Some technologies for industrial implementation in the area of Satu-Mare. Computer Aided Design for Development & Education. Virtual Approaches

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SOME TECHNOLOGIES FOR INDUSTRIAL IMPLEMENTATION IN THE AREA OF SATU-MARE

Computer Aided Design for Development & Education. Virtual Approaches

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Abstract: The paper presents recent achievements on three convergent technological fields: The 1st one deals with the high productive installation for production of spiral of pipe-lines, their design and process control; The 2nd one with the 4th Generation of Drives, the precesional drives, able to be implemented in a huge of fields, including the installation of pipe line production; the 3rd field is concerned with the hybrid intelligent tehnology for bearings' fault diagnosis, recongnition, prediction and data management for an economical management of the maintenance. Some examples concerning high integrated and modern Virtual Technologies used for design, development and product management in the three presented fields will offer an inside view of the state of art of the obtain results. The are show how complex but aslo valuable are modelling and simulation ind CED applied on a familly of mechatronic products. Facilities of the used technologies for kinematic and dynamic simulation of multi-body systems, SolidDynamics (SD) or MotionInventor (MI) as well of MATLAB/Simulink programs are emphasysed.

Keywords: Pipe Line Production Plants, Mechatronic Systems, CAE, Modelling & Simulation, Bearings Fault Diagnosis & Maintenance.

1. INTRODUCTION

The concept of Mechatronics appeared in Japan 30 years ago, and is a complex concept in a continuous change. It has had the meaning of a synergistic combination of mechanics and electronics, being related to electro-mechanics, but differing in the criteria of design. Therefore, Mechatronics is a significant interdisciplinary design trend that involves the application of the latest techniques in precision mechanical engineering, controls theory, computer science, and electronics (Fig. 1) to create and bring fast to the market more functional and adaptable products with precise performances. Some of the key elements of Mechatronics are presented in Fig. 2.

The concept of Mechatronics has a strong influence not only on the product design and development and the competition on the market, but also on the mechanical engineering education and team leaders or engineering managers.

Thus, the mechatronic products have specific characteristics, including the replacement of many mechanical functions with electronic ones. By applying new controls one expects from a mechanical device to reach new levels of performance. The mechatronic way of thinking and design leads to much greater flexibility and easy redesign or reprogramming.

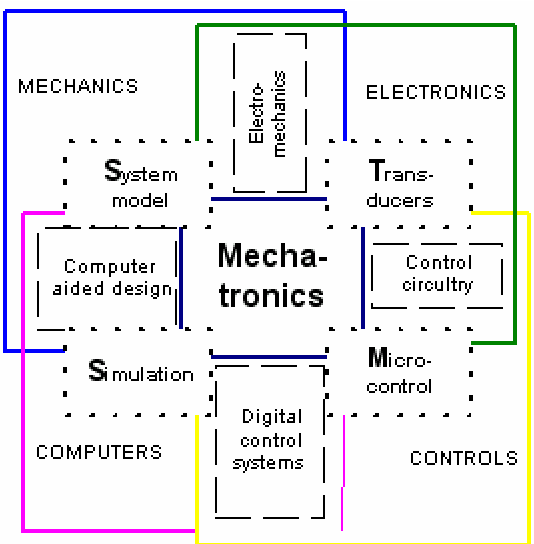


Fig. 1. Fundamental Elements of Mechatronics

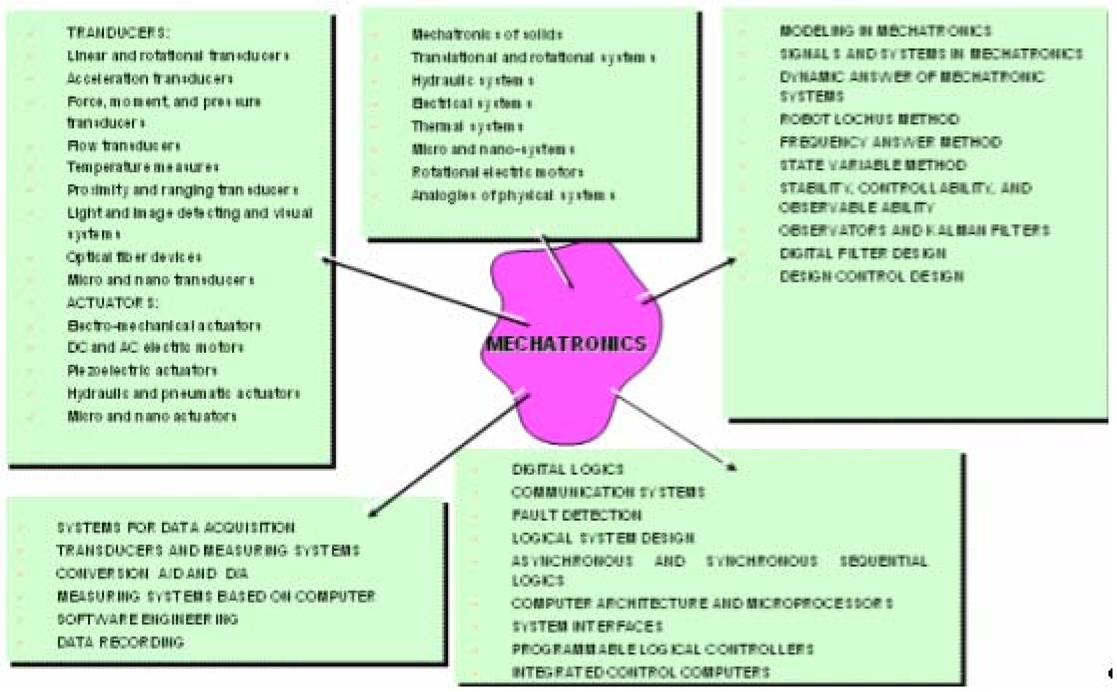


Fig. 2. Key elements and Features of Mechatronics

2. OPTIMIZED AND INTEGRATED DESIGN IN MECHATRONICS

Having permanently in view the achievement of a higher quality-price ratio and also the performances a product of relative high complexity has to satisfy, the application of the simulation on physical models at real or reduced scale, which do not allow flexibility, is not appropriate.

The optimization in closed loop is not possible in those cases. Important stages of the presented cycle can be easily done by using a computer. Thus, one has to use high integrated methods of computer aided design (Ionescu *et al*., 1996a). The advantages of the programs in this domain and their integration that are specialized on 3D geometry generation, kinematic and dynamic simulation, static and dynamic behavior analysis, are used. In Fig. 3 the diagram of the integration principle is shown staring with the pre-design and ending with de final product (Ionescu *et al*, 2003).

The integrated design technology incorporates the information model (Ionescu & Constantin, 1997) with multiple loops which allows the design and optimization at different levels. The stages in their sequence are as follows: project specification, preliminary draft, project achievement, model building for calculation and analyzing with kinematic and dynamic simulation programs, result obtaining, checking the validity, finite element analysis, decision on the analysis results, prototype creation, experimental test, optimization and procedure confirmation. The information transfer is realized in multiple lops, the loops of optimization being of great importance.

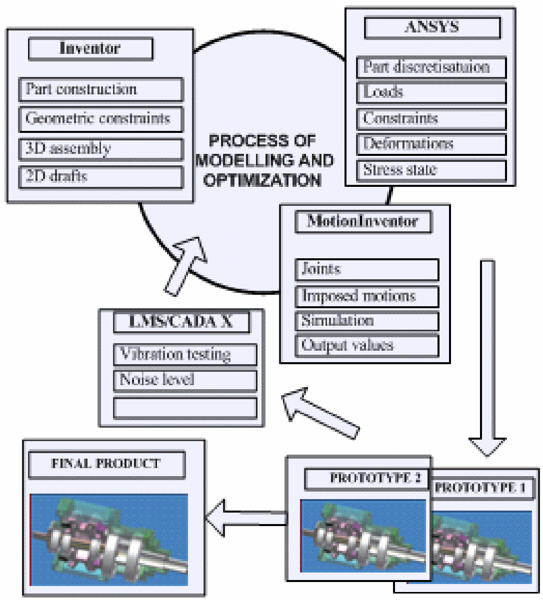


Fig. 3. Process of Developing the Precessional Drive Products using CAD-CAE Platform.

In SolidDynamics and ANSYS there are internal optimization loops that work on the basis of pre-established performance criteria.

After the pre-project realization, the three dimensional representation is achieved consisting of geometrical characteristics. These have parameters that can be specified in the drawing or calculated as part of the analysis. The geometric calculations are associated to the bodies that have mass properties.

3. MODELLING AND SIMULATION OF PLANTS FOR PIPE LINES PRODUCTION

The following example illustrates actual solutions. It is a proof that both the industry is interested to obtain advantages from this technology and the science is able and ready to deliver it. The application is an installation for rolling and welding of pipe lines. The implementation and the management of the enterprises have showed a high return rate.

An installation of this volume to model and simulate is defiance for any R & D engineer. Any company needs CAE means for an appropriate development of its products, more stringent smaller the number of products and company are, not only for CAE purposes, but also for product presentation, as shown in Fig. 4a (Ionescu, 2005-2006).

Using the achieved experience in modeling and simulation with technologies as SolidDynamics, models of all welding plant's units were achieved.

The whole lines were modelled in Inventor and simulated with Motion Inventor. An example is the transfer line having pears of driving rollers is shown in Fig. 4a. Other important device is the one for lifting and rotating in start welding position

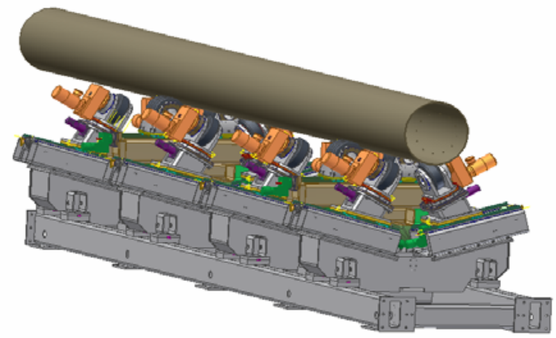


Fig. 4a. Segment of the Pipe Transport Line.

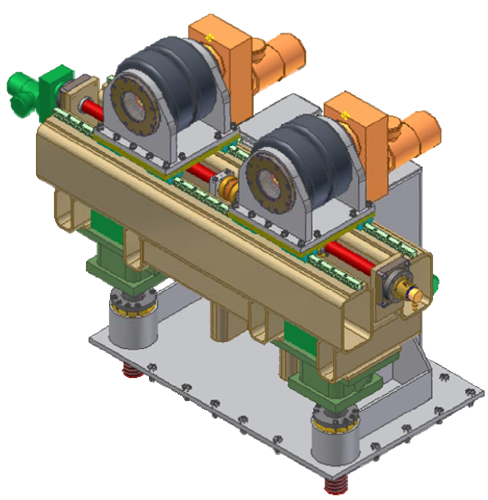


Fig. 4b. Double Rollers of the Lifting/Lowering and Rotating in Start Welding Position.

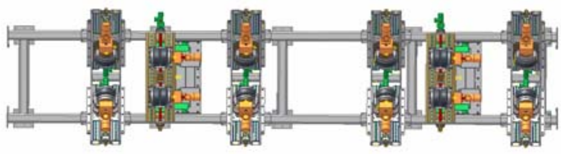


Fig. 4c. Line for positioning/orientation and technological motion for pipe welding.

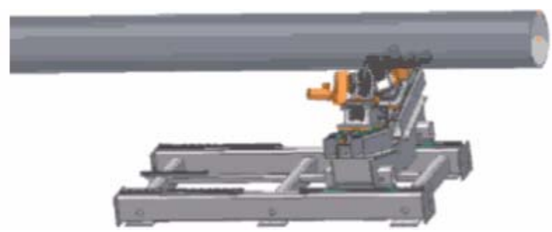


Fig. 5. Simulation of the both sides welding process (By courtesy of PWS GmbH)

presented in Fig. 4b. An entire segment of technological transport-welding line is shown in Fig. 4c. It consists of both transport-rotation devices with double inclined rollers for helical motion and also lifting/rotating devices. A simulation of the double (both sides) welding process is shown in Fig. 5.

4. MODELLING AND SIMULATION OF NEW GENERATIONS OF AUTOMOTIVE BRAKES

4.1. Goals of the Studies

Two new generations of brake systems for automotive were developed for the industry (Ionescu, 2005, 2006b). They were concerned with:

a. implementation of new modeling & simulation technologies for a higher approach of the phenomenon's intimacy;

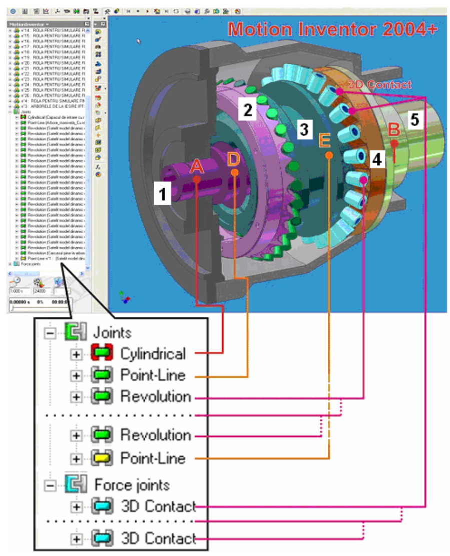


Fig. 6. 3D-Model of the Planetary Precessional Transmission with Joints Tree (By courtesy of: ARP GmbH, TU-MD and HTWG-Konstanz)

b. implementation of new actuation means;
c. achievement of higher static and dynamic behavior;
d. improvement of the brake efficiency via implementation of new geometry combinations and transmissions, planetary drives, Fig. 6, 7, and 8, (Bostan *et al*., 2004, 2006);
e. brake security;
f. improvement of self locking danger.

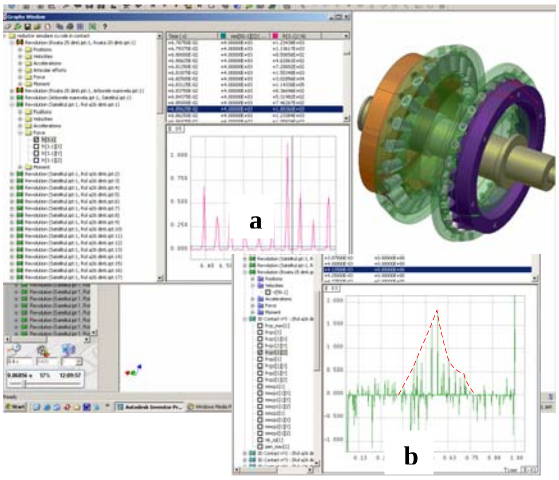


Fig. 7. Dynamic Simulation: a.Variation of the Total Force on a Roller Axis; *b.*Variation of thee Contact Force on the Tooth (By courtesy of ARP GmbH, TU-MD and HTWG-Konstanz)

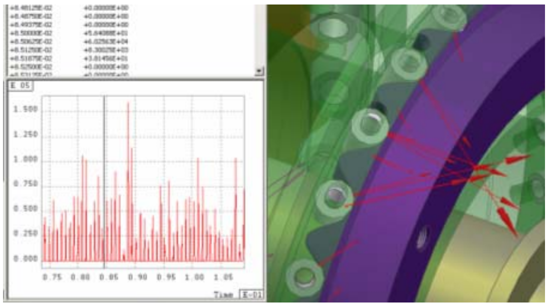


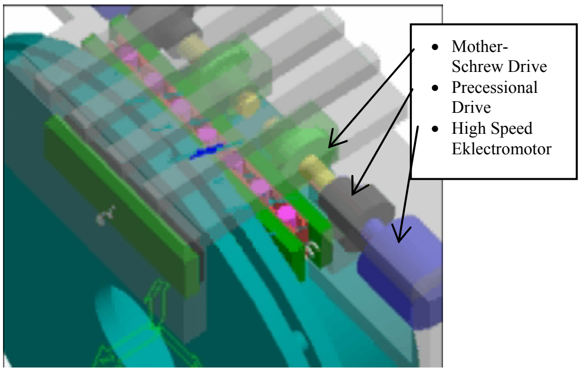
Fig. 8. Contact Forces Between the Crown Teeth and Satellite Rollers (By courtesy of ARP GmbH, TU-MD and HTWG-Konstanz).

4.2. Implementation of the prcessional Drive in the Siemens-VDO-Continental Brake

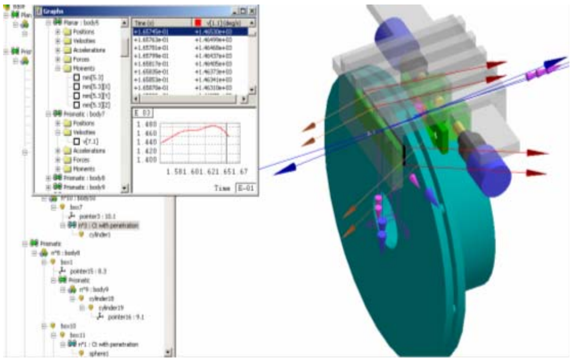
The construction was analysed. Both Solid Bodies as MATLAB/Simulink simulations (the last one based on new mathematical approaches) were parallel performed, results compared and data interpreted.

In Fig. 9,a one can observe the main parts of the construction. The brake discs are pressed by means of brakes paths which are axially actuated by means of the displacement of seven roles between two slides. The moving slide, having conical surfaces on it, has a tangential movement generated by two AC synchronous electric motors and spindle-mother- mechanisms. Contact forces between rolling elements and conical surfaces of the slide as well as between the brake blade and brake discs are shown in Fig. 9,b together with the graphical representation of the brake force over time.

The obtained data have delivered spectacular conclusions, which have permitted to obtain information for a new brake construction, for its actuation and to formulate a new concept the for force control.



a. 3D-Details of the Simulation Model



b. Results of Simulation, with Multiple Contacts and Brake Forces

Fig. 9. The SIEMENS- VDO-Continental Brake

4.3. Conclusions

Simulations have shown that new constructions variants could significantly improve the actual state or art, as well as the use of a high rotational speed matched with a high reduction rate by means of a precessional drive and a screw-muther-drive.

5. BEARINGS FAULT RECOGNITION, FAULT PREDICITION, MONITORING AND MANAGEMENT

The problem of faults detection and diagnosis (fdd) using signals provided by a monitored system is approached in this paper through the hybrid combination between a modern Signal Processing (SP) analysis method and an optimization strategy issued from the field of Evolutionary Computing (EC). The signals to analyze are mechanical vibrations provided by bearings in service and have been acquired in difficult conditions: far from the location of tested bearing, without synchronization signal and hostile environment. The resulted vibrations are therefore corrupted by interference and environmental noises (the SNR is quite small) and the main rotation frequency can only be estimated. Moreover, the rotation speed varies during the measurements, because of load and power supply fluctuations. In general, from such signals is difficult to extract the defects information by simple or conventional methods (Stefanoiu & Ionescu, 2004), (Ionescu, 1999).

The most important property of the method is the capacity of denoising (Ionescu & Stefanoiu, 2007). By denoising, until the component is separated from the noisy component of analyzed signal with a controlled accuracy. Another useful characteristic is the distribution of denoised signal energy over the time-frequency (tf) plane, which in general reveals the signal features better than the classical spectrum. Vibrations affected by defects and noises are non stationary signals that require tf analysis rather than classical spectral analysis methods.

Data were provided by bearings in Fig. 10.

Standard bearing (defects free) has been labelled by <B3850609>. Other 3 bearings with the same geometry have been used to provide vibration data that encode defects, as follows: <I3850609> (with a crack located on the inner race), <O3850609> (with wear of outer race) and <M3850609> (with cavities on inner and outer races). Figure 11 also shows the sampling rate value $(\nu_s = 20\ \text{kHz})$,nominal estimated shaft rotation speed $(\nu_s = 44.3\ \text{Hz})$, and natural frequencies of bearing in decreasing order.

The resulted vibration data have small SNR, especially in case of defect encoding vibrations (under 6 dB, i.e. more than 30% of energy consist of undesirable noise). A high pass filter in band 0.5-10 kHz was applied in order to remove some noises and the main rotation harmonics up to order 10. Figure 11 displays data (to the left) and spectra (to the right) for the aforementioned bearings.

After projecting the vibrations on tfs dictionary, the distributions of bmas over tfs plane have been drawn, as depicted in Fig. 12, for all tested bearings. The tf planes have been horizontally stacked, in order of scales, with time put on vertical axis. On the horizontal axis, the frequency band is split into a variable number of sub-bands, depending on scale index (from 0 to 8). Atoms are located into rectangles with variable size, depending on scale, because the frequency resolution varies along scales (larger scale index involves bigger rectangles). Also, the rectangles overlap in frequency, because atoms spectra overlap. The fitness value (in dB) of every bma is represented with a colour (or gray level) according to the scaling on the right side of figures. It starts with light colors (blue or gray) for small values and ends with dark colours (red or black) for large values.

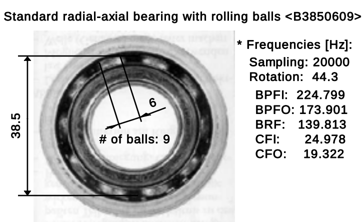


Fig. 10. The Bearing <B3850609>

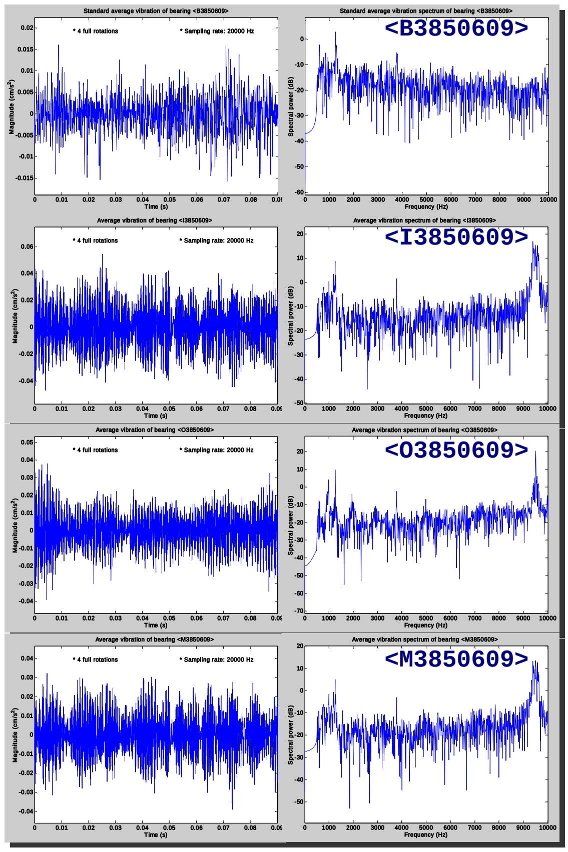


Fig. 11. Vibration Data and Spectra

Processing of noisy signals usually requires methods with high complexity degree. Some of such methods lead to greedy procedures, like the one presented in this paper. The complexity of method described above is involved by an optimization problem that cannot efficiently be solved by means of classical techniques, gradient based. Therefore, an evolutionary approach using GA has been proposed (Stefanoiu *et* Ionescu, 2006). The resulted GMPA proved interesting features, such as denoising and extraction of utile signal with a desired SNR or decoding of some information related to fdd. The algorithm can be used for a larger class of one dimension signals than vibrations, in a framework where a method issued from Signal Processing and a strategy relying on Evolutionary Computing proved that these two fields can work together.

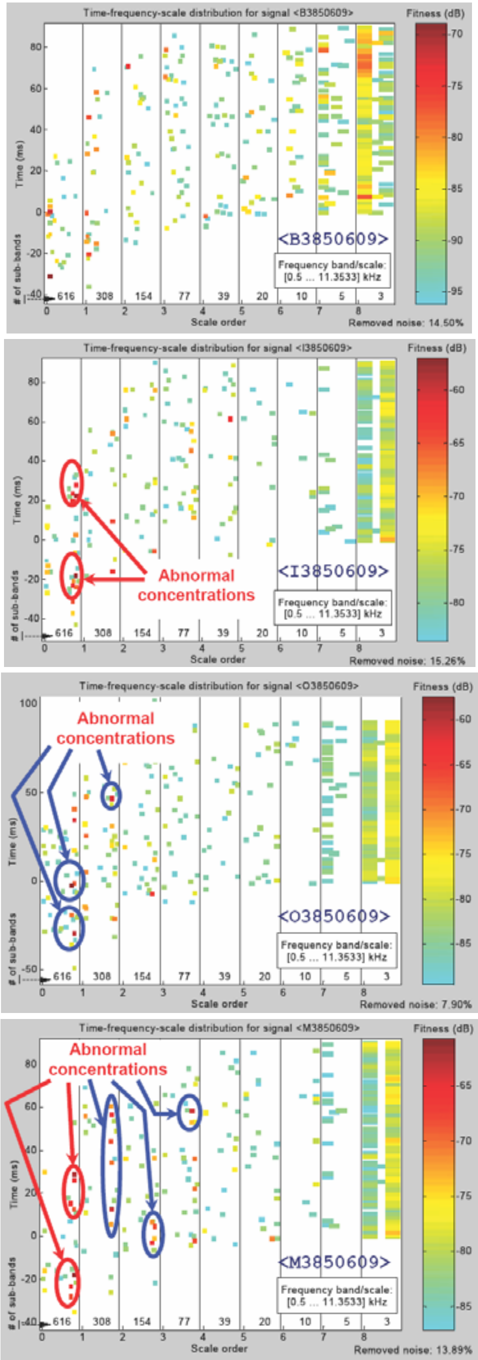


Fig. 12. Distributions of atoms over the tfs plane

6. CONCLUSIONS

As a consequence of the presented features and of the authors experience in modeling and simulation with technologies as MSATLAB/Simulink, SD and MI programs, one can conclude that this technique is a very powerful and useful tool, both for visualization with the improvement of user's capacity of representation, as well as for important gain of technological information in the design and optimization phases products. The presented examples underline that mechanic and hybrid systems independently of their complexity and dimensions can be nowadays more and more easy modeled (most of specialized Software dispose of more and more complete and sophisticated approaches). Thus the behavior of systems can be simulated, analyzed, and optimized with good results.

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