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(71) Applicant: **ILVA S.p.A.**
Viale Castro Pretorio 122
I-00185 Roma(IT)

(72) Inventor: **Aldrovandi, Aldo**
via Baccelli 6
Terni(IT)
Inventor: **Santafé, Aldo**
Piazza Dalmazia 20
Terni(IT)
Inventor: **Pizzimenti, Antonino**
Via S. Bartolomeo degli Armeni 25/14
Genova(IT)

(74) Representative: **Mariani, Giulio**
c/o Centro Sviluppo Materiali SpA P.O. BOX 10747
I-00100 Roma Eur(IT)

(54) Process for the production of fire-resistant structural steel.

(57) Process for the production of a fire-resistant structural steel, characterized by the combination of a low-C, low-Mn steel including definite quantities of Ti and Nb with a specific controlled rolling treatment.

The result is a product, for use in medium to small structures, which, through exploitation of the synergic effect of composition and treatment, is subject to a smaller loss of elevated temperature strength properties on esposure to fire than is the case with other similar products, thus reducing the need for protective coatings and hence lowering installation costs;steelmaking costs are also kept down because the use of chemical elements is minimized; good weldability is also guaranteed.

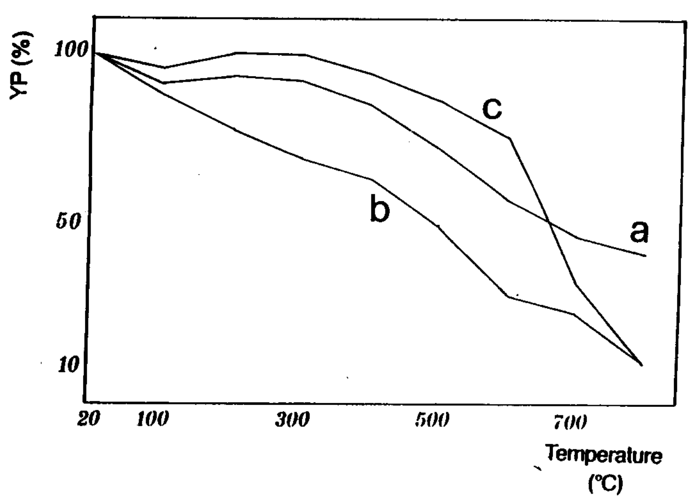

FIG. 1

EP 0 470 055 A2

The object of the present invention is a process for the production of fire-resistant structural steel which is subject to a very much smaller loss in strength on exposure to fire than is the case with other similar structural steels. During their lifetime, buildings may be esposed not only to such influences as static loads, wind, noise and humidity, but also to fire.

The heat of combustion that occurs during a fire may cause damage to various parts of a building, including those made of non combustible material. Even in the case of such a non-combustible material as steel, fire can cause expansion and lead to a decline in elastic limits, tensile properties and modulus of elasticity, thus resulting in a drop in strength, depending on the temperatures involved.

When there is a fire, the rise in temperatures causes elongations and deformations; these can result in the movement of bearings, which may lead to failure of the load-bearing structure. For instance, in the case of frame structures the elongation of beams may adversely affect the safety of the columns and the entire structure may collapse.

To protect human life, therefore, it is necessary to ensure that a load-bearing structure is stable even during a fire. The fire resistance of structures is certainly an extremely complex matter which involves many characteristic properties of the materials forming the structures themselves and is closely bound up with the type of materials employed. Construction steels such as Fe 360 (St37) and Fe 510 (St52) are generally adopted. However, though the cost of these steels is low, their elevated-temperature behaviour is unsatisfactory, so they require adequate protective coatings to ensure compliance with Fire Regulations. For instance, fire-resistant mineral fibres may be sprayed onto the steelwork or this may be covered by layers of cement.

The use of protective coatings leads to an increase in the total cost of construction, of course, reducing the competitive edge of steel. Then, too, there is the fact that it is not always possible to apply such coatings.

A proposed alternative solution is the use of hollow beams (JP No. 52-16021) with forced cooling to try to offset the low strength of the base material. However, it is necessary to bear in mind the complexity of building structures and hence the associated costs, as well as the operating and instrumentation problems involved with such cooling systems.

It has also been proposed to use Cr-Mo steels (JP No. 55-41960) but although these may have good elevated-temperature strength, weldability is not good, and this is an important feature as regards construction steels. Moreover, cost is a considerable problem.

Better properties than those offered by the preceding products have been attained by means of a steel (EP-347156 A2) made by the addition of a particular percentage of Mo and Nb to a low-C, low-Mn composition.

In this case, however, although the product behaves well up to around 600 °C, there is a decided decline at elevated temperatures, some 67% of ambient-temperature strength being lost at around 700 °C and 88% at about 800 °C, where behaviour is just the same as that of a much cheaper steel, namely SM50 (Fe 510).

There is thus a need for a steel with overally better mechanical properties, especially at elevated temperatures. This need is particularly pronounced in the case of medium and small structures where thicknesses are typically less than 15 mm, so high temperatures are attained more quickly than in structures where thicknesses are greater.

The steel in question should also have good weldability for that particular field of application where it makes little sense to think in terms of shielding or cooling, and where the material could be utilized without protection.

It has now surprisingly been found that through the combination of a steel of appropriate chemical composition and a controlled rolling procedure, conducted as per this invention, the ensuing prOducts, between 1.5 and 12 mm thick, have higher fire resistance, especially at elevated temperatures, than can be obtained using known methods.

Within the range of thicknesses involved it has been found experimentally that starting from a low-C and low-Mn steel alloyed especially with Ti, Nb and Mo, an alloy is obtained with properties that remain virtually unaltered after exposure to fire, so in the great majority of cases the relevant structural framework can be reused.

However, in relation to the specific composition claimed, precise thermomechanical treatment is of fundamental importance.

The production process which is the object of this invention requires that the slabs, billets or blooms from a heat of given composition should be heated prior to rolling, performed to obtain a minimum thickness of 1.5 mm, which is followed by controlled cooling, by means of a blade of water, and then hot coiling. The user can then purchase the product in the form of sheet and/or strip or as structural sections.

More precisely, the object of the present invention is the manufacture of a structural steel with improved fire-resistance, characterized by the combination of a steel containing the following elements (%wt): C = 0.03-0.14, Mn = 0.4-1.1, Mo = 0.3-0.8, Nb = 0.003-0.05, up to 0,20 Si, up to 0.02 P, up to 0.02 S, up to 0.20 Cr, up to 0,04 Al, up to 0.04 Ti, up to 0.20 Cu and at least one of the following elements: N = 0.002-0.010, V = 0.003-0,05, the remainder being iron and impurities, and the following production cycle:

- heating of said steel in the form of slabs, billets or blooms to a temperature between 1200 and 1300 °C prior to hot rolling.

Hot rolling of said steel with finishing rolling at a temperature between 800 and 950 °C to obtain a rolled steel between 1.5 and 12 mm thick

- water-cooling of the rolled steel from a temperature between 800 and 950 °C to between 550 and 700 °C at a rate of between 5 and 35 °C/s
- coiling of the rolled steel at a temperature between 550 and 700 °C.

Only by strict observance of the composition-treament combination, for the thickness range indicated, is it possible to obtain a product that can satisfy the most exacting demands.

To highlight the beneficial effects obtained via the present invention, this will now be described, purely by way of example and in no way limiting its scope and breadth, by comparison of the results of characterization tests performed on the steel as per the invention and on state-of-the-art steels.

Considering products in the 1,5 to 12 mm thickness range, tests were run on steels having the following compositions, espressed in terms of percent weight:

	Steel as per present invention	Fe 510	EP 0 347 156 A2
C	0.09	0.02	0.103
Si	0.13	0.36	0.333
Mn	0.64	1.45	0.99
P	0.01	0.02	0.01
S	0.002	0.006	0.029
Al	0.01	0.023	0.024
Cr	0.07	-	0.50
Mo	0.37	-	0.48
Nb	0.02	-	0.02
Ti	0.015	-	-
Cu	0.09	-	-
Ni	0.06	-	-
N	0.006	-	-

The results obtained from the experimental tests are reported in Fig.1 where temperatures in degrees centigrade (°C) are shown on the abscissa and percentage loss of yield strength (YP%) on the ordinate, taking the YP to be 100% at ambient temperature (20 °C).

As is evident from the graph, the behaviour of the steel as per the present invention (indicated by the letter "a" in the Figure) is markedly better throughout the 20° to 800 °C temperature range than that of the traditional high-strength structural steel Fe 510 (indicated by the letter "b"), while it is comparable with fire-resistant steel EP 0347156A2 (indicated by the letter "c") in the 20° to 500 °C range and decidedly better at temperatures in excess of 650 °C.

Claims

1. Process for the production of a structural steel with improved fire-resistance, characterized by the combination of a steel containing the following elements (%wt): C = 0.03-0.14, Mn = 0.4-1.1, M0 = 0,3-0.8, Nb = 0.003-0.05, up to 0.20 Si, up to 0.02 P, up to 0.02 S, up to 0.20 Cr, up to 0.04 Al, up to 0.04 Ti, up to 0.20 Cu and at least one of the following elements: N = 0.002-0.010, V = 0.003-0.05, the remainder being iron and impurities, and the following production cycle:

- heating of said steel in the form of slabs, billets or blooms to a temperature between 1200 and 1300 °C prior to hot rolling
- hot rolling of said steel with finishing rolling at a temperature between 800 and 950 °C to obtain a rolled steel between 1.5 and 12 mm thick
- water-cooling of said rolled steel from a temperature between 800 and 950 °C to between 550 and 700 °C at a rate of between 5 and 35 °C/s
- coiling of said steel at a temperature between 550 and 700 °C.

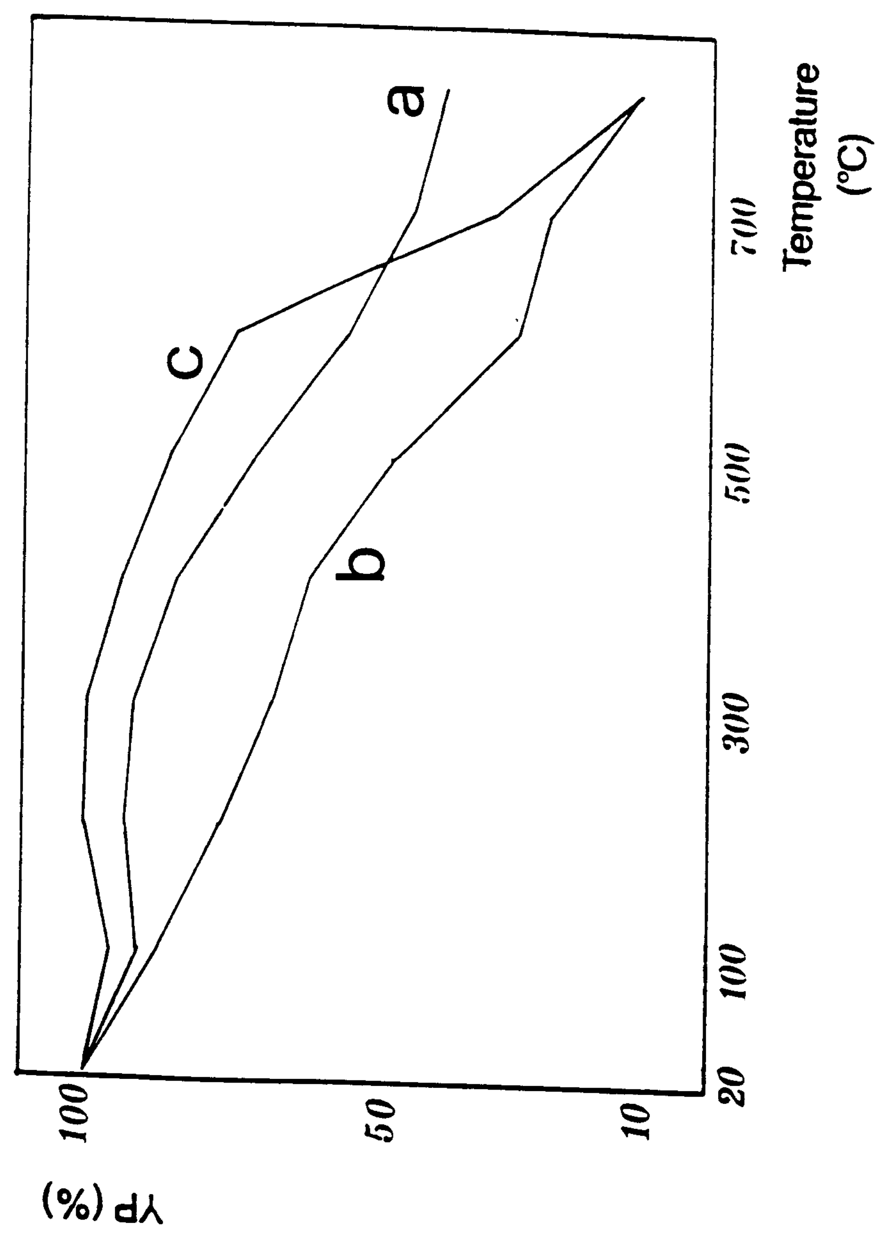

FIG. 1