THE ANNALS OF "DUNAREA DE JOS" UNIVERSITY OF GALATI .
FASCICLE IX. METALLURGY AND MATERIALS SCIENCE
N^0. 2 – 2007, ISSN 1453 – 083X

MANUFACTURE OF STUD LINK CHAIN CABLE MADE OF GRADE U1 AND U2 STEEL

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ABSTRACT

We have analyzed the fabrication technology of the link chain cable made of grade U1 and U2 steel from TREFO S.A. Galati and we had in view during the experiments several rolling programs. The main characteristics of a product quality, material or working process can be classified into the following groups: technological and contractual. Further on, we are going to present data regarding the link chain cable where samples were drawn, micro metallographic analysis referring to grade U1 and U2 steel and the characteristic obtained on the same areas where the metallographic analysis were made.

KEYWORDS: link chain cable, grade U1 and U2 steel

1. Introduction

Three grades of stud-link chain cable are covered, and are described in table 1.

All chain is to have a workmanlike finish and be free from injurious defects.

Table 1. *The grades of stud- link chain cable*

Strength Level	Grade	Method of Manufacture
Normal Strength	1	Flash Butt-welded
High Strength	2a 2b	Flash Butt-welded or Drop-forged Cast Steel
Extra-high Strength	3a 3b	Flash Butt-welded or Drop-forged Cast Steel

There is to be an odd number of links in each shot of anchor chain cable to insure shackles leading over the windlass in the same position. Steel chain made by processes or to requirements differing and certain types of drop-forged chain will be subject to special consideration. Manufacturers of Grades 1 and 2 chain and chain accessories are to submit their manufacturing process and material specifications for review. Data in support of mechanical properties, weld soundness (when applicable) and compliance with the Rules in all respects are also to be submitted for review and approval. Locking pins in detachable connecting links are to have taper contact at both top and bottom in the link halves.

Lead or other acceptable material is to be used for plugging the locking pin hole which is to contain an appropriate undercut recess or equivalent arrangement to secure the plug.

Studs are to be securely fastened by press fitting, or welding with an approved procedure. When the stud is welded in place, the weld is to be opposite the flash butt weld in the chain. The welding is to be carried out in the horizontal position at least on both faces of the link for a length sufficient to hold the stud securely in place. The grade U1 and U2 steel used for the ship and other structural applications, is in conformity with LR Rules. The chemical analysis prescribed for the grade U2 steel sheets was tested and the results are in table 2.

In order to realize a program for extended a fabrication authorization of the higher strength steels plates for ship or other structural applications Grades A, B, C, D and E, on effectuated an researches and experimental series which consists in: chemical analysis; Baumann sulphur print; metallographic analysis; non-destructive examination.

Table 2. *The chemical composition for U2a grade*

C	Mn	Si	P	S	Cr	Ni	Cu	Mo	As	Al
1.2 1.6	1.2 1.6	0.15 0.35	max 0.035	max 0.035	max 0.3	max 0.3	max 0.3	-	min 0.08	min 0.025

2. Experiments

2.1.Thermal treatment

Is realised according with the chain's grade: normalizing - for steel grade Ul and U2. The heat treatment is carried out in a deep furnace. The technical control - similar with the chains control.
The temperatures reached during the normalizing treatment are:
-normalizing temperature:

$T_{normalizing} = 735^0C$

-the furnace temperature is with 10 to 20 °C higher than the treatment temperature:

$T_{furnace} = 735 + 20 = 755$ °C.

The air cooling follows this treatment.
-the tempering temperature is:

$T_{tempering} = 590^0C$

-the furnace temperature would be with 20 °C higher than the treatment temperature:

$T_{furnace} = 610$ °C.

2.2. Test programme

Approval for Grade U2 chain cable also covers approval for the manufacture of lower gra des up to the same maximum diameter provided that such cable is supplied in the normalized condition.

Separate approval tests are to be carried out where it is proposed to supply Grade Ul or U2 cable in the "as welded" condition (fig. 1).

Fig. 1. *The common link.*

The approval tests were carried out on the 64 mm diameter, U1 and U2 grade anchor stud link chain. In addition, a suitable length (about six times the diameter) of the bar material used for the manufacture of the cable is to be provided for the test purposes. This sample of bar material is to be heat treated in a manner simulating that used for the completed chain cable. The bar material is supplied by S.C. "C.O.S. TIRGOVISTE" S.A., having the ladle analysis in conformity with table 3.

Table 3. *Chemical analysis of the ladle*

C	Mn	Si	S	P	Cr	Ni	Cu	Al	V	Nb	N_2
[%]											
0.24	1.64	0.23	0.015	0.021	0.25	0.19	0.22	0.02	0.08	0.03	0.0090

The dimensions of the enlarged link and the end link before the proof load are given in table 4.

Table 4. *The dimensions of the enlarged link and the end link before the proof load*

Enlarged link				End link			
L	W	P	d	L	W	P	d
[mm]							
420	256	277	70.5/ 72.5	435	260.5	280	76.8/ 78.1

The common links were manufactured from 26SiMnl7 steel, 65 mm diam. bar material, charge 79611, having the chemical composition according to table 3. A careful visual examination was carried out, with specially reference to the uniformity of dia meter, the shape of links. The links dimensions are shown in the table 4.

Magnetic particle inspection was carried out on 21 common links, 1pc. enlarged link and 1pc. end link. It was applied a load equal to 10% from 2190 kN and the chain cable's measured length was of 26810 m. Then, the chain length was submitted to a proof load of 2190 kN; after that the chain cable's length was submitted to 219 kN and there was measured the cable chain length: 26.94 m. The permanent elongation is of about 0.13 m. The length of chain cable was ultrasonic re-examined on a number of 10 common links, 64 mm diameter .

Table 5. *The dimensions of the link*

L (link's length)	**W (link's width)**	**P (pitch)**
[mm]		
383	230	254
384.5	234.5	256
388	231.5	260
383	235	254
386	234	258
385	234	258
387.5	236.5	261
385	235.5	259
388	234	261.5
386	235.5	258
387	234	261
386	235	261.2
383	234.5	255

There were dimensional checked 20 pcs common links; 5 pcs enlarged links and 5 pcs end links acc. There were checked all the cable's links at the outer surface and there were no objections (fig.2).

Fig.2. *The macrostructure of the commom link, 500:1.*

The specimen composed by 3 common links, lpc. enlarged link and 1 pc. end link was subjected at a tensile of 3130 kN and it wasn't destroyed.

The breaking test was continued until 3963 kN, when was broke a common link from the bend zone .

The values of the mechanical tests for the links cut from the chain cable subjected at the tensile test is according to the tables 6. The microstructure (fig. 3) and the Baumann's amprent (fig. 4) confirm the goods properties obtained by the mechnical te sts.

Fig.3. *The microstructure of the common link, 500:1.*

Fig.3. *The Baumann amprent of the common link.*

Table 6. *Common links (The side opposite the weld)*

Tensile strength	**Yield strength**	**Elongation**	**Red of area**	**Charpy V notch impact test Energy Joules**				**Cristalinity**
[N/mm^2]		[%]						
				Test temp	1	2	3	
813	701	21.4	63.2	0	194	184	234	80
				20	182	240	200	80
				-20	174	178	192	80
				-40	189	192	188	80

Conclusions

We have analyzed the fabrication technology of the link chain cable made of grade U1 and U2 steel from TREFO S.A. Galati and we had in view during the experiments several rolling programs. The main characteristics of a product quality, material or working process can be classified into the following groups: technological and contractual. Further on, we are going to present data regarding the link chain cable where samples were drawn, micro metallographic analysis referring to grade U1 and U2 steel and the characteristic obtained on the same areas where the metallographic analysis were made.

The manufacture program has been accepted in accordance with the requirements of Lloyd register.

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