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CAMSS 2016 – a new software for a computer aided selection of engineering materials

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ABSTRACT

Purpose: The main purpose of the paper is to present Computer Aided Materials Selection Software 2016 (CAMSS 2016) program, as well as to show its potential applicability as a tool for the selection of engineering materials.

Design/methodology/approach: The project assumed a formation of computer database of materials properties and a system for the selection of structural materials. The software should be useful in industry, research entities and universities.

Research limitations/implications: The only limitation of CAMSS 2016 software comes from a minimum screen resolution. The software properly display all information (including phase diagrams) when at least 1280x720 screen resolution is applied.

Practical implications: CAMSS 2016 includes information regarding chemical composition, physical and mechanical properties (at low and elevated temperature), and required conditions for thermomechanical processing. CAMSS 2016 may be also applied to: the identification of materials based on chemical composition of physical and mechanical properties, a material selection for particular applications or a selection of proper material substitute.

Originality/value: CAMSS 2016 is one of the few available computer programs joining two basic functions: engineering and educational.

Keywords: Materials and engineering databases; CAMS; Metallic alloys; Mechanical properties

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METHODOLOGY OF RESEARCH, ANALYSIS AND MODELLING

1. Introduction

An extensive technological progress taking place in recent years results with a development of new materials introduced to many industrial sectors related to e.g. energy, transport or medicine. Each structural material may be described by using a number of specific characteristics regarding its chemical composition, physical and mechanical properties (at low and elevated temperature), and required conditions for thermomechanical processing.

An analysis of such a great quantity of data upon a material selection requires a proper computer software aiding a work of engineers.

Actually, engineers may use in this regard:

- free materials properties databases available on websites [1-3];
- paid internet services: www.totalmateria.com [4];
- CES Edupack commercial software [5];
- academic books e.g. [6-15].

Among aforementioned sources a special attention should be paid to www.matweb.com service, in which basic materials properties are listed in tables, as well as an user may search for materials based on criteria of three strength properties. On the other hand, CES Edupack software, beside of basic material data also includes an extensive educational content and tools for a computer aided materials selection (CAMS).

Computer Aided Materials Selection Software 2016 (CAMSS 2016) is an author's computer software that may be used to the identification of materials based on their chemical compositions or mechanical and physical properties. It also includes a description of alloys denotations, heat treatment and plastic working processing symbols and binary phase diagrams.

2. CAMSS 2016 description

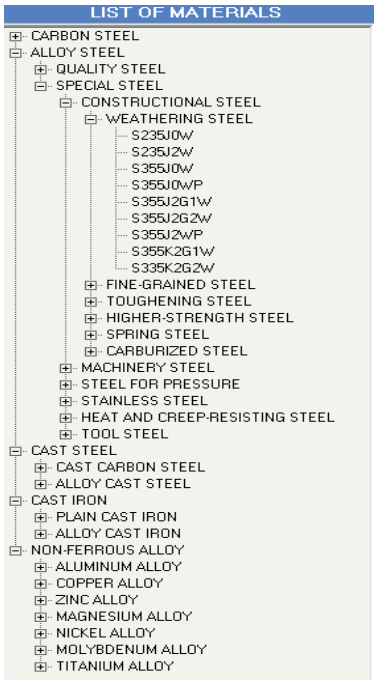


Fig. 1. List of materials included in CAMSS 2016

CAMSS 2016 is an interactive metallic materials database including 5 materials group (non-alloyed steels, alloyed steels, cast steels, cast irons, non-ferrous alloys) that are organized in a treeview. Each main node in the tree includes also sub-nodes that allows distinguishing various materials applications. An example of expanded node-tree showing special alloyed steels, structural steels and stainless steels is shown in Figure 1.

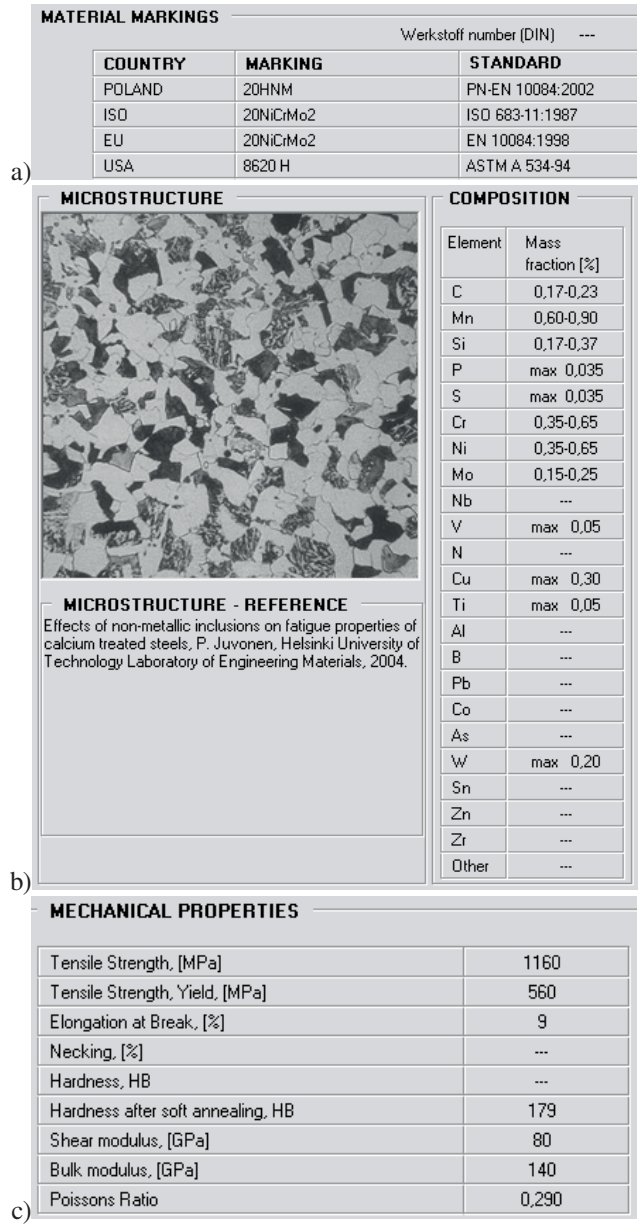


Fig. 2. 20HNM steel; data regarding: a) markings, b) microstructure and chemical composition, c) mechanical properties

Engineering materials included in CAMSS 2016 are described by data regarding their e.g. chemical compositions, microstructures, physical and mechanical properties that are consistent with PN-EN, ISO or ASTM standards (Fig. 2).

Depending on an application of particular material, some additional information are also included e.g. a temperature of hot working processing or heat treatment, low or elevated temperature properties, a hardness after various heat treatment steps. These additional data are mostly listed in Tables or graphs (Fig. 3).

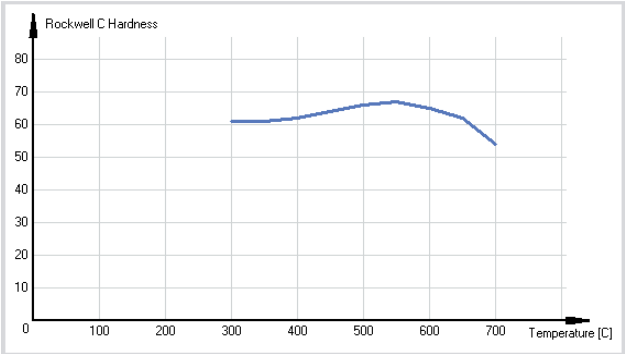


Fig. 3. A graph showing the hardness vs. temperature plot for HS10-4-3-10 high speed steel

A dataset for each available material may be edited and then rewritten. Additionally, each material characteristic card may be directly printed from CAMSS 2016.

Furthermore, a direct graphical comparison of selected properties (e.g. yield strength, tensile strength, elongation, hardness, density etc.) for whole groups of materials is an additional interesting function of CAMSS 2016 (Fig. 4).

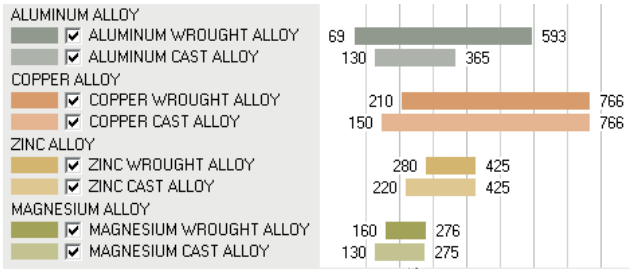


Fig. 4. A comparative graph showing the ultimate tensile strength for various materials groups (aluminum, copper, zinc, and magnesium alloys)

Moreover, arbitrarily selected up to 5 materials may be quickly compared in terms of their specific strength, hardness and microstructure. Figure 5 shows a comparison of microstructures of three steels, namely 10S20, 25HM, 55S2.

Additionally, a sub-programs for a conversion of mass percent to atomic percent contents (and reversely) in metallic alloys as well as for hardness units recalculations (Fig. 6) are also implemented into CAMSS 2016.

CAMMS 2016 also includes an educational content e.g. materials symbols, thermomechanical processing symbols or binary phase diagrams (Fig. 7).

3. CAMSS 2016 as a tool for a computer aided materials selection

The most basic method for a selection of a proper material substitute is by using an application criterion.

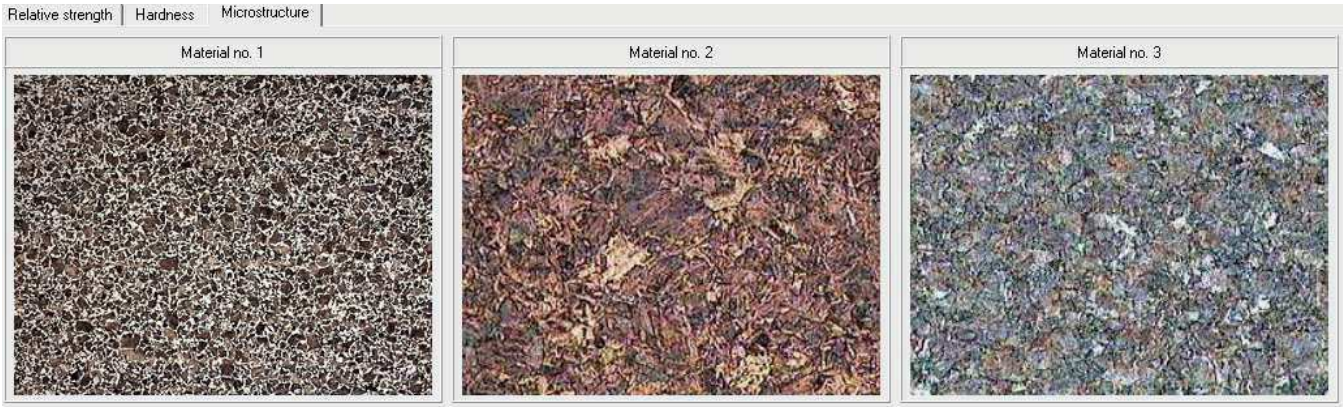


Fig. 5. A comparison of microstructures of three steels 10S20 steel, 25HM steel, 55S2 steel

Twardość Brinella HB (3000) 245 CALCULATE

HARDNESS	SYMBOL	VALUE	RANGE
Brinell Hardness (3000)	HB (3000)	245	80 - 445
Brinell Hardness (500)	HB (500)	219	78 - 220
Knoop Hardness	HK	268	101 - 920
Mosh Hardness	HM	3	2 - 7
Rockwell A Hardness	HRA	62	59 - 86
Rockwell B Hardness	HRB	97	41 - 98
Rockwell C Hardness	HRC	24	19 - 69
Rockwell D Hardness	HRD	43	39 - 70
Rockwell F Hardness	HRF	—	98 - 100
Vickers Hardness	HV	258	90 - 1000

* Hardness values outside of the range specified in the table are approximate values. CLOSE

Fig. 6. A hardness unit calculator panel

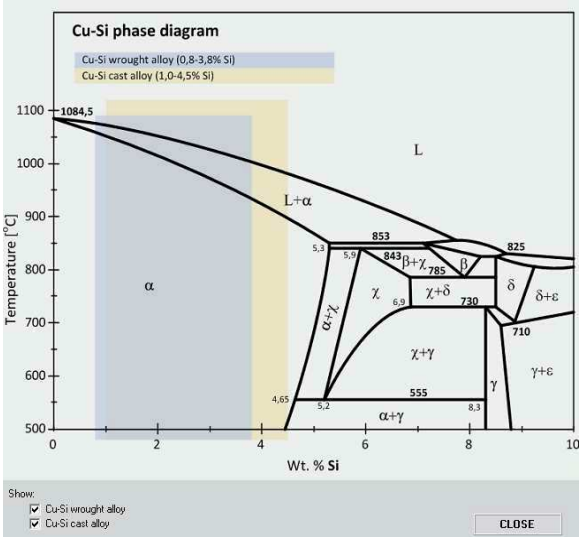


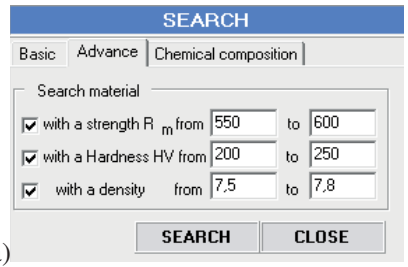
Fig. 7. A part of Cu-Si phase diagram

In this regard, an user should select a proper materials group from the materials list (shown in Fig. 1), then edit the list and choose (from the list on the right side) a proper substitute. The other, even more simple way is to just use the "search" function. Three following searching criteria are implemented in CAMSS 2016.

1. Basic - a searching of material by using its marking consistent with PN-EN, ISO or ASTM standards.
2. Advanced - a searching for material by using its properties e.g. a tensile strength, hardness or density.
3. By using material's chemical composition (based on a content of three alloying elements).

By using the basic criterion, the user receive an indication of one of the five main group of materials (shown in Fig. 1). In order to choose a specific material, the user needs to left-click on groups' name, and then select a right material.

By using the second criterion, a basic knowledge on properties (e.g. tensile strength, hardness or density) of substituted material is needed. By typing an exemplary values e.g. a tensile strength in the range of 550 to 600 MPa, a hardness of 200-250 HV and a density of 7.5-7.8 g/cm^3 (Fig. 8 a), results similar to these presented in Figure 8 b are received.



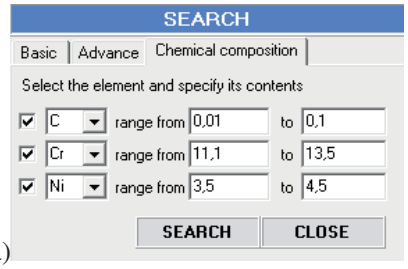
a)

Marking	Number DIN	Tensile Strength	Hardness HV	Density
LH19N14G	---	550	210	7,7
X2CrMoTi17-1	1.4513	550	210	7,7
X2CrNbZr17	1.4590	550	210	7,7
LH23N18G	---	550	210	7,8
LH25N19S2	---	550	210	7,8
X2CrMoTiS18-2	1.4523	600	210	7,7
X2CrNi12	1.4003	600	210	7,7

b)

Fig. 8. A materials selection based on three criteria, a) the advanced search panel, b) and obtained searching results

A material's selection may be also performed by using a chemical composition criterion by giving a content of three main alloying elements. By using this approach and typing following values: (0.01-0.1) carbon, (11.1-15.5) chromium, (3.5-4.5) nickel, CAMSS 2016 indicates three relevant materials (Fig. 9 b).



a)

Marking	Number DIN	Tensile Strength	C	Cr	Ni
GX3CrNi13-4	1.6982	700	0.05	12.0-13.5	3.50-5.00
GX4CrNi13-4	1.4317	760	0.06	12.0-13.5	3.50-5.00
X3CrNiMo13-4	1.4313	830	0.05	12.0-14.0	3.50-4.50

b)

Fig. 9. A selection of material according to the chemical composition based approach: a) the panel for introducing a content of three alloying elements, b) obtained results

4. Conclusions

CAMSS 2016 is a tool for computer aided materials selection that includes a large quantity of data regarding metallic materials.

Available data listed in the form of tables or graphs may be used by engineers working for industrial companies or research entities. The additional educational content of CAMSS 2016 e.g. a description of alloys denotations, heat treatment and plastic working processing symbols and binary phase diagrams gives an opportunity for its usage also upon lectures and academic training courses.

Furthermore, an application of CAMSS 2016 advanced filtering options additionally allows:

- a selection of engineering material giving the best performance properties of structural, functional or tool components;
- a selection of material's substitutes;
- a material's identification based on its chemical and phase composition or physical and mechanical properties.

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