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HSLA STEEL WITH HIGH WELDABILITY AND IMPROVED CHARACTERIZATIONS OBTAINED THROUGH VACUUM HEATED LADLE REFINING TECHNIQUE

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ABSTRACT

Increasing the tensile characteristics for normalized steels commonly results in lowered weldability and toughness, because of additions of increasing content in Mn, Ni, V...
The steel described herein allows to bypass this problem, i.e. to get at the same time high yield strength (> 500 MPa) while keeping toughness and weldability comparable to that of steel with Y.S > 460 MPa. Two conditions are necessary to achieve this :

- optimize the chemical composition through a computerized statistical analysis, linking together all needed properties (Y.S., impact strength, weldability) and cost. The additions of alloying elements are then reduced at the lowest level necessary for the requirements.
- use a steelmaking process capable of high chemical composition accuracy. This is done by electric furnace melting followed by high vacuum heating ladle refining. Thus composition ranges obtained are very close to the aimed values.

It will be shown that it is important to choose the impurities level (S,P) and alloys additions (V) in accordance with the specification, to obtain the toughness value in plates and in HAZ, before and after postweld heat treatment.

INTRODUCTION

A major problem of steel users is to make constructions such as pressure vessels as light as possible and hence to reduce wall thicknesses. There are three types of solutions to achieve this purpose (1).

. Quenched and tempered steels with a low carbon content (.10/.12 %) and eventually small additions of alloying elements (Ni,Cr,Mo,V,B) depending on the desired yield strength (YS > 420/700 MPa).

Controlled-rolled plates, with a very low carbon content (.05/.10 %) and additions also depending on YS level (Mn,Mo,Nb,Ti...).

. Normalized steels which have a medium C content (.12/.25 %) and also some alloying elements such as Mn,Ni,Mo,V...

For some applications requiring heavy plates (t > 40 mm), normalized steels must be prefered to controlled rolled steels to obtain the required properties through the entire thickness. Also,when large cold strain capacities or more, when hot forming is necessary, normalized steels have to be used. The additions of alloying elements, necessary to obtain the minimum strength level, can deteriorate toughness as well as weldability. So it is necessary to lower these additions as much as possible.

In Europe, the highest grade for normalized steels is that defined by the German standard SEW 089, St E 51 : YS > 51 kg/mm^2 (500 MPa) up to 16 mm thick plates, this value decreasing with thickness. These YS are obtained with relatively important additions of Mn,Ni,V,Cu,Ti [2] [3].
In this paper, we will demonstrate that it is possible to get steel plates according to St E 51, that have toughness and weldability properties similar to those of a lowest level, steel St E 47 (YS > 47 kg/mm^2 - 460 MPa), by reducing the alloying additions.

CHEMICAL ANALYSIS OPTIMIZATION - STEEL MAKING

Three main conditions have to be carried out, regarding strength, toughness and weldability, and this optimization must also take care of cost. This is achieved by computer calculation with an optimization program containing several equations giving strength (YS and TS), toughness, weldability as a function of thickness, heat treatment, welding conditions and analysis alloying elements and impurities (figure 1).

This optimum composition has then to be achieved with industrial equipments; the process which is used here can be briefly described (figure 2).

- melting, oxygen blowing and desphosphorization in an electric furnace,

- desulfurization, additions and degassing in a