GIFLO STEEL

ABSTRACT

High strength steel is a critical component of practically every aspect of modern civilization. Since the inception of the first inexpensive mass-production of steel in the mid 1800's, various alloys and treatments have been in use, usually tailored to a specific application or environment. However, the one thing all these had in common was the increase in hardness, elongation characteristics, and tensile/yield strength. The steel produced by the new alloys and processes gave rise to larger structures (bridges, buildings), increased destructive capabilities (cannons, tanks, warships) and greater force transmission (gears, boilers, turbines).

THE PROBLEM

High strength is achieved at the expense of elasticity. Internal stresses resulting from traditional quench and temper hardening processes can result in hot and cold cracking at welds. In many applications, structural or functional demands are met at the expense of increased weight. High hardness is achieved at the expense of ductility, machine workability, weldability, and elasticity/tensile strength. The process through which many characteristics are achieved is usually that of tempering already quenched material, thereby arriving at the desirable hardness. This creates a downstream processing issue whereby the application of heat can have the effect of further weakening/softening, creating a point of potential catastrophic failure.

HOW WE ADDRESS THE PROBLEM

Giflo steel has several unique formulations. Each formulation can then be tailored further with regards to tensile and yield strength, elongation and reduction characteristics, and hardness. These attributes are achieved through a chemical process rather than contemporary quench and temper.

Hardness distribution of Giflo M-2000 type 90 mm dia material

Horizontal and vertical direction. (Hardness in HRc)

Grain size: ASTM 8-9

As a result, the grain structure and physical properties are consistent along all three axis, and issues related to hardness achieved through heat treatment are eliminated. What this means in practical terms is that two plates of Giflo F-1000 can be welded with powder filled rods (which create the same formulation within the bead), creating a join with continuous properties. There are no temper related issues. If needed, the steel can be further treated to surface nitriding if the intended application calls for it (pins, for example).

THE FORMULATIONS *(see Appendix B for details)*

Giflo D–Grade High-strength weldable structural steels

Giflo F–Grade High fatigue strength limit, air corrosion resistance, weldable structural steels

Giflo M–Grade Ultra high strength, high fatigue strength limit structural steels

Giflo S–Grade High strength good machinability machine steels

Giflo U–Grade High strength, good machinability, free-cutting machine steels

Giflo Z–Grade High strength, easy polishing, ferrite/martensite stainless steels

Giflo M-2100

M-2100 is the newest formulation of Giflo steel, providing high hardness and wear resistance, extending the active lifespan of machinery and surfaces subject to high wear by three or more times.

In applications where material is subjected to extremes of stress and abrasion, there are a limited amount of choices regarding what can survive long enough to justify implementation. Generally, a material that is hard enough to exhibit good abrasive resistance will have a corresponding increase in brittleness, decreasing impact resistance. The M-2100 formulation is the most extreme of the bunch with regards to hardness (55 Rockwell with 8-12% elongation, 560 Brinell), strength, and wear resistance. This makes it an ideal candidate for extreme environment applications. In an application that presents abrasive wear, this means that there is no brittle hardened surface that can be removed through fragmentation and spalling, exposing softer material. The material that is exposed will be as hard as the initial surface through the entire section of the part. This will increase abrasive resistance by at least three times, significantly increasing the lifespan of parts exposed to abrasive environments.

It can be forged without losing these qualities (heat it up to 1140 degrees, you can forge it as you like and as it cools it returns back to 2100 MPa), and can be annealed to 1200 MPa for machining. Re-heating and air-cooling returns the material to its original properties without further treatment.

CONCLUSION

The Giflo steel ranges represent a huge leap forward in metallurgy. They can provide high strength without the need for hardening and tempering, while retaining weldability and wear resistance. Pricing per ton remains competitive, as there is no need for expensive upgrades or retrofits in a medium to large capacity mill.

Appendix A – Giflo Steel Explained

The invention relates to an additive composition consisting of a plurality of components which improves the metallurgic quality of iron-based alloy systems and considerably increases the strength thereof when used in the course of steel production and also improves the strength of a weld formed using a powder-cored welding wire in which the core is made of the composition.

The usefulness of a steel depends on its metallurgic quality, e.g. yield strength at permanent deformation, brittleness, stress limit of fatigue, weldability and resitance to wear.

One of the most important properties of a steel is the stress it can withstand without permanent deformation (0% yield strength). The value of 0% yield strength determines the load that can be placed on structures or structural elements made of the steel.

Another important property of a steel is its ductility. In general with steels, an increase in strength is accompanied by a decrease in ductility. The development of presently used steels has concentrated on processing technology. However, the use of alloying additives in iron-based metals in order to increase the load-bearing ability of the metal and thus reduce the quantity of metal necessary to bear a given load has not been properly emphasized in industrial application.

Presently used steels - with the exception of some functional properties required by special technologies - do not meet the requirements of modern technology.

Different methods are known for improving a single property of a steel for a particular final use by alloying of suitable elements or by heat treatment, in accordance with the intended final use. For example boron may be added to increase hardness (see WO 83/00167) in a composition that also contains rare earth elements and titanium and optionally silicon, calcium, manganese and zirconium; the balance of the composition is made up of iron.

With industrially produced steels, as a result of lattice faults and as a result of dislocations resulting from the different form, size and orientation of individual crystals (grains) in the steel, permanent deformation can be induced by a stress that is 1000-times lower than the theoretical lattice strength of the metal. Any means that hinders dislocations between the grains in steel increases the strength of the steels; such means are, for example, elements located in the metal lattice by substitution or interstition, dislocations, grain boundaries, twin crystals, alien phases, separations, all being independent strengthening mechanisms. Practice has confirmed the fact that presently used methods for increasing steel strength, which activate only one or two strengthening mechanisms and mainly by thermal treatment, can improve ductility but can only increase strength to a limited extent.

The object of the present invention is to provide an additive composition for strengthening steels while simultaneously maintaining the ductility of the steel at an acceptable level whereby the strength of a steel more closely approaches the strength of the metal lattice, thus increasing the load-bearing properties of the steel.

Accordingly, the present invention provides a composition for use in a quantity of 5 to 17 kg/t in the course of steel production or as a powder core of a welding wire electrode.

The proportion and quantity of the alloying components in accordance with the invention, as well as the method of alloying using such a composition ensure good physico-chemical and metallo-physical conditions in the course of steel production and in the course of welding when used as the powder core of a welding electrode. It thus improves the metallurigcal quality and simultaneously considerably increases the strength of industrial iron-based alloy systems and also maintains ductility properties at an acceptable level while, at the same time increasing the proportion of the theoretical lattice force that can be utilized for load bearing.

In the course of steel production the composition may be added with a maximum particle size of 8 mm during discharge of liquid steel into the ladle and the composition will be well-dispersed utilizing the agitating effect of the liquid steel discharge flow; alternatively the composition may be added by means of the widely used method of blowing the composition into the liquid steel after discharge. When producing filler wire with a powder core, the composition is charged in the prescribed fraction and well mixed.

The properties of the individual alloying components and a properly chosen composition thereof in the alloy systems result in local physico-chemical, nuclear and kinetic conditions in the course of alloying, strengthening, heating and hot working, as well as re-crystallization, which considerably increase the quantity of the elements that can be utilized for increasing the strength of a steel.

Some of the components in the additive composition of the present invention, when used in an expedient proportion, form complex compounds with a high melting point in the steel and form partly crystallized nuclei of active size early in the melt thus promoting crystallization of the steel melt and thereby shortening the time of solidification; partly by this effect, the primary grain size and the possibility of grain enrichment are reduced and the conditions of re-crystallization are considerably improved.

Furthermore, the additive composition in accordance with the invention establishes conditions in the course of solidification and re-crystallization that considerably increase the ability of the steel to dissolve interstitial elements in the metal lattice thereby increasing the solubility of such elements and so increasing the number of stressed lattice sites caused by interstital atoms and also increasing the extent of the stress they induce. Stressing of the lattice by interstitial atoms markedly increases the number of dislocations that promote and determine the formation of segregated phases for hindering displacement of the metal crystals (grains).

Some components of the composition of the present invention form complex metallic phases of high shear-strength, which both increase and stabilize the internal stress of the lattice of the base steel when built-in into lattice faults. Lattice faults produced metallurgicaly promote formation of these metallic phases and determine the location and density of the phases, thereby considerably increasing the efficiency of anchoring performed by the phases in preventing dislocation of the metal crystals under the influence of applied loads.

Some of the components of the composition, when deposited at the grain boundaries, decrease the rate of diffusion of the metal atoms in their vicinity thus delaying the formation there of non-coherent phases. In such a manner an increase in undesired phases along the grain boundaries is hindered and the segregation of alloying elements will be prevented. In such a manner, the strength of homogeneous grain boundaries will be considerably increased and cracking occurring as a result of stress can be delayed; elongation and contraction at creep break increases, as does the ductility of the alloy system, its cold and hot malleability and ductility, its fatigue limit and its strength for supporting loads.

Some of the components of the composition produce inclusions of low specific weight, which rise easily up into the slag, thus considerably reducing the content of harmful inclusions in the steel. In addition, complex spherical inclusions can also be formed that not only remain in the steel and keep their original shape even in the course of plastic deformation, but also they bind sulfur atoms on their surface, forming a sulfide coating, thus considerably reducing the formation of iron sulfide; in this way more advantageous plasticity and anisotropic properties can be assured for the steel.

Accordingly, the composition according to the invention provides improved metallurgical quality of given steels, promotes strengthening mechanisms without thermal treatment and provides several strengthening mechanisms whose effects are additive, thereby simultaneously increasing the utilizable strength of steels.

It should be noted that the composition according to the invention may be applied for welding as well. The composition can be used in the form of a powder to form the core of a powder-filled band electrode.

Appendix B – Giflo Steel Types

GIFLO D–Grade Steels

High-strength, weldable, structural steels

Type of Steel	C	Mn	Si	P	S	Rm MPa	$Rp^{0.2}$ MPa min.	A5 % min.	Z % min.
GIFLO D-800	0.08 0.15	1.20 1.60	0.20 0.70	max. 0.025	max. 0.020	700 900	600	16	50
GIFLO D-1000	0.15 0.20	1.20 1.60	0.20 0.70	max. 0.025	max. 0.020	900 1100	700	15	40
GIFLO D-1200	0.20 0.30	1.80 2.10	0.20 0.70	max. 0.025	max. 0.020	1100 1300	900	14	35

Note: the chemical composition is in weight %.

GIFLO F–Grade Steels

High fatigue strength, air corrosion resistant weldable structural steels

Type of Steel	C	Mn	Si	P	S	Cu	Rm MPa	$Rp^{0.2}$ MPa min.	A5 % min.	Z % min.
GIFLO F-800	0.08 0.12	1.20 1.60	0.20 0.70	max. 0.025	max. 0.020	1.00 1.20	800 1000	600	16	50
GIFLO F-1000	0.10 0.14	1.20 1.60	0.20 0.70	max. 0.025	max. 0.020	1.80 2.10	900 1100	700	15	40
GIFLO F-1200	0.15 0.20	1.20 1.60	0.20 0.70	max. 0.025	max. 0.020	1.80 2.10	1100 1300	900	14	35

Note: the chemical composition is in weight %.

GIFLO S–Grade Steels

High strength, good machinability machine steels

Type of Steel	C	Mn	Si	P	S	Rm MPa	$Rp^{0.2}$ MPa min.	A5 % min.	Z % min.
GIFLO S-800	0.15 0.25	1.20 1.60	0.20 0.70	max. 0.025	0.020 0.040	700 900	600	16	50
GIFLO S-1000	0.25 0.30	1.20 1.60	0.20 0.70	max. 0.025	0.020 0.040	900 1100	800	15	40
GIFLO S-1200	0.35 0.50	1.20 1.60	0.20 0.70	max. 0.025	0.020 0.040	1000 1300	900	14	35

Note: the chemical composition is in weight %.

GIFLO U–Grade Steels

High strength, good machinability, free-cutting machine steels

Type of Steel	C	Mn	Si	P	S	Pb	Rm MPa	$Rp^{0.2}$ MPa min.	A5 % min.	Z % min.
GIFLO U-800	0.15 0.25	1.20 1.60	0.20 0.70	max. 0.025	0.020 0.060	0.15 0.25	700 900	600	16	50
GIFLO U-900	0.25 0.30	1.20 1.60	0.20 0.70	max. 0.025	0.020 0.060	0.15 0.25	900 1100	800	14	40
GIFLO U-1000	0.35 0.50	1.20 1.60	0.20 0.70	max. 0.025	0.020 0.060	0.15 0.25	1000 1300	900	12	35

Note: the chemical composition is in weight %.

GIFLO M–Grade Steels

Ultra high strength, high fatigue strength limit structural steels

Type of Steel	C	Mn	Si	P	S	Cu	Rm MPa	$Rp^{0.2}$ MPa min.	A5 % min.	Z % min.
GIFLO M-1400	0.20 0.24	1.20 1.60	0.20 0.70	max. 0.025	max 0.020	1.80 2.10	1300 1500	1200	12	35
GIFLO M-1600	0.25 0.29	1.20 1.60	0.20 0.70	max. 0.025	max 0.020	1.80 2.10	1500 1700	1300	10	30
GIFLO M-1800	0.30 0.35	1.20 1.60	0.20 0.70	max. 0.025	max 0.020	1.80 2.10	1700 1900	1500	8	27
GIFLO M-2000	0.40 0.50	1.20 1.60	0.20 0.70	max. 0.025	max 0.020	1.80 2.10	1800 2100	1600	7	25

Note: the chemical composition is in weight %.

GIFLO Z–Grade Steels

High-strength, easy polishing, ferrite, martensite stainless steels

Type of Steel	C	Mn	Si	P	S	Cr	Rm MPa	$Rp^{0.2}$ MPa min.	A5 % min.	Z % min.
GIFLO Z-1000	0.08 0.12	0.60 0.90	0.20 0.70	max. 0.025	max 0.020	17.00-19.00	900 1100	800	16	50
GIFLO Z-1300	0.08 0.12	0.60 0.90	0.20 0.70	max. 0.025	max 0.020	12.00-14.00	1200 1400	1000	14	45
GIFLO Z-1500	0.15 0.25	0.60 0.90	0.20 0.70	max. 0.025	max 0.020	12.00-14.00	1400 1600	1200	12	40

Note: the chemical composition is in weight %.