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Proprietor: Neue Schule Ltd North Yorkshire TS9 7DB (GB)

Inventor: CROSS, GRAHAM HUGH Durham TS21 1HN (GB)

Representative: Lunt, Mark George Francis Harrison Goddard Foote Fountain Precinct Balm Green Sheffield S1 2JA (GB)

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Description

FIELD OF THE INVENTION

[0001] The present invention relates to the manufacture of horse bridle bit mouthpieces, and a copper alloy used in the manufacturing thereof.

THE PRIOR ART

[0002] The materials used for the mouthpiece of a bit for the control of a horse by its rider must satisfy some well known requirements. The mouthpiece materials and the design of the mouthpiece must first satisfy the engineering constraints imposed by the forces expected to be exerted upon it in normal use and then a margin for forces in excess of those normally exerted must be allowed. This first requirement has led to the widespread adoption of metallic materials as the engineering option of choice as these materials are available in a wide range of compositions whose basic physical properties such as the tensile strength and the yield strength are sufficiently high to withstand the forces expected in normal use. For ductile materials of the present invention and prior art, the important parameter is the yield strength (hereafter also YS), being the applied pressure at which the material undergoes a permanent deformation. The most common material used for horse bits is therefore stainless steel which has high yield strength.

[0003] Further preferred requirements of a metallic horse bit that have become known are that the metal should taste pleasant to the horse so that the horse accepts the bit and therefore is willing to be controlled through actions on it made by the rider. Bit metals formed from low carbon steel have been used historically as a metallic bit with a pleasant taste, and this is due to the natural oxidation of the iron component in this metal which appears as common rusting on the mouthpiece surface. Rusting of the metal imposes some restrictions on the design of mouthpieces because it can degrade the nominal values of the main engineering properties such as ultimate tensile strength and there is an aesthetic effect which is not desirable. Further advances have therefore been made by the specification of copper alloys for the mouthpiece metal as described in US5669210 and US5885377 whereby metals with a high copper content satisfy the basic engineering physical property requirements but also provide a pleasant tasting mouthpiece due to the oxidation of the copper component.

[0004] What is not clearly appreciated, however, is that a further requirement of a horse bit is that it should adapt to the temperature of the horse’s mouth as rapidly as possible in order that the bit soon feels comfortable to the horse and is not a source of chill that may cause more than a fleeting discomfort but which may distract a horse for some time. This process is termed thermal equilibration. The horse will accept a bit more readily if the mouthpiece becomes equal to the internal temperature of the mouth within the shortest possible time when it is first placed in the mouth. The bit will also quickly adjust its temperature to that of the mouth as the bit moves in the horse’s mouth during normal use. The horse will therefore better accept the foreign body represented by the mouthpiece and become more readily controlled by the rider.

[0005] The physical properties that determine the rate of thermal equilibration of the bit in the mouth include the thermal conductivity of the mouthpiece material (hereafter, $\lambda$) and the specific heat capacity, $c_p$. The thermal conductivity determines the rate of heat energy transfer along a length of the material proportionate to a gradient in temperature along its length and is expressed in units of watts per meter per Kelvin; W/m.K. The specific heat capacity determines the quantity of heat energy that is required to raise the temperature of a piece of metal by one degree Kelvin and is expressed in units of joules per kilogram per Kelvin; J/kg.K.

[0006] For equivalent designs of mouthpiece having identical volume, a figure of merit for comparison is given by:

$$F.O.M. = \frac{\lambda}{\rho c_p}$$

where $\rho$ is the density of the material.

[0007] Metals can then be compared for a combination of these properties. Providing a metal with a high thermal conductivity and with low specific heat capacity and low density will enhance the figure of merit.

[0008] It is known that metals of the copper alloy family have almost identical $c_p$ and $\rho$, regardless of composition and it is therefore most instructive to consider solely the variations in thermal conductivity amongst the copper alloys.

[0009] Copper is alloyed with zinc to provide brass materials for a wide range of applications including horse bit mouthpieces. As the percentage by weight of copper in the copper/zinc brass rises, the thermal conductivity rises proportionately up to the maximum value of thermal conductivity of pure 100 % copper. This value is documented as 385 W/m.K. At this point we note that the thermal conductivity of stainless steel, used most commonly for bit mouthpieces, is 16 W/m.K. The thermal conductivity of copper is therefore 24 times that of stainless steel. However, the tensile strength and the yield strength of pure copper is low. The tensile strength and yield strength is measured in units of pressure, $P$, being the force, $F$, applied over a specified area, $A$ of contact. Mathematically this is expressed as: $P = F/A$ with units
of megapascals (MPa). Pure copper has a tensile strength of 210 MPa and yield strength of 33.3 MPa. In most horse bits the minimum area over which forces are applied are in the order of a few square millimeters (mm²). Typical forces applied in normal use would not exceed the average mass of the rider were they to be fully applied, as in a fall from the horse for example. Force may be measured in units of mass, kg, multiplied by the acceleration due to gravity, g with units of km/s². The acceleration due to gravity is approximately 10 ms⁻². As an example, if a part of the bit with a diameter of 4 mm represents the smallest dimension over which a force is applied then the area over which the force is applied is 12 mm² which is equal to 12 x 10⁻⁶ m². The full force of that of an average rider of mass 80 kg is equal to 800 kgm⁻². The pressure that would be exerted on the bit over the smallest area would be approximately 70 MPa. This value is higher than the yield strength of pure copper and in the event of such a force being applied the bit metal would permanently deform in the region where the applied pressure was highest. Such a situation is a concern for safety as well as product reliability. As with other metal systems copper is intentionally alloyed with further elements to improve its strength without unduly degrading ductility or workability. However, it should be recognized that additions of alloying elements also degrade electrical and thermal conductivity by various amounts depending on the alloying element, its concentration and location in the microstructure (solid solution or dispersoid). The choice of alloy and condition is most often based on the trade-off between strength and acceptability to horse. In the case of the alloys described in US5669210 and US5885377 these elements include silicon, aluminium and iron. However, the effect of these additions is to undesirably reduce the thermal conductivity.

[0010] The alloy described in US5669210 has a composition covered by the international Unified Numbering System (UNS) C69400, known as silicon red brass, comprising an alloy of copper, silicon and zinc. The thermal conductivity of this alloy is 56.5 W/m.K and the specific heat capacity is 375 J/Kg.K. The percentage copper is 85 % and that of zinc is 14.5 % with silicon no more than 3.5 to 4.4 %.

[0011] The alloy described in US5885377 has a composition covered by the international Unified Numbering System (UNS) C61400, known as aluminium bronze, comprising an alloy of copper, aluminium and iron. The thermal conductivity of this alloy is 56.5 W/m.K and the specific heat capacity is 375 J/Kg.K.

[0012] By way of example, the effect of the addition of silicon for changing the thermal conductivity and strength can be seen by comparing the properties of copper alloy C22000 with that of the prior art C69400 described in US5669210. C22000 has a copper content of between 89 and 90 % copper and between 10 and 11 % zinc. The thermal conductivity of C22000 is 26 W/m.K and the specific heat capacity is 380 J/Kg.K. The percentage copper is 85 % and that of zinc is 14.5 % with silicon no more than 3.5 to 4.4 %.

[0013] There is a requirement therefore to manufacture a bit from a metal having yield strength significantly in excess of 70 MPa but which retains a significant enhancement of thermal conductivity in excess of 100 W/m.K (which is more than that of the copper alloy metals heretofore used in the manufacture of bits). The high thermal conductivity enhances the acceptance by the horse of the bit mouthpiece and results in better control of the horse by the rider. The high strength provides a safe margin above the anticipated maximum forces in normal use of the horse bit mouthpiece.

[0014] While there are a number of materials that meet these criteria, there are also other, more subjective, requirements. As mentioned above, the taste of the metal is also a determinative factor in acceptance of the bit by the horse. There are a number of metals that seem acceptable in this regard, including iron and copper. Furthermore, the appearance of the metal is important to the rider and owner. Stainless steel that maintains its shine is acceptable. However, copper alloys that also maintain their shine are desirable and, perhaps more importantly, a gold or coppery colour, are preferred by users.

[0015] Thus, it is an object of the present invention to overcome the deficiencies of the metals heretofore used in prior art horse bits and to provide bits that meet the diverse requirements mentioned above.

SUMMARY OF THE INVENTION

[0016] In accordance with the present invention, there is provided a horse bit mouthpiece comprising a copper alloy consisting of:

65 - 75 %, by weight, of copper, and one selected from the group comprising:

a) 25 - 35 %, by weight of zinc and impurities,  
0 - 2.0 %, by weight, of tin, and  
0 - 0.5 % by weight of XV, where XV is one or more elements selected from Group 15 of the periodic table;
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wherein the alloy has a thermal conductivity greater than 100 W/m.K and a yield strength greater than 70 MPa.

[0017] Preferably, the alloy consists of:

68 - 75 %, by weight, of copper,
0.5 - 1.5 %, by weight, of tin,
0 - 0.2 % by weight of XV,
the remainder being zinc and impurities.

[0018] More preferably, the alloy consists of:

70 - 73 %, by weight, of copper,
0.9 - 1.2 %, by weight, of tin,
0 - 0.1 % by weight of XV,
the remainder being zinc and impurities.

[0019] Indeed, the alloy may consist of:

70 - 73 %, by weight, of copper,
0.9 - 1.2 %, by weight, of tin,
0.05 - 0.1 % by weight of XV,
the remainder being zinc and impurities.

[0020] XV may a member of the group 15 elements antimony, phosphorus, arsenic.

[0021] Preferably, the alloy has a thermal conductivity greater than 100 W/m.K and a yield strength greater than 400 MPa. Indeed, better still, the alloy has a thermal conductivity greater than 100 W/m.K and yield strength greater than 450 MPa.

[0022] Given its potential allergenic reaction in some horses, nickel is specifically excluded from compositions according to the present invention beyond unavoidable impurity levels.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

[0023] In a preferred embodiment of the invention, a horse bit mouthpiece comprises a copper alloy with composition: 70 % copper and 30 % zinc and other impurities. This alloy has minimum yield strength of 75 MPa and a thermal conductivity of 120 W/m.K and provides advantages as given in the summary. The high thermal conductivity being higher than that of the prior art enhances the acceptance of the horse by the horse by the rider. The high strength provides a safe margin above the anticipated maximum forces in normal use of the horse bit mouthpiece.

[0024] In a further preferred embodiment of the invention, a horse bit mouthpiece comprises a copper alloy of composition; 70 - 73 % copper, 0.9 - 1.2 % tin and 0 - 0.1 % phosphorous, the remainder being zinc and impurities. This alloy has yield strength of 152 MPa and a thermal conductivity of 110 W/m.K. and provides further advantages as described in the summary. The high thermal conductivity being higher than that of the prior art enhances the acceptance by the horse of the bit mouthpiece and results in better control of the horse by the rider. The higher strength provides a safer margin above the anticipated maximum forces in normal use of the horse bit mouthpiece.

[0025] In a yet further preferred embodiment of the invention, a horse bit mouthpiece comprises a copper alloy of composition; 70 - 73 % copper, 0.9 - 1.2 % tin, and 0 - 0.1 % antimony, the remainder being zinc and impurities. This alloy has yield strength of 496 MPa and a thermal conductivity of 110 W/m.K and provides yet further advantages as described in the summary. The high thermal conductivity being higher than that of the prior art enhances the acceptance by the horse of the bit mouthpiece and results in better control of the horse by the rider. The yet higher yield strength provides a yet safer margin above the anticipated maximum forces in normal use of the horse bit mouthpiece.

EXAMPLES

[0026] The following exemplary alloys when formulated provide the yield strengths and thermal conductivities mentioned. The skilled person has no difficulty in formulating such alloys that can be made by any conventional means, and casting them into horse bits.
In the table above, \(\sim 0\) means less than 0.01%. UNS grades C18400 and C18500 are also not within the scope of the present invention.

### Claims

1. A horse bit mouthpiece comprising a copper alloy consisting of:

   65 - 75 %, by weight, of copper, 25 - 35%, by weight of zinc and impurities, 0 - 2.0 %, by weight, of tin, and 0 - 0.5 % by weight of XV, where XV is one or more elements selected from Group 15 of the periodic table; wherein the alloy has a thermal conductivity greater than 100 W/m.K and a yield strength greater than 70 MPa.

2. A horse bit mouthpiece as claimed in claim 1, wherein the alloy consists of:

   68 - 75 %, by weight, of copper, 0.5 - 1.5 %, by weight, of tin, 0 - 0.2 % by weight of XV, and the remainder being zinc and impurities.

3. A horse bit mouthpiece as claimed in claim 2, wherein the alloy consists of:

   70 73 %, by weight, of copper, 0.9 - 1.2 %, by weight, of tin, 0 - 0.1 % by weight of XV, and the remainder being zinc and impurities.

4. A horse bit mouthpiece as claimed in claim 3, wherein the alloy consists of:

   70 - 73 %, by weight, of copper, 0.9 - 1.2 %, by weight, of tin, 0.05 - 0.1 % by weight of XV, and the remainder being zinc and impurities.
5. A horse bit mouthpiece as claimed in any preceding claim, wherein XV is antimony.

6. A horse bit mouthpiece as claimed in any of claims 1 to 4, wherein XV is phosphorus.

7. A horse bit mouthpiece as claimed in any of claims 1 to 4, wherein XV is arsenic.

8. A horse bit mouthpiece as claimed in any preceding claim, wherein the alloy has a thermal conductivity greater than 100 W/m.K and yield strength greater than 400 MPa.

9. A horse bit mouthpiece as claimed in any preceding claim, wherein the alloy has a thermal conductivity greater than 100 W/m.K and yield strength greater than 450 MPa.

Patentansprüche

1. Pferdemundstück, das eine Kupferlegierung umfasst, die folgendes aufweist:
   65 bis 75 Gewichtsprozent Kupfer, 25 bis 35 Gewichtsprozent Zink und Unreinheiten;
   0 bis 2,0 Gewichtsprozent Zinn, und
   0 bis 0,5 Gewichtsprozent XV, wobei es sich bei XV um ein oder mehrere Elemente handelt, die aus der Gruppe 15 der Periodentabelle ausgewählt werden;
   wobei die Legierung eine Wärmeleitfähigkeit von über 100 W/m.K und eine Streckgrenze von über 70 MPa aufweist.

2. Pferdemundstück nach Anspruch 1, wobei die Legierung folgendes aufweist:
   68 bis 75 Gewichtsprozent Kupfer;
   0,5 bis 1,5 Gewichtsprozent Zinn,
   0 bis 0,2 Gewichtsprozent XV, und
   wobei es sich bei dem Rest um Zink und Unreinheiten handelt.

3. Pferdemundstück nach Anspruch 2, wobei die Legierung folgendes aufweist:
   70 bis 73 Gewichtsprozent Kupfer;
   0,9 bis 1,2 Gewichtsprozent Zinn,
   0 bis 0,1 Gewichtsprozent XV, und
   wobei es sich bei dem Rest um Zink und Unreinheiten handelt.

4. Pferdemundstück nach Anspruch 3, wobei die Legierung folgendes aufweist:
   70 bis 73 Gewichtsprozent Kupfer;
   0,9 bis 1,2 Gewichtsprozent Zinn,
   0,05 bis 0,1 Gewichtsprozent XV, und
   wobei es sich bei dem Rest um Zink und Unreinheiten handelt.

5. Pferdemundstück nach einem der vorstehenden Ansprüche, wobei es sich bei XV um ein Antimon handelt.

6. Pferdemundstück nach einem der Ansprüche 1 bis 4, wobei es sich bei XV um Phosphor handelt.

7. Pferdemundstück nach einem der Ansprüche 1 bis 4, wobei es sich bei XV um Arsen handelt.

8. Pferdemundstück nach einem der vorstehenden Ansprüche, wobei die Legierung eine Wärmeleitfähigkeit von mehr als 100 W/m.K und eine Streckgrenze von über 400 MPa aufweist.

9. Pferdemundstück nach einem der vorstehenden Ansprüche, wobei die Legierung eine Wärmeleitfähigkeit von mehr als 100 W/m.K und eine Streckgrenze von über 450 MPa aufweist.
Revendications

1. Embouchure de mors de cheval comprenant un alliage de cuivre constitué de :
   65 à 75 % en poids de cuivre, 25 à 35 % en poids de zinc et d’impuretés,
   0 à 2,0 % en poids d’étain, et
   0 à 0,5 % en poids de XV, où XV est un ou plusieurs éléments choisis dans le groupe 15 du tableau périodique ;
   dans laquelle l’alliage a une conductivité thermique supérieure à 100 W/m.K et une limite d’élasticité supérieure à 70 MPa.

2. Embouchure de mors de cheval selon la revendication 1, dans laquelle l’alliage est constitué de :
   68 à 75 % en poids de cuivre,
   0,5 à 1,5 % en poids d’étain,
   0 à 0,2 % en poids de XV, et
   le reste étant du zinc et des impuretés.

3. Embouchure de mors de cheval selon la revendication 2, dans laquelle l’alliage est constitué de :
   70 à 73 % en poids de cuivre,
   0,9 à 1,2 % en poids d’étain,
   0 à 0,1 % en poids de XV, et
   le reste étant du zinc et des impuretés.

4. Embouchure de mors de cheval selon la revendication 3, dans laquelle l’alliage est constitué de :
   70 à 73 % en poids de cuivre,
   0,9 à 1,2 % en poids d’étain,
   0,05 à 0,1 % en poids de XV, et
   le reste étant du zinc et des impuretés.

5. Embouchure de mors de cheval selon l’une quelconque des revendications précédentes, dans laquelle XV est de l’antimoine.

6. Embouchure de mors de cheval selon l’une quelconque des revendications 1 à 4, dans laquelle XV est du phosphore.

7. Embouchure de mors de cheval selon l’une quelconque des revendications 1 à 4, dans laquelle XV est de l’arsenic.

8. Embouchure de mors de cheval selon l’une quelconque des revendications précédentes, dans laquelle l’alliage a une conductivité thermique supérieure à 100 W/m.K et une limite d’élasticité supérieure à 400 MPa.

9. Embouchure de mors de cheval selon l’une quelconque des revendications précédentes, dans laquelle l’alliage a une conductivité thermique supérieure à 100 W/m.K et une limite d’élasticité supérieure à 450 MPa.
REFERENCES CITED IN THE DESCRIPTION

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