310 steel in by GEAR-Steel allows reducing weight of components without sacrificing their durability and lifetime.

## DESCRIPTION

GEAR-Steel is being offered as bar products in three grades [1-2]. Grade 1 is carburizing steel for powertrain and transmission components, such as shafts, gears, axels, etc. Carburized Grade 1 has surface hardness of Rockwell C (HRC) 61-63 and core hardness of HRC 45-46 at 0.06/1.5 in/mm minimum case depth, which is higher than the SAE 4320, 8620, and 9310 [3] at the same level of ductility and toughness. Production cost of Grade 1 is similar to SAE 4120 grade.

Grade 2 is a deep nitriding steel perfect for high precision components, such as bearings, gears, shafts, pinions, crankshafts, camshafts, bolts, etc. After normalizing, quenching, tempering, and nitriding by conventional methods, Grade 2 has the case depth of 0.01-0.02/0.25 - 0.50 in/mm with the surface hardness Vickers (HV) of 760-800 and core hardness of HRC 46-48; an ultimate tensile strength (UTS) of 225-235/1550-1625 ksi/MPa, a yield strength (YS) of 205-215/1415-1485 ksi/MPa, elongation (El) of 9-10 percent, reduction of area (RA) of 40-45 percent, and Charpy v-notch impact toughness energy of 14-18.5/19-25 ft-lb/J. Production cost of Grade 2 is similar to SAE 4140 grade. Vacuum melted Grade 2 is high strength substitution of the vacuum melted Nitralloy 135 grade [4] and it is applicable for the aircraft gears, shafts, pinions, crankshafts, camshafts, and bolts.

Grade 3 is a super-high strength steel for powertrain and transmission components such as gears, crankshafts, camshafts, axle shafts, connecting rods, etc. After quenching and tempering, Grade 3 has surface and core hardness of HRC 58-60, UTS of 325-335/2245-

2310 ksi/MPa, YS of 255-265/1760-1830 ksi/MPa, El of 7-9 percent, RA of 30-32 percent and CVN of 12-16/16-22 ft-lb/J. Production cost of the Grade3 is similar to that of SAE 4150 grade.

The following method of manufacturing of the automotive transmissions and powertrains components such as gears, camshafts, axle shafts and others from Grade 3 is proposed:

- ▶ Hot rolled or hot forged bars are normalized and stress relieved.
- ▶ The components are machined from the bars.
- ▶ The components are hardened by normalizing,



| Steels  | YS, ks/MPa            | UTS, ksi/MPa          | El, % | RA, % | CVN, ft-lb/J      |
|---------|-----------------------|-----------------------|-------|-------|-------------------|
| Grade 1 | 175-185/<br>1210-1275 | 220-230/<br>1520-1590 | 11-13 | 45-50 | 18.5-25/<br>25-34 |
| Grade 2 | 205-215/<br>1415-1480 | 225-235/<br>1550-1620 | 9-10  | 40-45 | 14-18.5/<br>19-25 |
| Grade 3 | 255-265/<br>1760-1830 | 325-335/<br>2240-2310 | 7-9   | 30-32 | 12-16.5/<br>16-22 |

austenizing, oil quenching, and tempering.

After hardening, components made from Grade 3 have core and surface hardness of HRC 58-60. Grade 3 has significantly higher core hardness compared the carburized, quenched, and tempered SAE 8620, 4320, and 9310 steels that have surface hardness of HRC 59-61 and core hardness of HRC 38-40. High hardness of Grade 3 is obtained without sacrificing its ductility and toughness.

Using Grade 3 allows reducing weight of the transmission and power train components by reducing their thickness. For example, projected weight reduction of gears of an automatic transmission of




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230/104 lb/kg with gears of 130/59 lb/kg from carburized SAE 8620, 4320, and 9310 steels will be around 20 percent or 26/12 lb/kg in case of substitution of the carburized steels by Grade 3.

Granted, using Grade 3 requires additional investment in the redesigning of the automotive transmissions and powertrain components and the changing some tools. However, benefits of utilizing Grade 3 significantly exceed the expenses of its implementation.

The table shows a comparison of mechanical properties of three grades of GEAR-Steel after hardening to maximum strength.

#### SUMMARY

Newly developed high-strength steel for car powertrain and transmission components includes three grades. After carburizing and hardening, Grade 1 has strength and core hardness higher than 9310 grade at the same surface hardness. Vacuum melted deep nitriding Grade 2 is high-strength substitution of the vacuum melted Nitralloy 135 grade and it is applicable for the nitride aircraft components. Super-high strength Grade 3 allows reducing weight of the car components compared to the traditional carburizing grades. 

#### REFERENCES

- [1] Vartanov, Gregory, "High strength low alloy steel and method of manufacturing," U.S. Patent No 9,869,009, 2018.
- [2] Vartanov, Gregory, "New steel competes with AISI 4340," Advanced Materials & Processes, July 2014, p.p. 6-7.
- [3] ATI Allvac® Vasco® 9310 Specialty Steel, MatWeb, [www.matweb.com/search/DataSheet.aspx?MatGUID=3a548b79622945eb8bd1ca53d2dd18c0](http://www.matweb.com/search/DataSheet.aspx?MatGUID=3a548b79622945eb8bd1ca53d2dd18c0)
- [4] Latrobe Nitralloy® 135 Modified VAC-ARC, MatWeb, [www.matweb.com/search/DataSheet.aspx?MatGUID=36648594f886472a8f86f9d5f17a8b9e&ckck=1](http://www.matweb.com/search/DataSheet.aspx?MatGUID=36648594f886472a8f86f9d5f17a8b9e&ckck=1).

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