Claims

1. Steel for marine engineering, comprising the following chemical elements by mass percentage:

C: 0.01-0.05%, Si: 0.05-0.60%, Mn: 0.50-1.30%, Cr: 0.6-1.20%, Ni: 2.0-3.0%, Al: 0.01-0.06%, Ti: 0.005-0.012%, and Mg: 0.0005-0.0015%; $0<Ca\leq0.0045\%$, $0<Cu\leq0.5\%$, and $0<Mo\leq0.40\%$; at least one of the following chemical elements: $0<Nb\leq0.04\%$, $0<V\leq0.05\%$, and $0<B\leq0.0005\%$, and the remainder of Fe and inevitable impurities, wherein in the inevitable impurities $P\leq0.015\%$, and/or $S\leq0.0040\%$,

wherein the steel has a microstructure of tempered bainite with a phase ratio of 95% or more and the austenite grain size is 20-25 μm.

2. The steel for marine engineering according to claim 1, wherein the mass percentages of the chemical elements are as follows:

C: 0.015-0.04%, Si: 0.15-0.60%, Mn: 0.50-1.30%, Cr: 0.6-0.90%, Ni: 2.0-2.85%, Al: 0.01-0.06%, Ti: 0.005-0.012%, and Mg: 0.0005-0.0015%; $0<Ca\leq0.0045\%$, $0<Cu\leq0.5\%$, and $0<Mo\leq0.40\%$; and the remainder of Fe and inevitable impurities.

3. The steel for marine engineering according to claim 1 or 2, wherein the mass percentages of the chemical elements further satisfy at least one of the following relationships:

$1.8\leq\alpha\leq2.0$, wherein $\alpha=1.2Cr+5Ni-Cr^2-Ni^2-4.61$; and

$35\leq\gamma\leq65$, wherein $\gamma=10Si+30\sqrt{Mo}+57\sqrt{Cu}$.

4. The steel for marine engineering according to claim 1 or 2, wherein the mass percentages of the chemical elements further satisfy: $4.2\leq\beta\leq7.9$, wherein $\beta=40Al+60Ti+20\sqrt{Nb+V+Ti}$.

5. The steel for marine engineering according to claim 1 or 2, wherein the steel has a yield strength of 355 MPa or more, a tensile strength of 500-650 MPa, an elongation rate of 22% or more, an impact energy at -60°C of 100 J or more, a CTOD at -60°C of 0.8 mm or more, an NDTT of -65°C or less, and a corrosion rate in a highly humid and hot atmospheric environment of 0.85 g/(m^2*h) or less.

6. A manufacturing method for the steel for marine engineering according to any one of claims 1-5, comprising the following steps:

(1) smelting and continuous casting;

(2) heating as such that a slab heating temperature T_h satisfies T_h=1150+600C+$120\sqrt{Nb+Ti+V}$ with a unit being °C;

(3) controlled rolling as such that the initial rolling temperature T_{sr} satisfies T_{sr}=0.92T_h-0.96T_h , with a unit being °C, a final rolling temperature T_{fr} satisfies T_{fr}=1100-199C-$98\sqrt{Mn}$ - $42\sqrt{Ni}$ -21Cr, with a unit being °C, rolling reduction in a single pass is 8-12% and cumulative rolling reduction is 60% or more, so that an original austenite grain size after rolling being 20-25 μm;

(4) air cooling; and

(5) quenching and tempering as such that a quenching temperature T_q satisfies T_q=955-11C-14Mn-$17\sqrt{Cr}$ +$16\sqrt{Mo}$ with a unit being °C, so that an austenite grain size after quenching being 20-25 μm, and a tempering temperature T_t satisfies T_t=710-$203\sqrt{C}$ -15.2Ni+44.7Si+104V+31.5Mo with a unit being °C.

7. The manufacturing method according to claim 6, wherein in step (1), hot metal pretreatment, converter smelting, LF refining, RH refining, inclusions beneficial treatment and continuous casting are performed successively, wherein in the stage of

inclusions beneficial treatment, composite inclusions having a size of 0.2-2.5μm are formed, and the composite inclusion comprises $MgO+Al_2O_3$ coated with CaS and MnS as its core and a number of the composite inclusions within the size range accounting for 95% or more of a total number of inclusions.

8. The manufacturing method according to claim 7, wherein in step (1), at the stage of converter smelting, slag cutoff tapping is performed, with a thickness of a slag layer being controlled to be smaller than 30 mm; at the stage of LF refining, a sum of the mass percentages of FeO and MnO in slag is controlled to be smaller than 1%, and a formula is satisfied: $(CaO+MgO+MnO)/(SiO_2+P_2O_5)>9$, in the formula, each substances represents their corresponding mass percentages; at the stage of inclusions beneficial treatment, Mg treatment or Mg and Ca composite treatment is performed; and when Mg and Ca composite treatment is performed, Ca and Mg are fed at the same time with a wire feeding speed of 150-250 m/min.