FLARE TEST ON WELDED STEEL TUBES; 2D SIMULATION

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ABSTRACT

This work address the simulation of the flare test as it performed on tubes welded by HF (high frequency) induction. Usually, at ENTTPP (National company of pipe mill and processing of flat products) where the test is carried out, the final products (tube) undergo a series of CD (destructive testing) in order to examine the efficiency of welding. In our context, the focus is on the flare test as one of these CD tests and by exerting efforts (pressure) on a predefined length sections from the pipe (of S235JR steel type in our case) and due to its share parameters namely mechanical (fracture resistance) and geometrical (thickness tube, outside diameter), the variation of this efforts is recorded, and the results is well investigated in order to be simulated on computer using finite element method based programing language (Castem version 2001).

Keywords: *Flare test, Destructive Testing, S235JR , Pressure, Drafts Tube, Finished Tube, finite element method, Castem 2001.*

NOMENCLATURE

Symbols:	**Greek letters:**
E Young's modulus, N/mm2	α_T Thermal coefficient, °C
	v Poisson's ratio (coefficient of expansion on the transverse axial)
G Slip modulus, KN/mm2	
L Specimen length, mm	γ Charge volume, KN/m3
	β the cone mandrel Angle, (°)

1. INTRODUCTION

The definition of the steel weldability is complex as being a qualitative property assessed due to various criteria that involve different parameters (the steel chemical composition is only one example) and strictly related to the desired characteristics the final product to achieve. Therefore no specific safeguards are guarantee, rather than the steel pipe producers provide the user with the necessary information for a successful welding and assembly integrity completion as it is essential to avoid any risk of destruction by cracking or breaking due to the defects [1]. Welding techniques are benefiting from the latest innovations in numerous technological domains like process engineering and metallurgy, robotics and information technology, MRI imaging and the application of new sources of energy (laser). A process perfectly meet the industrial requirements tubes welding using high frequency induction (HF) is one of the major welding techniques in manufacturing pipes and other products in closed steel, aluminum or copper [2]-[3]. For this latter and other, an earnest quality control series of test is an urge to refine the use of these techniques in term of a good knowledge about the material used namely its chemical and mechanical properties. As the used material is the E24–2 type of steel (also known as the S235JR), it is of a known chemical compositions, we aim toward the the final product's mechanical characteristics using the flare test known to be of a destructive nature to the workpiece (tubes and tube sections). In addition to flare, this category of destructive nature tests includes: traction, hardness, resilience, bending, flattening. Notice that the tests exertion applies on draft (non–welded tube rolling) as well as finished products (hot rolled pipe regenerated by annealing for Standardization).

2. MATERIALS AND METHODS

The produced pipes are steel type S235JR construction (after the EN 10025-2:2004 standard, European standard for hot-rolled structural steel). Table 1 shows the chemical composition of this type of steel. The E24-2 is the equivalent of S235JR in the french standard NFA 35-50 where the grade is indicated by the letter E followed by a number corresponding to the minimum yield tensile strength. Finally and possibly number vary between 2, 3 or 4 to indicate quality [4]. The mechanicals proprieties of steel are registered in Figs. 1 and 2.

C %	Mn %	Si %	P%	S%	Al %
0,10	**0,40**	**0,02**	**0,003**	**0,007**	**0,042**

TABLE 1 . Chemical composition of steel S235JR

By nuance selon NF EN 10025-2	Grade under the old standard NF EN 10025	By Nuance the old standard NF A 35-501
S235JR	**S235JR**	**E 24-2**
S235J0	**S235J0**	**E 24-3**
S235J2	**S235JRG3**	**E 24-4**

TABLE 2 . Equivalencies Nuances Between NF EN 10025–2, NF 10025 and NF A 35–501 [5].

Modulus of Young	Slip modulus	Thermal Coefficient	Poisson's ratio	Charge volume
E	$G = \frac{E}{2(1+v)}$	α_T	**v**	γ
210 N/mm2	**81 KN/mm2**	**10-5/°C**	**0,3**	**78,5KN/m3**

TABLE 3 . Values for calculating standard features steel construction [6].

Principle of the test flaring EN10234 (Oct. 1993):

This European standard specifies a method for determining the formability of plastic flaring metal tubes of circular section, it is applicable to tubes of outer diameter not greater than 150 mm (100 mm for light metals) and wall thickness not exceeding 10 mm. The flare using a mandrel tapered end of a specimen cut from a tube, until the maximum outer diameter of the tube and flare reaches the value specified in the relevant product standard (see Figs. 1 and 3) [7].

The choice of the length of specimen (section of the tube) is made according to the angle of the mandrel (see Table 4). The draft tubes are rolled strip by the forming rolls and welded, while the finished tubes are tubes blanks followed by operation of hot rolling (hot drawing) to set size then a final annealing in air (see Fig. 2).

Length of specimen L (mm)	**2de**	**1,5de**	**1,5de**
Angle of the cone mandrel β (°)	**30°**	**45°**	**60°**

TABLE 4 . Dimensions of the specimens according to the angle of the cone.

Figure 1 .Flaring tube.

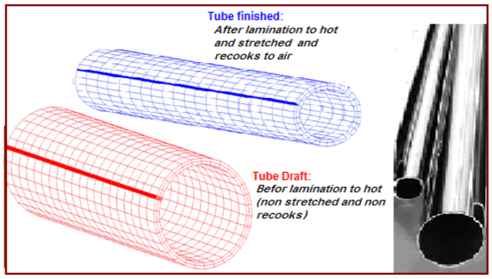

Figure 2 .Draft tube (large diameter) and finished tube (small diameter).

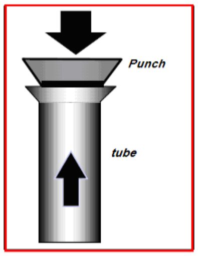

Figure 3 .Principle operation of flare, penetration of the punch in the tube [8].

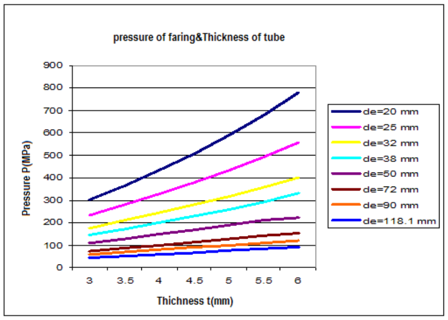

Figure 4 .Evolution of pressure depending on thickness of tubes for different outside diameters.

3. RESULTATSAND DISCUSSION

The results for the two cases considered (ie. draft tube before hot stretching and annealing) and (finished tube after dac hot drawing and annealing in air), reveal:

- Increased pressure values of flare depending on thickness of the tube to different diameters (see Fig. 4);
- Increased pressure values of flare depending on thickness of the tube for different tensile strengths and for both tube (draft and final) (see Figs. 5 and 6); This change in pressure tubes with flared changing thicknesses for different diameters is due mainly to the growing resistance to the tube walls thicker and stronger which requires more effort and load to be deformed. The welding operation produces more than the creation of residual stresses due to shrinkage created by the welding operation on the tubes it is the explanation of the great pressure values recorded in the case of draft tube (see Fig. 5).

In the case of finished tubes are subjected to stress relieving annealing, one can notice a balance in mechanical properties, which guarantee ductility can ease the flare while keeping pressure values valid and logical (see Fig. 6). The hot forming, that is to say forming at temperatures above 580 °C, maximum temperature allowed for the stress relieving annealing, modifies the initial state of the material. It is not possible to restore an additional heat treatment, material properties obtained during the initial manufacturing. The production of this tube, in general, excellent formability cold, that is to say forming at temperatures below 580 °C. We must nevertheless bear in mind that a cold forming results in a hardening of steel and a decrease in its toughness. In general, this change in mechanical properties may be offset in part by a stress relieving treatment (annealing). Increasing the pressure function of thickness with the evolution of resistance to breakage provides the logical behavior of a mechanical resistant material requires a lot of effort to be deformed.

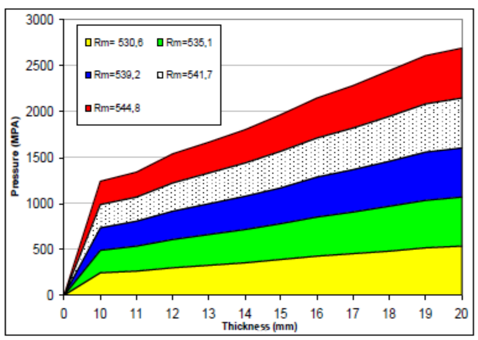

Figure 5 .Evolution of pressure depending on big thickness of the tube blanks for different Rm.

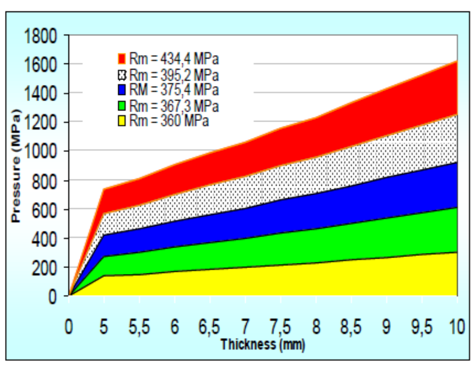

Figure 6 .Evolution of pressure depending on middle weak thickness of the finished tubes for different Rm.

4. NUMERICAL SIMULATION BY CAST2001

Manufacturers show the need for modeling tools and / or simulation of welding, or predictive methodology, to improve the reliability of assemblies. A major challenge for development teams of welded structure is the prediction of mechanical effects of welding (stress and strain). To do the numerical method for describing the behavior of a structure point of resistance is therefore the finite element method [9]. In our case, it is a computer program for structural steel (S235JR) to isotropic elastic behavior, in a state of plane stress with the software Castem 2001. The program provides:

- The 1/4 of tube considered in 2 D (see Fig. 7).
- The deformation at different amplitudes (see Fig. 8);
- The Von Mises stress (see Fig. 9).

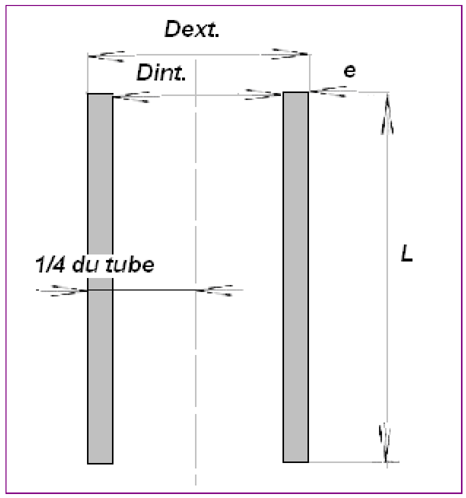

Figure 7 .The quard (¼) of the tube is considered in simulation (longitudinal section of the tube section).

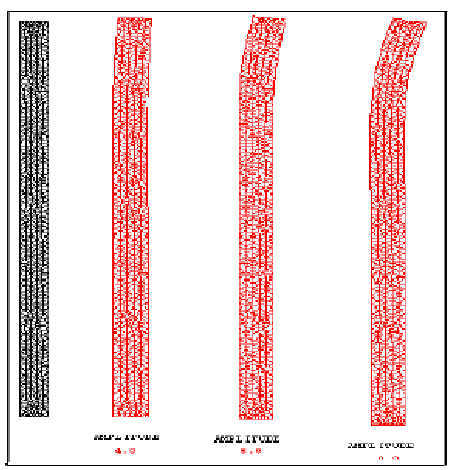

Figure 8 .The quard (¼) numerical simulation of tube ¼ 2D and his deformation.

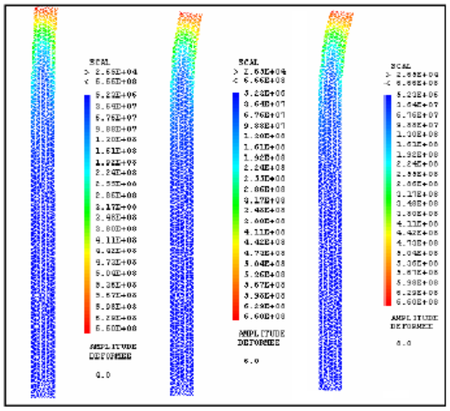

Figure 9 .Visualization of Von Mises stresses of registration of deformations.

5. CONCLUSIONS

In the field of tube production, research is regularly conducted to gain innovative knowledge, this need resulting from intense competition and rapidly changing technology to meet market demands and ensure satisfactory and continuous security product quality and conception's experiment done at ENTTPP Tebessa to satisfactory results, without revealing defects on the four tube samples (blanks and finished). Followed by the numerical finite element (EF), helped us to see closely the deformation of samples at different amplitude. As recorded in the charts the flare increase with outer diameters and thicknesses, and pressure of flare measured tube (blanks and finishes) is important as flares calculated. It is still clearly visible on the mesh of ¼ (one Quard) tube is considered by the finite element code Castem 2001. For quality control testing is considered a procedure to determine the relative ductility of metal forming (usually tubes) and certification of nondestructive testing (NDT) is involved, because they (NDA) are generally row. The test is considered bad if it reveals a lack of ductility of metal or appearance defects of cracking (tearing) and especially at the joints welded.

REFERENCES

[1] Colombie, M. 2000 Industrial materials, Metallic materials (eds.Dunod), pp 127-130.
[2] BENISAAD, S. (1995). TEC Welding 340, (eds. Office of Academic publications), p 7.
[3] Pender, J.A. (1973). Welding (eds. Metric), pp 3-4.
[4] Bautin, R., and Pinot, M. (1981). Mechanical manufacturing, (eds. Foucher), p. 27. Paris.
[5] Murry, Guy., Pascator, J.P. Structural steels, Technical Engineering, Construction treated C 2 501, p.13.
[6] Technical Engineering, Volume M4 Metallurgy. p. 125-4.
[7] Document Factory No. 5, Quality Control – Metallic, Test Tube Flaring – NF EN FR 10,234 (October 1993), p.9.
[8] Hannachi, M.T. (2005/2006). Optimization of welding parameters tubes by RF induction, Magister Mechanical, July, p 172 .
[9] Lefichoux, E. (2000). Introduction and Use of CASTEM, ENSTA-LME, pp37-38.