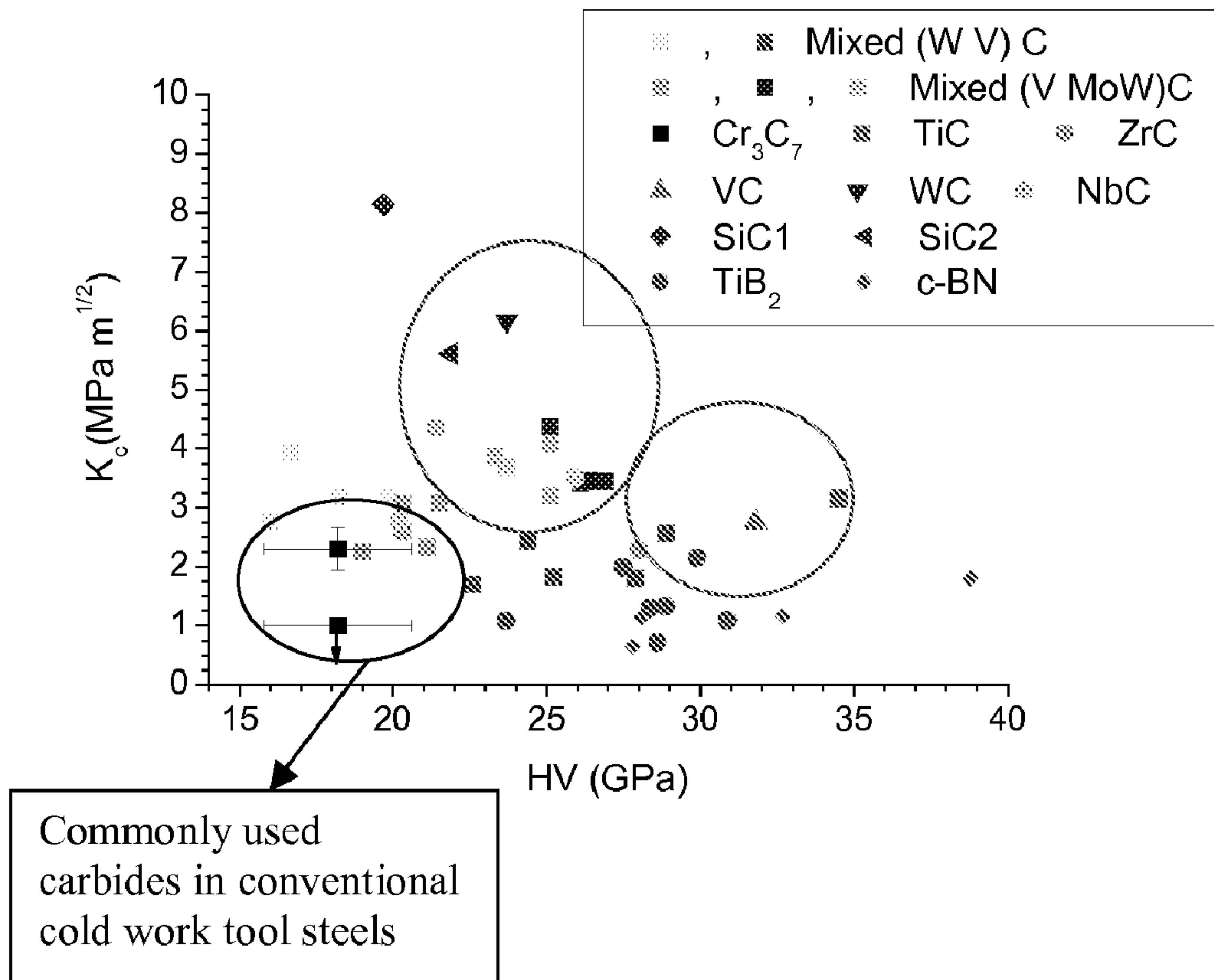




(86) **Date de dépôt PCT/PCT Filing Date:** 2008/01/11
 (87) **Date publication PCT/PCT Publication Date:** 2008/07/17
 (45) **Date de délivrance/Issue Date:** 2017/06/27
 (85) **Entrée phase nationale/National Entry:** 2009/07/10
 (86) **N° demande PCT/PCT Application No.:** EP 2008/050308
 (87) **N° publication PCT/PCT Publication No.:** 2008/084108
 (30) **Priorité/Priority:** 2007/01/12 (EP07381003.8)

(51) **Cl.Int./Int.Cl. C22C 38/06** (2006.01),
C22C 38/44 (2006.01), **C22C 38/46** (2006.01),
C22C 38/48 (2006.01), **C22C 38/50** (2006.01),
C22C 38/56 (2006.01), **C22C 38/58** (2006.01)
 (72) **Inventeur/Inventor:**
 VALLS, ISAAC, ES
 (73) **Propriétaire/Owner:**
 ROVALMA, S.A., ES
 (74) **Agent:** NORTON ROSE FULBRIGHT CANADA
 LLP/S.E.N.C.R.L., S.R.L.

(54) **Titre : ACIER POUR OUTIL D'ESTAMPAGE A FROID PRESENTANT UNE REMARQUABLE SOUDABILITE**
 (54) **Title: COLD WORK TOOL STEEL WITH OUTSTANDING WELDABILITY**



(57) **Abrégé/Abstract:**

A cold work tool steel with average or above wear resistance, a hardness in excess of (60) HRc and a very good toughness but with considerably lower carbon contents leading to highly improved weldability is obtained by combining the presence of primary

(57) Abrégé(suite)/Abstract(continued):

carbides (or alternatively nitrides and/or borides) with other strengthening mechanisms like precipitation hardening or even solid solution. Vanadium rich MC type carbides, modified with refractory metal additions, present the best compromise of hardness and fracture toughness for several applications, while for other applications harder carbides, such as Ti carbides or Ti mixed carbides (primarily with V, Mo and/or W) will be the preferred ones, alternatively using Zr and Hf mixed carbides.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau(43) International Publication Date
17 July 2008 (17.07.2008)

PCT

(10) International Publication Number
WO 2008/084108 A1

(51) International Patent Classification:

C22C 38/06 (2006.01) C22C 38/50 (2006.01)
C22C 38/44 (2006.01) C22C 38/56 (2006.01)
C22C 38/46 (2006.01) C22C 38/58 (2006.01)
C22C 38/48 (2006.01)

(74) Agents: ELZABURU MARQUEZ, Alberto de et al.; c/
Miguel Angel, 21, 2º, E-28010 Madrid (ES).

(21) International Application Number:

PCT/EP2008/050308

(22) International Filing Date: 11 January 2008 (11.01.2008)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:

07381003.8 12 January 2007 (12.01.2007) EP

(71) Applicant (for all designated States except US):
ROVALMA SA [ES/ES]; c/ Apol.lo, 51 Pol. Ind.,
CAN PERELLADA, Terrassa, E-06228 Barcelona (ES).

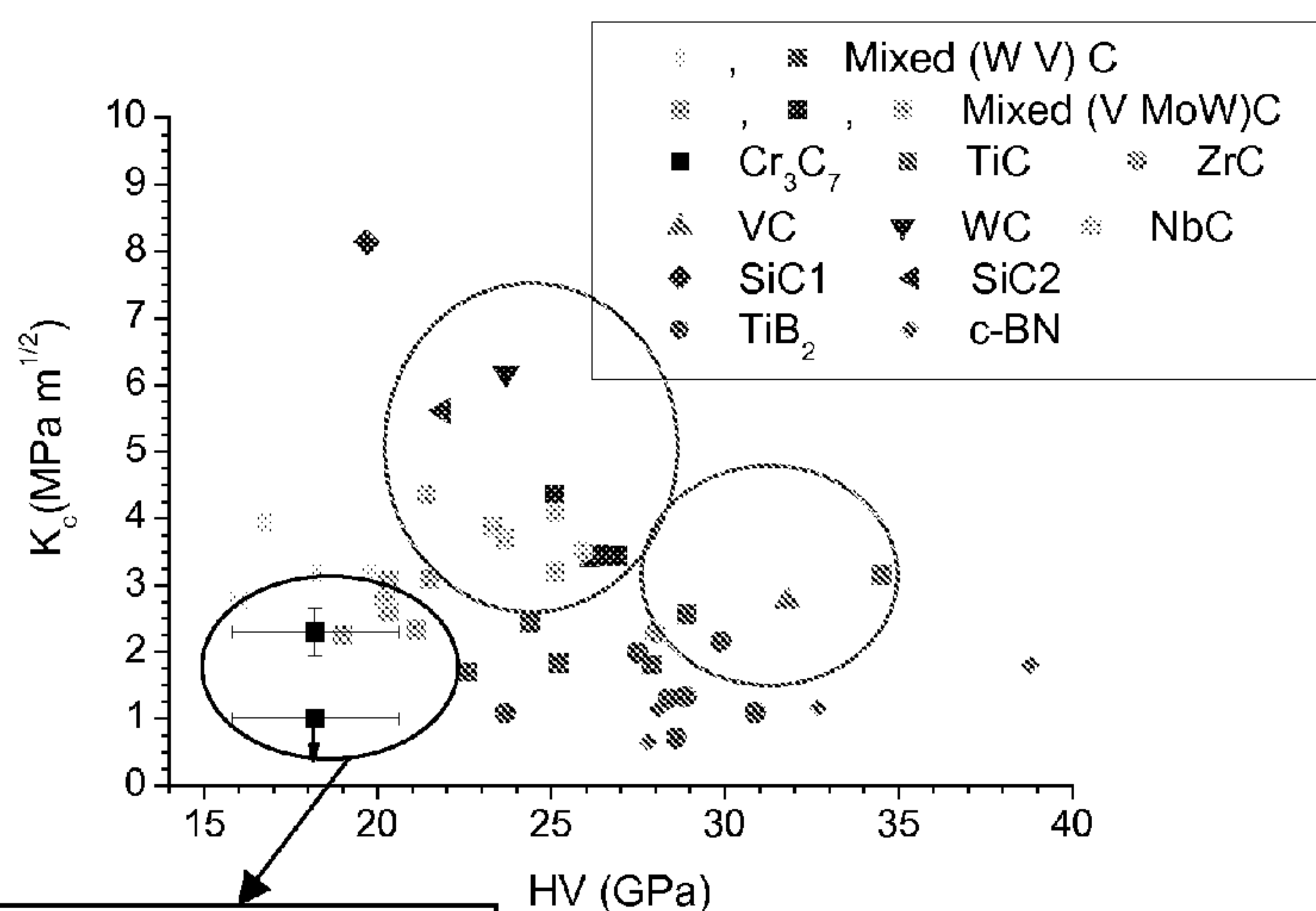
(72) Inventor; and

(75) Inventor/Applicant (for US only): **VALLS, Isaac**
[ES/ES]; c/ Apol.lo, 51 Pol. Ind., CAN PERALLADA,
Terrassa, E-06228 Barcelona (ES).(81) Designated States (unless otherwise indicated, for every
kind of national protection available): AE, AG, AL, AM,
AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA,
CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE,
EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID,
IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC,
LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN,
MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH,
PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, SV,
SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN,
ZA, ZM, ZW.(84) Designated States (unless otherwise indicated, for every
kind of regional protection available): ARIPO (BW, GH,
GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM,
ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM),
European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI,
FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL,
NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG,
CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:

— with international search report

(54) Title: COLD WORK TOOL STEEL WITH OUTSTANDING WELDABILITY

Commonly used
carbides in conventional
cold work tool steels

(57) Abstract: A cold work tool steel with average or above wear resistance, a hardness in excess of (60) HRC and a very good toughness but with considerably lower carbon contents leading to highly improved weldability is obtained by combining the presence of primary carbides (or alternatively nitrides and/or borides) with other strengthening mechanisms like precipitation hardening or even solid solution. Vanadium rich MC type carbides, modified with refractory metal additions, present the best compromise of hardness and fracture toughness for several applications, while for other applications harder carbides, such as Ti carbides or Ti mixed carbides (primarily with V, Mo and/or W) will be the preferred ones, alternatively using Zr and Hf mixed carbides.

WO 2008/084108 A1

CLAIMS:

1. An at least partly martensitic cold work tool steel having the following composition, all percentages being in weight percent:

%Ceq= 0.25 - 2.5	% C = 0.25 - 2.5	%N =0 - 2	%B =0 - 2
%Cr=0.1-10	%Ni=3-12	%Si= 0.01-1	%Mn= 0.08 - 3
%Al= 0.5 - 5	%Mo= 0-10	%W= 0-15	%Ti= 0 - 3
%Ta = 0-2	%Zr = 0-2	%Hf = 0 - 2,	%V= 0 - 12
%Nb = 0-2	%Cu = 0-4	%Co = 0-8,	%S= 0 - 1
%Se = 0-1	%Te = 0-1	%Bi = 0-1	%As= 0 - 1
%Sb = 0-1	%Ca = 0-1,		

the rest consisting of iron and unavoidable impurities, wherein

$$\%Ceq = \%C + 0.86 * \%N + 1.2 * \%B,$$

characterized in that

$$\%Cr + \%V + \%Mo + \%W > 3 \text{ and}$$

$$\%Al + \%Mo + \%Ti > 1.5,$$

with the proviso that

when $0.45 \leq \%Ceq < 2.5$, then $\%V = 0.6 - 12$; or

when $0.25 \leq \%Ceq < 0.45$, then $\%V = 0.85 - 4$; or

when $\%Ceq = 0.25 - 0.45$, then $\%Ti + \%Hf + \%Zr + \%Ta = 0.1 - 4$,

characterised in that the cold work tool steel contains Ni-based intermetallic compounds.

2. A steel according to claim 1, wherein, when $0.45 \leq \%Ceq < 2.5$ and $\%Cr < 2.5$, then $\%Mo + \frac{1}{2} \%W = 1.5 - 17$.

3. A steel according to claim 1 or 2, wherein $\%Al = 1-5$.

4. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45-1.95 %Cr= 1-8 %V= 0.6-6 %Ni= 4-9
 %Mn= 0.08-2 %Al= 1-3.5 %Mo= 0 – 6 %W=0-12
 %Co=0-6 %Cu= 0 - 2, and %Hf + %Zr + %Ta + %Nb= 0 - 2.

5. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %Cr= 0.1-8 %V= 0.85-4 %Ni= 4 – 9
 %Mn= 0.08 – 2 %Al= 1-3.5 %Mo= 0 – 6 %W= 0-12
 %Co= 0 - 6 %Cu= 0 - 2, and %Ti + %Zr + %Hf = 0.1-4.

6. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45 - 0.6 %V= 0.6 – 4 %Ni= 4 – 8 %Si= 0.05 -1
 %Mn= 0.08 – 2 %Al= 1 - 2.5 %Mo= 0.3 – 3 %W= 0 - 2
 %Ti= 0.1 - 1.5 %Co= 1-3.5 %Cu= 0 - 2, and
 %Hf+ %Zr+ %Ta+ %Nb= 0-0.5.

7. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 0.85 – 4 %Ni= 4 – 8 %Si= 0.01-1
 %Mn= 0.08 – 2 %Al= 1 - 2.5 %Mo= 0.3 – 3 %W= 0 - 2
 %Ti= 0.1 - 1.5 %Co= 1-3.5 %Cu= 0 - 2, and
 %Ti + %Zr + %Hf =0.1-4.

8. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45-1.2 %Cr= 0.1-8 %V= 0.6-4 %Ni= 4-10
 %Si= 0.05 - 1 %Al= 1 – 3 %Mo= 0.3 – 5 %W= 0 – 5
 %Ti= 0.1-3 and %Hf+ %Zr+ %Ta+ %Nb = 0-2.

9. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 0.85 – 4 %Cr= 0.1-8 %Ni= 4-10
 %Si= 0.05 -1 %Al= 1 – 3 %Mo= 0.3 – 5 %W= 0 – 5
 %Ti= 0.1-3, and %Ti + %Zr + %Hf = 0.1-4.

10. A steel according to any one of claims 1 to 3, wherein

$\%C_{eq} = 0.45 - 0.55$ $\%Cr = 1 - 4$ $\%V = 0.6 - 3$ $\%Ni = 4 - 9$
 $\%Si = 0.05 - 1$ $\%Mn = 0.08 - 0.5$ $\%Al = 1.5 - 2.5$ $\%Mo = 0.8 - 1.5$
 $\%W = 0 - 2$ $\%Ti = 0.1 - 1.2$, and $\%Hf + \%Zr + \%Ta + \%Nb = 0-2$.

11. A steel according to any one of claims 1 to 3 wherein:

$\%C_{eq} = 0.25 - 0.43$ $\%V = 0.85 - 4$ $\%Cr = 1 - 4$ $\%Ni = 4 - 9$
 $\%Si = 0.01-1$ $\%Mn = 0.08 - 0.5$ $\%Al = 1.5 - 2.5$ $\%Mo = 0.8 - 1.5$
 $\%W = 0 - 2$ $\%Ti = 0.3 - 1.2$, and $\%Ti + \%Zr + \%Hf = 0.1-4$.

12. A steel according to any one of claims 1 to 3, wherein:

$\%C_{eq} = 0.8-2.5$ $\%Cr = 2 - 8$ $\%V = 2 - 12$ $\%Ni = 5 - 8$
 $\%Si = 0.05 - 1$ $\%Al = 1.5-3$ $\%Mo = 1 - 10$ $\%Ti = 0.3 - 3$, and
 $\%Hf + \%Zr + \%Ta + \%Nb = 0-2$.

13. A steel according to any one of claims 1 to 3, wherein:

$\%C_{eq} = 1.25 - 2.5$ $\%Cr = 2 - 8$ $\%V = 3 - 6$ $\%Ni = 5 - 8$
 $\%Si = 0.05 - 1$ $\%Al = 1.5 - 3$ $\%Mo = 2 - 4$ $\%W = 1-15$
 $\%Ti = 0.3 - 3$ $\%Co = 0 - 7$, and $\%Hf + \%Zr + \%Ta + \%Nb = 0-2$.

14. A steel according to claim 1 or 2, wherein:

$\%C_{eq} = 0.45 - 0.55$ $\%Cr = 2 - 5$ $\%V = 1 - 3.5$ $\%Ni = 3 - 7$
 $\%Si = 0.05 - 1$ $\%Mn = 0.08 - 2$ $\%Al = 0.5 - 2$ $\%Mo = 0 - 3$
 $\%W = 0 - 2$ $\%Ti = 0-1.5$ $\%Co = 0 - 2.5$, and
 $\%Hf + \%Zr + \%Ta + \%Nb = 0 - 2$.

15. A steel according to claim 1 or 2, wherein:

$\%C_{eq} = 0.25 - 0.43$ $\%V = 1 - 4$ $\%Cr = 2 - 5$ $\%Ni = 3 - 7$
 $\%Si = 0.05 - 1$ $\%Mn = 0.08 - 2$ $\%Al = 0.5 - 2$ $\%Mo = 0 - 3$
 $\%W = 0 - 2$ $\%Ti = 0-1.5$ $\%Co = 0 - 2.5$, and
 $\%Ti + \%Zr + \%Hf = 0.1-4$.

16. A steel according to claim 1 or 2, wherein:

%Ceq= 0.45 - 0.55 %Cr= 2 - 5 %V= 1 - 3.5 %Ni= 3 - 6
 %Si= 0.05 - 1 %Mn= 0.08 - 2 %Al= 0.5 - 2 %Mo= 0 - 3
 %W= 0 - 2, and %Cu= 0 - 4.

17. A steel according to claim 1 or 2, wherein:

%Ceq= 0.25 - 0.43 %V= 1 - 4 %Cr= 2 - 5 %Ni= 3 - 6
 %Si= 0.05 - 1 %Mn= 0.08 - 2 %Al= 0.5 - 2 %Mo= 0 - 3
 %W= 0 - 2, and %Ti + %Zr + %Hf = 0.1-4.

18. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45 - 0.6 %Cr= 2 - 8 %V= 1-3.5 %Si= 0.01-1
 %Mn= 0.2 - 3 %Al= 1.5-4 %Mo= 1 - 3 %W= 0.5 - 2
 %Ti= 0.2 - 2 %Co= 1 - 6 %Cu= 0 - 2 %Ni= 6 - 12, and
 %Hf + %Zr + %Ta + %Nb = 0-1.

19. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 1 - 4 %Cr= 2 - 8 %Si= 0.01 - 1
 %Mn= 0.2 - 3 %Al= 1.5 - 4 %Mo= 1 - 3 %W= 0.5 - 2
 %Ti= 0.2 - 2 %Co= 1 - 6 %Cu= 0 - 2 %Ni= 6 - 12, and
 %Ti + %Zr + %Hf = 0.1-4.

20. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45 - 0.8 %Cr= 0.1-4 %V= 0.6 - 2 %Ni= 5 - 12
 %Si= 0.01-1 %Al=1.5-5 %Mo= 1 - 5 %W=0-2
 %Ti=0.5-3 %Cu=0-2 %Co=1.5-3.2,
 wherein %Hf+ %Zr+ %Ta+ %Nb= 0 - 2 and %Ti + %Hf + %Zr + %Ta + %Nb > 0.7.

21. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 0.85 - 4 %Cr= 0.1-4 %Ni= 5 - 12
 %Si= 0.01-1 %Al=1.5-5 %Mo= 1 - 5 %W=0-2
 %Ti=0.5-3 %Cu=0-2 %Co= 1.5 - 3.2, and
 %Ti + %Zr + %Hf = 0.1-4.

22. A steel according to any one of claims 1 to 21, wherein $\%C_{eq} = \%C$, with no intentional B or N added.
23. A steel according to any one of claims 1 to 22, wherein the hardness level is at least 58 HRc.
24. A die, tool or part comprising at least one steel according to any one of claims 1 to 23.

CLAIMS:

1. An at least partly martensitic cold work tool steel having the following composition, all percentages being in weight percent:

%Ceq= 0.25 - 2.5	% C = 0.25 - 2.5	%N =0 - 2	%B =0 - 2
%Cr=0.1-10	%Ni=3-12	%Si= 0.01-1	%Mn= 0.08 - 3
%Al= 0.5 - 5	%Mo= 0-10	%W= 0-15	%Ti= 0 - 3
%Ta = 0-2	%Zr = 0-2	%Hf = 0 - 2,	%V= 0 - 12
%Nb = 0-2	%Cu = 0-4	%Co = 0-8,	%S= 0 - 1
%Se = 0-1	%Te = 0-1	%Bi = 0-1	%As= 0 - 1
%Sb = 0-1	%Ca = 0-1,		

the rest consisting of iron and unavoidable impurities, wherein

$$\%Ceq = \%C + 0.86 * \%N + 1.2 * \%B,$$

characterized in that

$$\%Cr + \%V + \%Mo + \%W > 3 \text{ and}$$

$$\%Al + \%Mo + \%Ti > 1.5,$$

with the proviso that

when $0.45 \leq \%Ceq < 2.5$, then $\%V = 0.6 - 12$; or

when $0.25 \leq \%Ceq < 0.45$, then $\%V = 0.85 - 4$; or

when $\%Ceq = 0.25 - 0.45$, then $\%Ti + \%Hf + \%Zr + \%Ta = 0.1 - 4$,

characterised in that the cold work tool steel contains Ni-based intermetallic compounds.

2. A steel according to claim 1, wherein, when $0.45 \leq \%Ceq < 2.5$ and $\%Cr < 2.5$, then $\%Mo + \frac{1}{2} \%W = 1.5 - 17$.
3. A steel according to claim 1 or 2, wherein $\%Al = 1-5$.

4. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45-1.95 %Cr= 1-8 %V= 0.6-6 %Ni= 4-9
 %Mn= 0.08-2 %Al= 1-3.5 %Mo= 0 – 6 %W=0-12
 %Co=0-6 %Cu= 0 - 2, and %Hf + %Zr + %Ta + %Nb= 0 - 2.

5. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %Cr= 0.1-8 %V= 0.85-4 %Ni= 4 – 9
 %Mn= 0.08 – 2 %Al= 1-3.5 %Mo= 0 – 6 %W= 0-12
 %Co= 0 - 6 %Cu= 0 - 2, and %Ti + %Zr + %Hf = 0.1-4.

6. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45 - 0.6 %V= 0.6 – 4 %Ni= 4 – 8 %Si= 0.05 -1
 %Mn= 0.08 – 2 %Al= 1 - 2.5 %Mo= 0.3 – 3 %W= 0 - 2
 %Ti= 0.1 - 1.5 %Co= 1-3.5 %Cu= 0 - 2, and
 %Hf+ %Zr+ %Ta+ %Nb= 0-0.5.

7. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 0.85 – 4 %Ni= 4 – 8 %Si= 0.01-1
 %Mn= 0.08 – 2 %Al= 1 - 2.5 %Mo= 0.3 – 3 %W= 0 - 2
 %Ti= 0.1 - 1.5 %Co= 1-3.5 %Cu= 0 - 2, and
 %Ti + %Zr + %Hf =0.1-4.

8. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45-1.2 %Cr= 0.1-8 %V= 0.6-4 %Ni= 4-10
 %Si= 0.05 - 1 %Al= 1 – 3 %Mo= 0.3 – 5 %W= 0 – 5
 %Ti= 0.1-3 and %Hf+ %Zr+ %Ta+ %Nb = 0-2.

9. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 0.85 – 4 %Cr= 0.1-8 %Ni= 4-10
 %Si= 0.05 -1 %Al= 1 – 3 %Mo= 0.3 – 5 %W= 0 – 5
 %Ti= 0.1-3, and %Ti + %Zr + %Hf = 0.1-4.

10. A steel according to any one of claims 1 to 3, wherein

%Ceq= 0.45 - 0.55 %Cr= 1 - 4 %V= 0.6 - 3 %Ni= 4 - 9
 %Si= 0.05 - 1 %Mn= 0.08 - 0.5 %Al= 1.5 - 2.5 %Mo= 0.8 - 1.5
 %W= 0 - 2 %Ti= 0.1 - 1.2, and %Hf + %Zr + %Ta + %Nb = 0-2.

11. A steel according to any one of claims 1 to 3 wherein:

%Ceq= 0.25 - 0.43 %V= 0.85 - 4 %Cr= 1 - 4 %Ni= 4 - 9
 %Si= 0.01-1 %Mn= 0.08 - 0.5 %Al= 1.5 - 2.5 %Mo= 0.8 - 1.5
 %W= 0 - 2 %Ti= 0.3 - 1.2, and %Ti + %Zr + %Hf =0.1-4.

12. A steel according to any one of claims 1 to 3, wherein:

%Ceq=0.8-2.5 %Cr= 2 - 8 %V= 2 - 12 %Ni= 5 - 8
 %Si= 0.05 -1 %Al=1.5-3 %Mo= 1 - 10 %Ti= 0.3 - 3, and
 %Hf + %Zr+ %Ta+ %Nb = 0-2.

13. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 1.25 -2.5 %Cr= 2 - 8 %V= 3 - 6 %Ni= 5 - 8
 %Si= 0.05 - 1 %Al= 1.5 - 3 %Mo= 2 - 4 %W= 1-15
 %Ti= 0.3 - 3 %Co= 0 - 7, and %Hf + %Zr + %Ta + %Nb = 0-2.

14. A steel according to any one of claims 1 to 3 wherein:

%Ceq= 0.45 - 0.55 %Cr= 2 - 5 %V= 1 - 3.5 %Ni= 3 - 7
 %Si= 0.05 - 1 %Mn= 0.08 - 2 %Al= 0.5 - 2 %Mo= 0 - 3
 %W= 0 - 2 %Ti= 0-1.5 %Co= 0 - 2.5, and
 %Hf + %Zr + %Ta + %Nb= 0 - 2.

15. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 1 - 4 %Cr= 2 - 5 %Ni= 3 - 7
 %Si= 0.05 - 1 %Mn= 0.08 - 2 %Al= 0.5 - 2 %Mo= 0 - 3
 %W= 0 - 2 %Ti= 0-1.5 %Co= 0 - 2.5, and
 %Ti + %Zr + %Hf = 0.1-4.

16. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45 - 0.55 %Cr= 2 - 5 %V= 1 - 3.5 %Ni= 3 - 6
 %Si= 0.05 - 1 %Mn= 0.08 - 2 %Al= 0.5 - 2 %Mo= 0 - 3
 %W= 0 - 2, and %Cu= 0 - 4.

17. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 1 - 4 %Cr= 2 - 5 %Ni= 3 - 6
 %Si= 0.05 - 1 %Mn= 0.08 - 2 %Al= 0.5 - 2 %Mo= 0 - 3
 %W= 0 - 2, and %Ti + %Zr + %Hf = 0.1-4.

18. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45 - 0.6 %Cr= 2 - 8 %V= 1-3.5 %Si= 0.01-1
 %Mn= 0.2 - 3 %Al= 1.5-4 %Mo= 1 - 3 %W= 0.5 - 2
 %Ti= 0.2 - 2 %Co= 1 - 6 %Cu= 0 - 2 %Ni= 6 - 12, and
 %Hf + %Zr + %Ta + %Nb = 0-1.

19. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 1 - 4 %Cr= 2 - 8 %Si= 0.01 - 1
 %Mn= 0.2 - 3 %Al= 1.5 - 4 %Mo= 1 - 3 %W= 0.5 - 2
 %Ti= 0.2 - 2 %Co= 1 - 6 %Cu= 0 - 2 %Ni= 6 - 12, and
 %Ti + %Zr + %Hf = 0.1-4.

20. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.45 - 0.8 %Cr= 0.1-4 %V= 0.6 - 2 %Ni= 5 - 12
 %Si= 0.01-1 %Al=1.5-5 %Mo= 1 - 5 %W=0-2
 %Ti=0.5-3 %Cu=0-2 %Co=1.5-3.2,
 wherein %Hf+ %Zr+ %Ta+ %Nb= 0 - 2 and %Ti + %Hf + %Zr + %Ta + %Nb > 0.7.

21. A steel according to any one of claims 1 to 3, wherein:

%Ceq= 0.25 - 0.43 %V= 0.85 - 4 %Cr= 0.1-4 %Ni= 5 - 12
 %Si= 0.01-1 %Al=1.5-5 %Mo= 1 - 5 %W=0-2
 %Ti=0.5-3 %Cu=0-2 %Co= 1.5 - 3.2, and
 %Ti + %Zr + %Hf = 0.1-4.

22. A steel according to any one of claims 1 to 21, wherein $\%C_{eq} = \%C$, with no intentional B or N added.
23. A steel according to any one of claims 1 to 22, wherein the hardness level is at least 58 HRc.
24. A die, tool or part comprising at least one steel according to any one of claims 1 to 23.

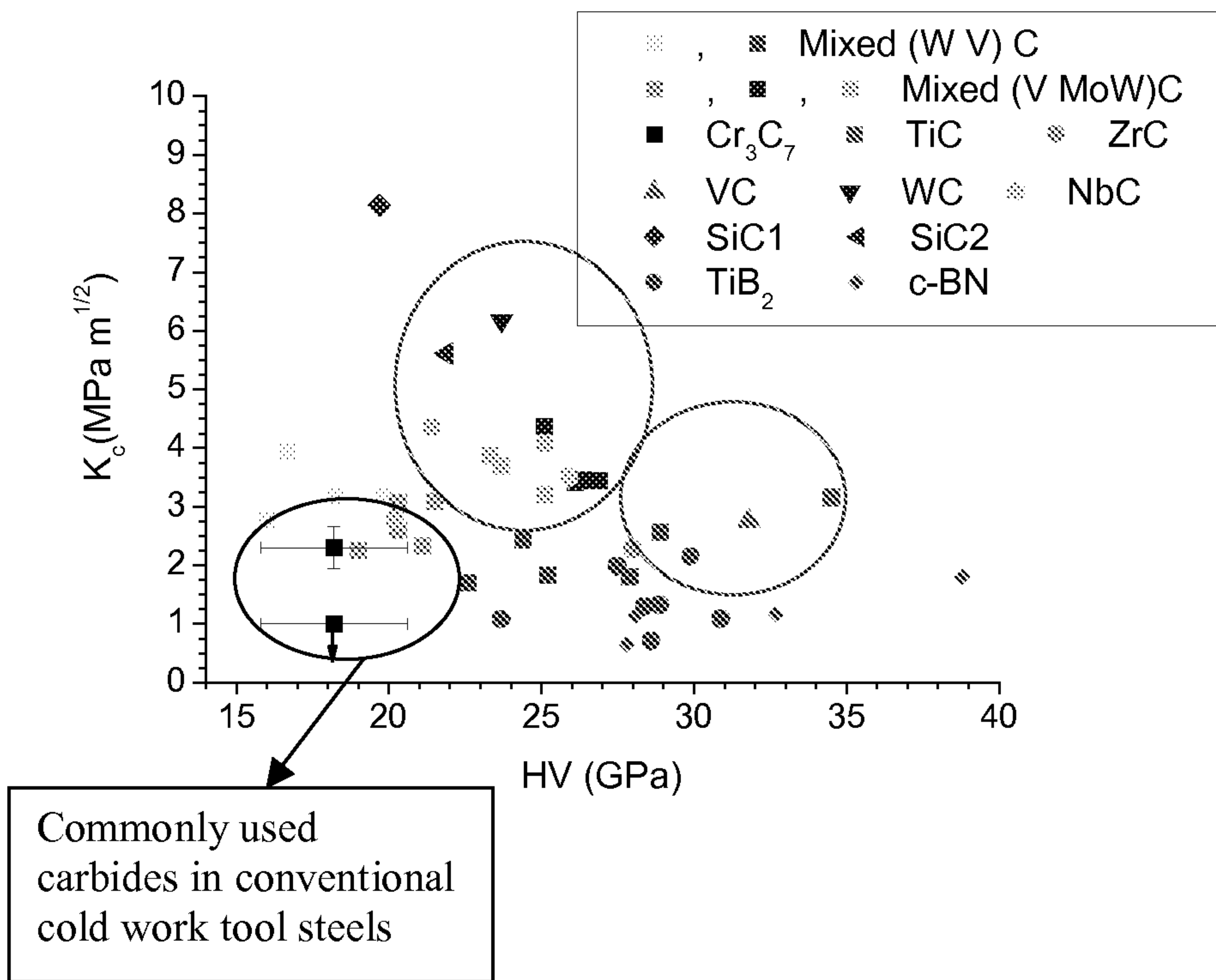
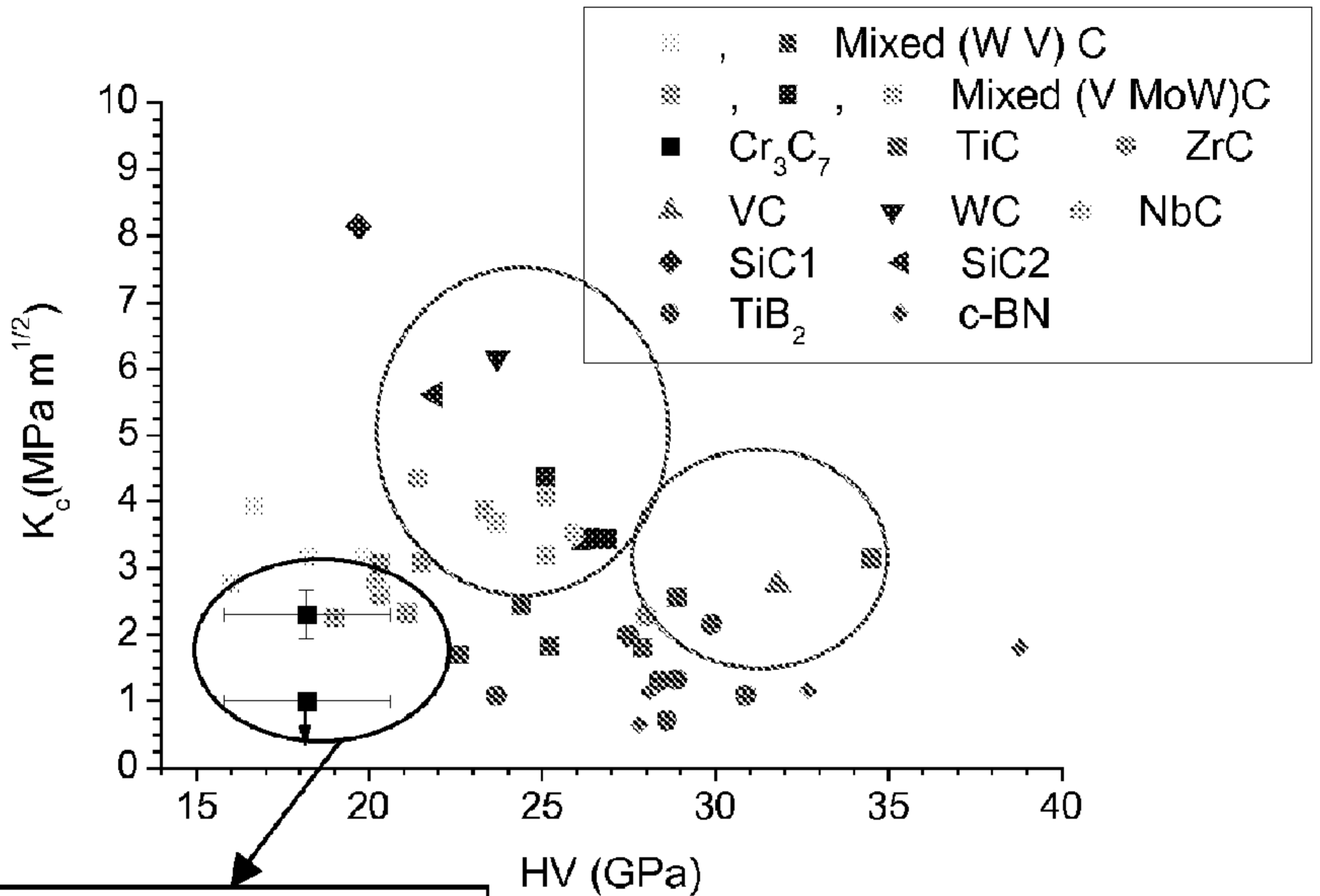


FIGURE 1



Commonly used
 carbides in conventional
 cold work tool steels