News Release

October 25, 2021

SANYO SPECIAL STEEL

New Lineup of Nickel- and Molybdenum-free High Strength Case-hardening Steel

Sanyo Special Steel Develops ECOMAX5 for Omitting or Simplifying Parts Manufacturing Processes

— Contributes to reduction of cost and CO_2 emissions when manufacturing high-strength parts such as gears and shafts —

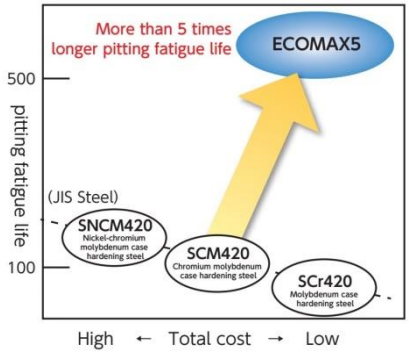
Sanyo Special Steel Co., Ltd. (President: Katsuhiro Miyamoto; Head Office: Himeji, Hyogo Prefecture) has developed ECOMAX5 as a new addition to its proprietary ECOMAX series of nickel- and molybdenum-free high-strength case hardening steels. The developed steel meets the expectations for compact and lightweight designs of parts with excellent strength, which is a prominent feature of the ECOMAX Series. It also features a new alloy design that enables customers to omit or simplify their parts manufacturing processes, thereby contributing to the reduction of CO_2 emissions, which has recently become increasingly desirable in terms of life cycle assessment (LCA).

In addition to having equivalent or higher strength than the existing ECOMAX series, ECOMAX5 has further enhanced properties sought by customers who want to omit or simplify various heat treatment processes (annealing, normalizing, carburizing) in their parts manufacturing process. Not only does this allow customers to reduce costs, it promises to contribute to drastic reductions in CO_2 emissions.

- ECOMAX5 is expected to be used for gears and shafts

Contributions to the miniaturization and weight reduction of automotive parts such as gears and shafts

Parts that require high strength are typically made from materials with added or increased amounts of rare and costly alloy elements such as nickel and molybdenum. The ECOMAX series, including ECOMAX5, is based on high-cleanliness steelmaking technology that maximizes the inherent performance of steel. By optimizing the balance of alloy elements such as chromium and silicon, and the operating conditions during the steelmaking process, ECOMAX5 achieves significant strength improvements despite using less alloys. It achieves more than five times the life of typical case hardened steel (JIS SCM420), particularly against peeling damage (pitting corrosion) on gear teeth surfaces. The improved fatigue strength of parts promises further downsizing and weight reduction of various mechanical units, including those for automobiles.



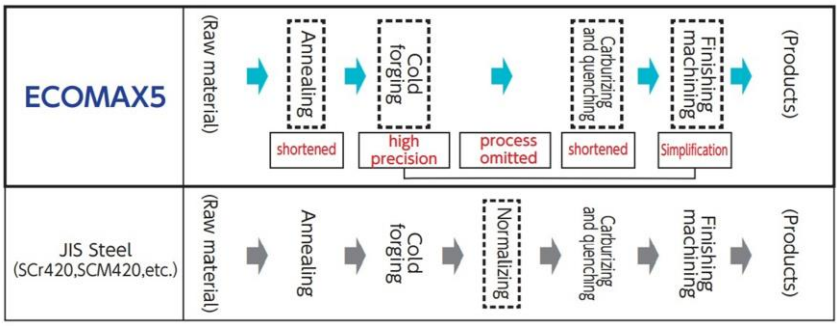
- Anti-pitting characteristics of ECOMAX5

Contributions to the reduction of CO_2 emissions by simplifying or omitting parts processes

In parts manufacturing processes that use case hardening steel, when cold forging, a heat treatment process called "annealing" is used to soften the material. To anneal alloy steels such as case hardened steel, the material is usually heated to about 800°C until it becomes an austenite structure, and then slow-cooled over a long period of time to precipitate spherical carbides, which softens the material. With ECOMAX5, carbides spheroidize and soften in less than half the processing time of conventional methods without slow cooling by holding the material in the low temperature range for a short time.

In addition, the presence of evenly dispersed spherical carbides due to annealing facilitates high-precision forming in cold forging and improves compatibility with near net shaping.

Additionally, because of its superior properties for preventing grain coarsening during carburization compared to typical case hardened steels and other grades in the ECOMAX series, the normalizing process—usually applied after cold forging and before carburizing and quench—can be omitted, and the processing time can be greatly reduced due to higher carburizing temperatures.



- Simplification and omission of the manufacturing process for gear and shaft parts (example)

Sanyo Special Steel will continue to develop eco-products, which are products that allow the manufacture of smaller and lighter parts while reducing CO_2 emissions, in order to meet the sophisticated and diverse needs of customers toward a decarbonized society.

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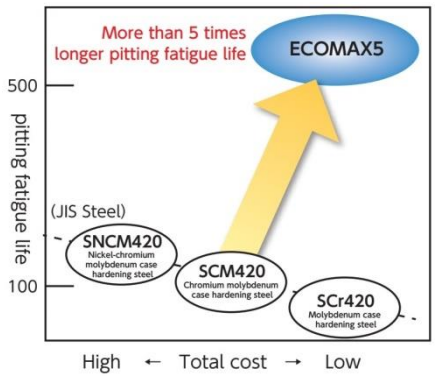
(Reference)

High strength (fatigue life) while saving scarce resources

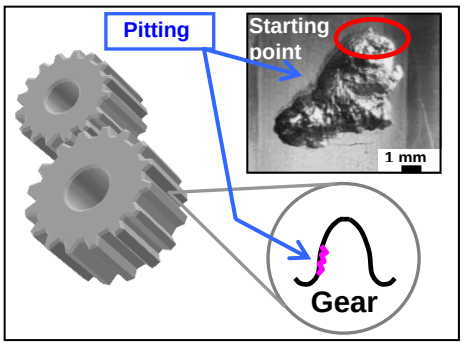
Pitting strength greatly affects the service life of gear parts used in automotive drivetrain units. Pitting is a phenomenon that occurs when gear teeth and their counterparts repeatedly come into contact with each other under high stress with slippage, causing cracks to form and propagate on the gear tooth surface due to metal fatigue, eventually leading to fracture. This phenomenon is expected to become increasingly important as the use of low-viscosity lubricants aimed at improving fuel efficiency and the use of high speed motors in electric vehicles gain momentum. In order to reduce the damage caused by this phenomenon, adding rare resources such as nickel (Ni) and molybdenum (Mo) are said to be effective in improving the softening resistance to temperature rises during contact with the tooth surfaces.

The high pitting fatigue life of ECOMAX5 was achieved by optimizing the amount of silicon (Si) and chromium (Cr) without using rare metal resources such as nickel and molybdenum, and by giving it higher softening resistance than typical case hardened steel, and properties that prevent cracks from initiating in the surface layer of carburized parts.

Achieves outstanding fatigue strength and



Conceptual diagram and external view of gear pitting corrosion



· Drastic reduction of annealing time and prevention of forging cracks

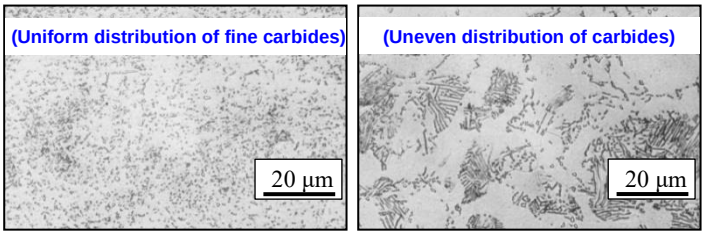
In manufacturing processes that use typical case hardened steel, annealing is performed to soften the material before cold forging. This heat treatment requires a long period of time, from 12 to 24 hours, under precise temperature control, because the structural changes in the steel need to be properly controlled.

ECOMAX5 leads itself to the shortened annealing method, which is unparalleled elsewhere in the world, to soften steel in a short period of time at a relatively low temperature that does not cause structural in typical case hardened steel. This promises to halve the existing processing time (6 to 8 hours).

Uneven distribution of carbides in the annealed structure will lead to uneven deformation during cold forging, making the material prone to cracking.

The annealing process of ECOMAX5 forms a structure in which carbides are evenly dispersed, making it less likely to crack during deformation, and thus making it easier to achieve near netting in applications such as gear tooth forming.

Structure of annealed material (optical microscope)



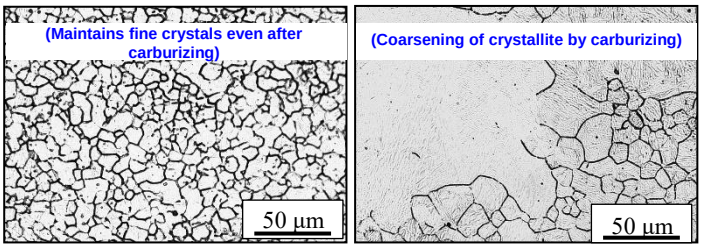
ECOMAX5 Typical case hardened steel (JIS SCr420)

· Excellent grain coarsening resistance

With typical case hardened steel, direct carburizing and quenching after cold forging coarsens the crystal grains, and causes the strength and toughness of the part to weaken. To prevent this, a heat treatment called normalizing was indispensable before carburizing and quenching.

ECOMAX5 appropriately precipitates niobium (Nb) carbonitrides in the steel, which are fine pinning grains that inhibit grain coarsening, and the alloy design enhances the homogeneity of the structure before carburizing. This causes the crystal grains to remain stable in a fine state even during carburizing and quenching, which allows the previously required normalizing process to be omitted.

Crystal grains of parts carburized and quenched after cold forging (optical microscope photo)



ECOMAX5 Typical case hardened steel

In addition, these excellent properties enable the application of high-temperature, short-time carburization, which shortens the overall processing time by increasing the carburizing temperature.

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