BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXII No. 2/2010	120 – 126	Seria Tehnică

Practical Aspects of Vibratory Stress Relieving

Romul Chiorean

Galaxy SRL, str.Clujului nr.98, Teius
e-mail: romul.chiorean@gmail.com

Abstract

We present some of achievements on Vibratory Stress Relief, one of most controversial no-conventional technology. We have invented a new method and equipment for VSR and we patented this since 1983. An important number of workpiece was treated by this technology and a know-how was developed. The equipment was updated and redesigned based on latest achievements of electronics, computers and IT. Our method was compared with most known devices and the most limitations of VSR was established.

Key words: *stress relief, vibration, application, analysis*

Introduction

Speaking about VSR (Vibratory Stress Relieving) always is a challenge.

Why? Because it is a very controversial subject even as related in the 1943 paper by Saunders and McGoldrick, published in the Journal of American Society of Naval Engineers, Vol. 55, No. 4, pgs. 589-609, the US Navy used vibratory stress relief to stabilize a variety of components, especially large jigs and fixtures used in shipyards.

The new technical challenges, the contemporary crisis, the theoretical, experimental and applied research work put this no-conventionally technology in a new light.

Our research on the field start 30 years ago and we open a new way in VSR process evaluating with our method [1]. Our principle (VSR evaluation by spectrum analysis) was adopted as-is or modified by a lot of VSR equipment producers and it is the basic element of Chinese standard JB/T 5926-91 on VSR [13].

Our Practical and Applied Knowledge

Until 1990, we were focused on:
- to demonstrate the correctness of our solution,
- to achieve an industrial Romanian equipment,
- to apply the our new patented technology for a large variety of workpieces,
- to establish the limitations of VSR technology.

To achieve all this, we had a very close and special cooperation with the most significant Romanian research institutes and universities like ICCEM, ICPTT, ICPTCM, Polytechnical Institute of Cluj-Napoca, Polytechnical Institute of Bucharest, University of Craiova, University

of Iassy. Our special gratitude to regretted Dumitru Remus Mocanu, Prof.Dr.Doc.Eng. who lead us and managed the check tests to prove the efficiency of our invention to be patented.

In cooperation with Polytechnical Institute of Cluj-Napoca and ITC Cluj-Napoca we achieved one industrial model and a homologated prototype of VSR equipment named IDV-287 [9], [10] and [11], and a model of device to be developed EGAVIB-1 [12].

On the usability of VSR as alternative of Thermal Stress Relief and the limits of this usability, we checked a large variety on materials (all the usual industrial metals) and pieces from few grams (hardened steel munitions for weapons) to tens of tones (welded steel assemblies).

The most spectacular result was obtained for workpieces with high dimensional stability and tolerances exigency, unable to be solved by TSR, surface treated workpieces and large size welded assemblies.

Our method can be used very well also like a qualitative nondestructive testing method if a part or structure is well thermal treated or no.

On the limitations of VSR, we observed that generally, the workpieces or components that have had their physical properties extensively altered by cold working or tempering, or have been through hardened resists VSR.

Even within this category of borderline candidates, however, there are exceptions which can make the use of vibratory stress relief a viable alternative to heat treating. In the case of aluminum weldments, for example, even if the weldment's components are of a highly tempered metal, the weldment remains a candidate for treatment.

Since 1990, our goal was to update, to redesign the equipment according the new achievements especially on electronics, computers and IT. Also, we were focused on comparing the most known usual VSR equipments to observe the differences and to find the specific range of application of each model.

We were able to compare our ancient equipment, our new equipment, Meta-Lax and TX-VSR in real industrial conditions. Also, in a technical cooperation with an European representative of Meta-Lax we checked our new VSR evaluating software and device by verifying it for a Meta-Lax process in real conditions in a Hungarian factory. More then that, our discussion with Chinese TX-VSR and Navigator manufacturers emphasized the correctness of our way.

Since 2006, we applied our method for hundreds of welded steel components and assemblies from tens kilos to tons with a large field of sizes, components included in huge machine-tools manufactured by an important international company.

It is obvious that this company checked our technology and our VSR treatment according to all their rules and demands and we were accepted as VSR services provider.

A VSR on site working point and some components are shown in Fig.1.

Fig. 1. On site VSR working point and some components to be treated

On site, we verified accidentally the result of our VSR treatment by cracking an auxiliary element and observing the dimensional stability as shown in Fig.2.

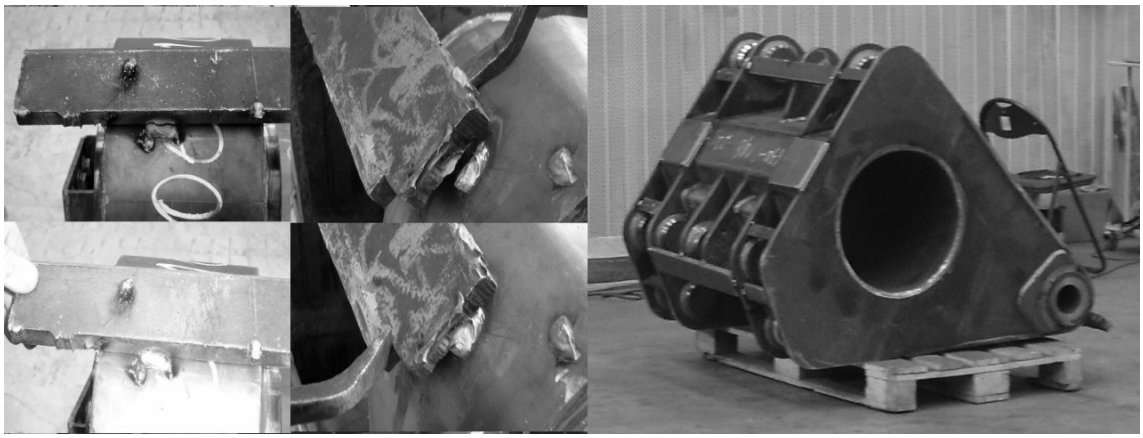

Fig. 2. Auxiliary elements broken after VSR (left) and the component (right)

In Fig.3 is illustrated the evidence of spectrum changes during the VSR process for two identical welded components, one cold and other treated few time after last welding (warm).

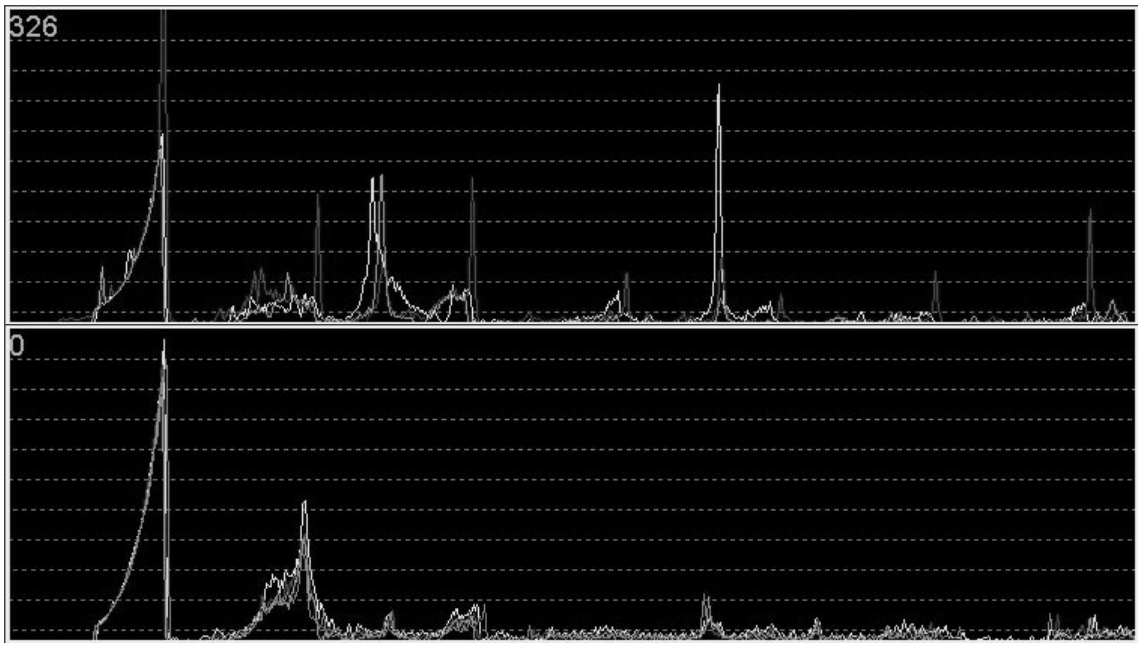

Fig. 3. Spectrums of cold (top) and warm (down) of two identical components

A major spectrum changes is shown in Fig.4.

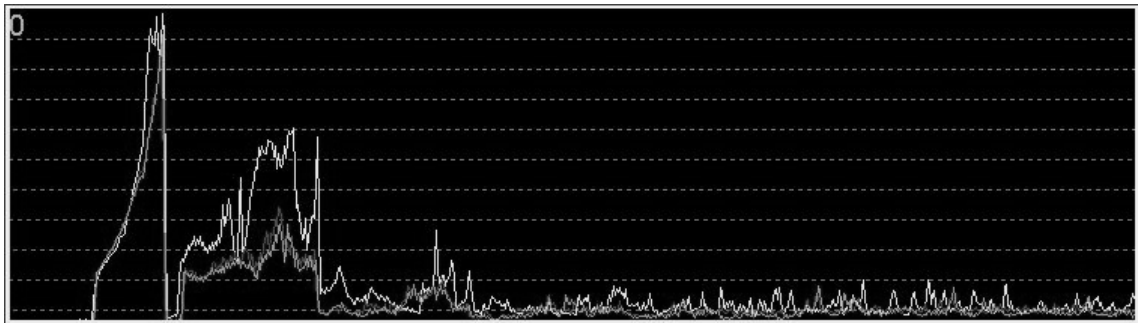

Fig. 4. A major spectrum changes

Usually, for most cases, three spectrums are enough to describe the VSR process.

The shape of spectrums can be very different from a workpiece to an other workpiece and depends of many variable factors. A very important feature of our VSR method is that we compare always the spectrums obtained in the same constant process conditions (parameters), the unique variable being the residual stress.

Fig. 5 shows the changes of spectrums step by step, from initial to intermediate and to final.

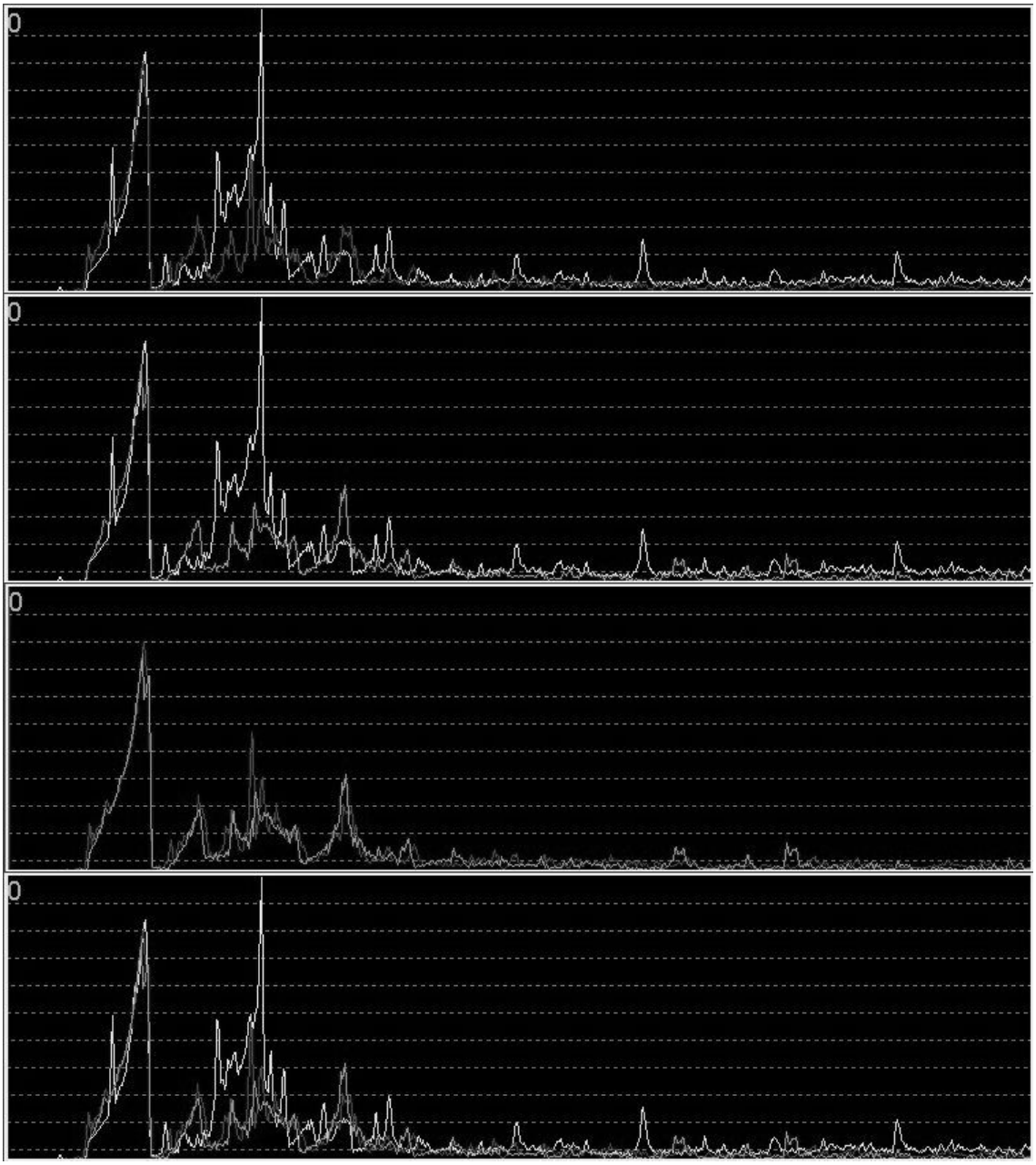

Fig. 5. The spectrum changes from initial to intermediate (top), initial to final, intermediate to final and all the three spectrums in a diagram (bottom)

By analyzing the evolution of spectrum changes we observe that in most cases the important changes occur in the first part of VSR process, but we can not exclude important changes especially when big or large components are treated. Such situation occurs also when a large workpiece is treated by moving the vibrator's fixture during the process.

In Fig.6 is illustrated our evaluation of a Meta-Lax VSR treatment in a Hungarian factory.

Fig. 6. Evaluation of Meta-Lax VSR treatment; our laptop with spectrum analyzer software (bottom)

Fig.7 shows the intermediate and the final spectrums of the upper Meta-Lax VSR treatment.

Fig. 7. The intermediate and final spectrums of Meta-Lax VSR treatment shown on Fig.6

The characteristics of spectrums changes for welded workpiece shown on Fig.6 is that the piece is very rigid and vibrate only on low frequencies. The acceleration is depending very close on induced force.

A very important feature of our method is that we can use the information revealed by the spectrums as a NDT (Non Destructive Technology).

Few years ago we found in a lot of identical large workpieces one with a very different shape of spectrum. Very curious, we have investigated the cause and we have found that the "different workpiece" was assembled "in mirror" because of error of assembling team.

Conclusions

After a deep analysis of known VSR patents and equipments, we can say that our invention was really revolutionary and our principles are used on modern VSR equipments and standards.

Our VSR process evaluation method based on spectrum analysis is used now on German and American equipments [17] and as variant on Chinese VSR standard [13].

By analyzing the behaviour of treated components, we concluded that a most important kind of welded steel parts and assemblies are suitable for VSR treatment but it is very important that the technologist must cooperate with VSR specialist to establish the best way of manufacturing.

VSR can not replace TSR in few cases because PWHT (Postweld Heat Treatment) does more than relieve stress. [18]

The most resistant to VSR treatment are the very rigid components, especially the components with high deformed elements. We recommend is such cases a TSR for the high deformed element or an accurate PWHT.

We can observe also that the spectrum changes for cold piece is more important compared to the warm piece. For each piece we recommend three spectrums, initial, intermediate and final sweep.

The spectrum analysis method can be used together with all known VSR equipments and it is possible to optimise all the VSR process including the sensitive frequencies and the treatment duration. Now the duration is based on experience.

For large components or assemblies we recommend using two vibration exciters simultaneously to reduce the time and using better the vibration energy.

TX-VSR equipment provide a larger frequency range but its power decrease for lower frequencies. Other equipments based on classical eccentric vibrator are limited on frequency range but they are efficient enough to low frequencies too.

Many important companies reconsider this technology like a real money, time and medium protective alternative to the Thermal (Heat) Stress Relief and are looking for implementation on their manufacturing lines [16].

References

1. Chiorean, R. – *Metoda si aparat pentru reducerea tensiunilor interne cu ajutorul vibratiilor,* Brevet de inventie nr.82449, OSIM, Bucuresti, 1983.
2. Chiorean, R. – Procedeu de reducere a tensiunilor interne din metale prin vibratii. Perfectionare*, Sesiunea omagiala de comunicari stiintifice*, MIM, Institutul Central de Cercetari Metalurgice, pp. 150-159, Bucuresti, 20 ianuarie 1983.
3. Chiorean, R. – Aspecte aplicative ale detensionarii prin vibratii, *A XXVI-a Sesiune de comunicari stiintifice in cinstea "ZILEI METALURGISTULUI"*, MIM, Institutul Central de Cercetari Metalurgice, Facultatea de Metalurgie Bucuresti, Bucuresti, 7 – 8 septembrie 1983.
4. Chiorean, R. – Unele consideratii privind detensionarea prin vibratii si evaluarea rezultatelor, *Al III-lea Simpozion national de Tensometrie,* Consiliul National pentru Stiinta si Tehnologie, Ministerul Educatiei si Invatamantului, Ministerul Transporturilor si Telecomunicatiilor, Timisoara, 28 sept. – 1 oct. 1983.
5. Chiorean, R., Butnaru, S. – Tratamentul fizico-mecanic al aliajelor turnate prin vibrare, *A VII-a sesiune de comunicari si referate,* Comisia judeteana a inginerilor si tehnicienilor Alba, Comisia inginerilor si tehnicienilor de la I.M.Aiud, Aiud, 7 – 8 iunie 1984.
6. Chiorean, R., Szocs, L. – Consideratii privind restrictiile detensionarii prin vibratii, *A V-a sesiune de comunicari tehnico-stiintifice,* MIMUEE, CIES, Intreprinderea Mecanica Cugir, Comisia judeteana a inginerilor si tehnicienilor Alba, Cugir, 12 – 13 iulie 1984.

7. Chiorean, R. – Method and apparatus for internal unstable residual stress relieving by vibration, *World Exhibition of Young Inventor's Achievements,* Pavilion of The Socialist Republic of Romania, Plovdiv - Bulgaria, 4 - 30.XI.1985.
8. Chiorean, R. – Consideratii privind detensionarea prin vibratii a pieselor turnate sau sudate, *Sesiune de comunicari tehnico-stiintifice,* Consiliul judetean Arad al sinsicatelor, Comisia judeteana a inginerilor si tehnicienilor, Comitetul judetean Arad al UTC, Arad, 21 - 23 mai 1986.
9. Darie, S., Chiorean, R., Vadan, I. – Instalatie pentru detensionarea prin vibratii a pieselor turnate si sudate*, Seminarul "DETENSIONAREA PRIN VIBRATII",* Universitatea Craiova, CIE Craiova, CNIT – Comisia Centrala de Tensometrie, INCETRANS Bucuresti, Craiova, 15 – 16 mai 1987.
10. Darie, S., Chiorean, R., Caraiani, M., Vadan, I., Toth, Z., Ciascai, I. – Instalatie pentru detensionarea prin vibratii a pieselor turnate si sudate IDV - 287, *Simpozionul "Tehnologii si echipamente de utilizare a vibratiilor in tehnica", VIBROTEHNICA,* Institutul Politehnic Cluj-Napoca, Cluj-Napoca, 3 - 6 noiembrie 1988.
11. Caraiani, M., Acris, M., Ciascai, I., Haiduc, I., Ionescu, D., Ionescu, M., Miclea, T., Mitrea, P., Chiorean, R. – Echipamente pentru tehnica vibratiilor realizate la I.T.C.I. Filiala Cluj-Napoca, *Simpozionul "Tehnologii si echipamente de utilizare a vibratiilor in tehnica", VIBROTEHNICA,* Institutul Politehnic Cluj-Napoca, Cluj-Napoca, 26 - 27 octombrie 1989.
12. Caraiani, M., Acris, M., Ciascai, I., Haiduc, I., Ionescu, D., Ionescu, M., Miclea, T., Mitrea, P., Chiorean, R. – EGAVIB–1, Echipament pentru Generarea si Analiza vibratiilor, *Simpozionul "Tehnologii si echipamente de utilizare a vibratiilor in tehnica", VIBROTEHNICA,* Institutul Politehnic Cluj-Napoca, Cluj-Napoca, 26 - 27 octombrie 1989.
13. JB/T5926-91 – *The Selection of Technological Parameters and Requirement for Vibration Stress Relief Process,* Mechanical Industry Standard of the People's Republic of China, 1991.
14. Hornsey, J.S. – *Stress Relief Basics,* VSR (Africa) cc, Johannesburg, August 2004.
15. Hornsey, J.S. – *Vibratory Stress Relieving – It's Advantages as an alternative to thermal treatment,* VSR (Africa) cc, Johannesburg, December 2004.
16. Lindqvist, S., Holmgren, J. – *Alternative Methods for Heat Stress Relief,* Master's Thesis, Luleå Univesity of Technology, Department of Applied Physics and Mechanical Engineering, Division of Manufacturing Systems Engineering, 14 December 2007.
17. Klauba, B. B. – *Report on Vibratory Stress Relief,* VSR Technology Group, Case studies & Reports, www.vsrtechnology.net.
18. AWS D1.1 – *Structural Welding Code,* American Welding Society, Structural Welding Committee.

Aspecte practice ale Detensionării prin Vibrații

Rezumat

Prezentam cateva dintre realizarile noastre in domeniul DV (Detensionarii prin Vibratii), una dintre cele mai controversate tehnologii neconventionale. Am inventat o noua metoda si un nou echipament pentru DV si le-am brevetat inca din 1983. Un important numar de piese au fost tratate cu aceasta tehnologie si am dezvoltat un know-how. Echipamentul a fost reactualizat si reproiectat pe baza ultimelor realizari in electronica, calculatoare si IT. S-a comparat metoda noastra cu cele mai cunoscute echipamente si s-au stabilit cele mai multe restrictii ale utilizarii DV.