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(54) Title: CUTTING TOOL

(57) Abrégé/Abstract:
The object of the invention is to improve the performance characteristics of a cutting tool for wood material. According to the invention, the cutting tool is characterized by a material toughness of more than 100J measured in longitudinal direction as impact energy AV (SBP) pursuant to Stahl-Eisen-Prüfblatt [steel-iron test sheet] (SEP) 1314, with a material hardness of more than 60 HRC and increased corrosion resistance as well as wear resistance thereof consisting of an alloy with a chemical composition in % by weight of:
C = 0.7 to 0.9
Si = ≤ 0.8
Mn = 0.35 to 0.45
S = < 0.005
Cr = 7.5 to 8.5
Mo = 1.4 to 1.8
Ni = < 0.4
V = 0.5 to 0.7
W = < 0.3
Al = 0.003 to 1.0
Fe = remainder as well as production-related contaminations, wherein the thermally treated material of the cutting tool has a total carbide content of more than 3% by volume, of which at least 0.35% by volume are monocarbides and the matrix consists of annealed martensite.

Abstract

The object of the invention is to improve the performance characteristics of a cutting tool for wood material.

According to the invention, the cutting tool is characterized by a material toughness of more than 100J measured in longitudinal direction as impact energy AV (SBP) pursuant to *Stahl-Eisen-Prüfblatt* [steel-iron test sheet] (SEP) 1314, with a material hardness of more than 60 HRC and increased corrosion resistance as well as wear resistance thereof consisting of an alloy with a chemical composition in % by weight of:

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Al = 0.003 to 1.0
Fe = remainder as well as production-related contaminations,

wherein the thermally treated material of the cutting tool has a total carbide content of more than 3% by volume, of which at least 0.35% by volume are monocarbides and the matrix consists of annealed martensite.

Cutting Tool

The invention relates to a cutting tool, in particular, for cutting wood.

In the woodworking industry, knives or cutting strips which are simultaneously subjected to wear due to adhesive and abrasive stresses, to deflection and to pressure in the cutting edge region, largely abruptly, are used for cutting wood, in particular logs, i.e. for so-called "chipper applications". The material of tools or knives of this type should therefore also be resistant to stress due to tannin from a corrosion-chemical point of view and should, at the same time, obtain or have both maximum toughness and maximum wear resistance as well as a high degree of hardness by means of a thermal tempering treatment.

The demands for continuously increasing performance with maximum safety in operation of the woodworking facilities can ultimately only be met by cutting tools with an appropriately adapted performance profile. In other words: Wear, peripheral damages due to plastic deformations on the one hand, and conchoidal or lenticular breaks of the edges primarily due to impact stresses on the other hand, as well as a premature knife breakage due to material properties adapted to one another are to be prevented, in particular in the cutting region of the knife, .

It is known to use steels with the material No. 1.2362 according to DIN for "chipper applications". Knives made of this steel have a high material toughness in the thermally hardened state, however, their wear resistance, the inherent stability of the cutting region and the corrosion resistance is, for the most part, too low. To improve the inherent stability of the cutting edge, knives or cutting strips are often made of steel according to material No. 1.2363, said cutting tools usually not having a sufficient resistance to wear. Attempts have already been made to use an alloy according to AT 393 387 as cutting tool material, whereby the best results with respect to the wear performance could be obtained, though errors occasionally occurred which indicate a material toughness which is too low.

The object of the invention is to overcome the respective disadvantages of the prior art and to create a cutting tool, in particular a knife, of the aforementioned type which exhibits synergetically improved performance characteristics during processing, in particular when cutting wood with sporadic stresses or interrupted cuts, as a result of a limited selection of the concentration of the respective elements in the steel or of the chemical composition as well as the thermal tempering and the microstructure of the material.

This object is obtained with a cutting tool of the aforementioned type having a material toughness of greater than 100J, measured in longitudinal direction, as impact energy AV (SBP) pursuant to *Stahl-Eisen-Prüfblatt* [steel-iron test sheet] (SEP) 1314; with a material hardness of more than 60 HRC and increased corrosion resistance as well as wear resistance thereof consists of an alloy having a chemical composition of % by weight:

C	=	0.7 to 0.9
Si	=	$\leq$ 0.8
Mn	=	0.35 to 0.45
S	=	< 0.005
Cr	=	7.5 to 8.5
Mo	=	1.4 to 1.8
Ni	=	< 0.4
V	=	0.5 to 0.7
W	=	< 0.3
Al	=	0.003 to 1.0
Fe	=	remainder as well as production-related contaminations,

wherein the thermally treated material of the cutting tool has a total carbide content of more than 3% by volume, of which at least 0.35% by volume are monocarbides and the matrix consists of annealed martensite.

The advantages obtained with the invention can essentially be seen therein that the required or the desired individual properties are simultaneously maximized by the limited selection of the respective contents of the alloying components, adjusted to one another, and a conventional thermal treatment of the steel with a hardening, with a cooling of about 1030°C followed by a triple annealing at a temperature of about 550°C and creating a desired microstructure.

A high toughness of the tool material is, as was found, necessary because breakages at the cutting edges and even knife breakages can occur at a value of less than 100J for the impact energy measured on an impact bending test in longitudinal direction. At the same time, according to the invention, high material hardness values which ensure an extensive inherent stability of the entire cutting region during high sudden stresses are necessary. A hardness of less than 60 HRC enables plastic deformations of the tool material which can lead to an adverse affect of the tool function in the cutting operation.

According to the invention, the concentration of the respective alloying components is important for a chemical stability and for the profile of the mechanical properties of the tool material, because they determine the separation and conversion kinetics and the structure during a thermal treatment.

By relating the alloying components, one can see, in particular, the contents of carbon simultaneously with the contents or the activity of the respective carbide-forming components to carbon. In a limited range of 0.7 to 0.9% by weight carbon, monocarbides are produced by 0.5 to 0.7 % by weight vanadium, said monocarbides have a small diameter, are distributed homogeneously and deliver a substantial contribution to the wear resistance of the material with a content of at least 0.35% by volume without negatively affecting its toughness. High contents of carbon and vanadium can disadvantageously affect the interaction of the alloying components and usually lead to a coarser carbide structure, as a result of which the material toughness deteriorates. Low concentrations of these components of less than 0.7% by weight carbon and 0.5% by weight vanadium overproportionally reduce the wear resistance of the material.

According to the invention, the carbon content of the alloy is set in the range of 0.7 to 0.9% by weight also with respect to forming M_7C_3 and $M_{23}C_6$ carbides with the further carbide-forming components of the steel, the desired properties of the matrix which consists of annealed martensite are also obtained with said content. In this case, the respective concentration of chromium and molybdenum in the range of 7.5 to 8.5 or 1.4 to 1.8 are essential for a desired total carbide content of more than 3.0% by volume, however, the tungsten content is restricted to a value of less than 0.3% by weight due to the material embrittling effect.

Manganese promotes the hardenability of the steel in contents of 0.35 to 0.45 and binds the sulphur which should exhibit a concentration value of less than 0.005% by weight to manganese sulfide.

Nickel acts in a disturbing manner on the separating and converting kinetics of this cutting steel during a hardening treatment, so that a Ni content of less than 0.4% by weight is essential for the desired tool quality.

The content of aluminum in the steel in the limits of 0.003 to 1.0% by weight, provided according to the invention, has an especially advantageous effect on the one hand on the hardening and annealing behaviour or on the annealed structure and the mechanical properties of the material; on the other hand, the quality of a surface layer, e.g. a nitride layer, or the adhesion of a coating, e.g. a nitride, carbon nitride or oxide carbon nitride layer of metals, in particular of titanium and/or chromium, is also promoted by aluminum. Aluminum increases the activity and the diffusion coefficients of carbon in austenite. The diffusion coefficients of chromium, molybdenum and vanadium are lowered in the austenite and in the ferrite by aluminum. This means a reduction in the solubility of carbon in the austenite, so that the stability of the austenite is lowered and, as a result, the martensite starting point increased, as a result of which the residual austenite content is in turn greatly lowered in the hardened structure. Aluminum is mainly dissolved in the matrix and delivers a contribution to the mixed crystal hardness. The high affinity of aluminum to nitrogen increases the hardness of the diffusion layer of nitrided steels.

An aluminum content of 0.15 to 0.25% by weight in the alloy is preferred.

The invention will be described in greater detail with reference to an example:
A molten mass having a composition, in % by weight, of C = 0.81, Si = 0.68, Mn = 0.39, P = 0.015, S = 0.003, Cr = 8.06, Mo = 1.59, Ni = 0.26, V = 0.61, W = 0.19, Al = 0.17, Fe remainder was poured to form blocks after a ladle-metallurgical treatment. After a reheating and annealing time of 31 hours, it was rolled to form flat stock from which "chipper knives" were produced by machining.

After heating and thoroughly warming the knives or the cutting strips to 1030°C, they were forcibly cooled to a temperature of about 50°C which was followed by a triple annealing at a temperature of between 545°C and 560°C. After this thermal treatment, the hardness of the material from a sample tool was 61 HRC free of residual austenite. Impact bending samples with the following dimensions were removed from the concrete tool: length 55 mm, width 10 mm and height 7 mm. A toughness test of the material on these samples resulted in an impact bending energy of essentially 115J. Metallographic and residual tests showed that the material in a matrix consisting of annealed martensite had a total amount of carbides of 3.21% by volume, of which carbides 0.43% by volume were monocarbides of the MC type and the remainder carbides of the formation M_7C_3 and $M_{23}C_6$. It should thereby be remembered that no residual austenites were present in the structure.

A "chipper knife" according to the invention, made parallel to the test tool, was inserted in a device for cutting logs under more difficult conditions due to adhering soil particles and resulted in a tool life improvement of 120% in comparison to a high-performance knife from the market compared to it.

Patent Claims

1. A cutting tool, in particular knives for machining wood as well as for products with wood, such as chipboards and the like, having a material toughness of more than 100J measured in longitudinal direction as impact energy AV (SBP) pursuant to *Stahl-Eisen-Prüfblatt* [steel-iron test sheet] (SEP) 1314, with a material hardness of more than 60 HRC and increased corrosion resistance as well as wear resistance thereof consisting of an alloy with a chemical composition in % by weight of:

C	=	0.7 to 0.9
Si	=	≤ 0.8
Mn	=	0.35 to 0.45
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V	=	0.5 to 0.7
W	=	< 0.3
Al	=	0.003 to 1.0
Fe	=	remainder as well as production-related contaminations,

wherein the thermally treated material of the cutting tool has a total carbide content of more than 3% by volume, of which at least 0.35% by volume are monocarbides and the matrix consists of annealed martensite.

2. The cutting tool according to claim 1, wherein the alloy has an Al content of 0.15 to 0.25% by weight.

3. The cutting tool according to claim 1 or 2, whose surface zone has an increased nitrogen content.

4. The cutting tool according to any one of the claims 1 to 3,

which has a coating which is preferably formed as a compound with carbon and/or nitrogen and/or oxygen.

5. The cutting tool according to claim 4, in which the coating contains a chromium compound.