wjert, 2019, Vol. 5, Issue 1, 249-253. *Original Article* ISSN 2454-695X

World Journal of Engineering Research and Technology

WJERT

www.wjert.org SJIF Impact Factor: 5.218

ANALYSIS OF HYDRAULIC PIPE IN PUNCHING MACHINE

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Article Received on 25/10/2018 **Article Revised on 15/11/2018** **Article Accepted on 06/12/2018**

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ABSTRACT

The reduction of elevated dynamic loads, affecting the elements of the hydraulic drive, is an important task in production equipment maintenance. In case of the hydraulic drive with actuators, remotely located from the power source, the piping defines the working capacity of the whole system. Hence the development of piping vibroacoustic analysis methods appears to be the vital task. The said methods would not only help to define the cause of increased loads, but also permit to develop an adequate design solution without prolonged experimental checks.

KEYWORDS: Vibration analysis, Vibroacoustic.

INTRODUCTION

The increase of the piping systems efficiency is vital due to its direct connection with the overall facility performance and operation quality. The automatic press line "Erfurt" breakdown, caused by the piping system problems, is an example of production machin ery failure.[1] The press-forging process of the considered line is represented by the deep-drawing of billet sheet. The construction of punching machine is shown on Figure 1. Half of the stamp which performs reciprocation is attached to a sliding bar 1. A billet sheet 2 is placed on supports 3 which are rigidly held by a bottom plate 4. A fixed counterpart 5 is placed under the billet sheet 2.Downward motion and press-forging are performed with the sliding bar 1 with a die block. This process is counteracted by press forces in the extraction cylinders 6. Extraction cylinders 6 lean on bottom plate 4 via endthrust bearings 7.During the automatic line operation the drain piping of extraction cylinders power hydraulic system and upper piston chamber of the central cylinder periodically broke off and suffered from a total loss of power fluid, which led to the shutdown of the whole press-forging line line.[1] The disruption took place x in the junctions of drain line and hydraulic cylinder automatic control device 1 (Fig. 2), x in the drain line and collector, x between left and right collectors (Fig. 2). The crosscut character of breakage indicated that the pipe bending vibrations were the cause of the disruption.

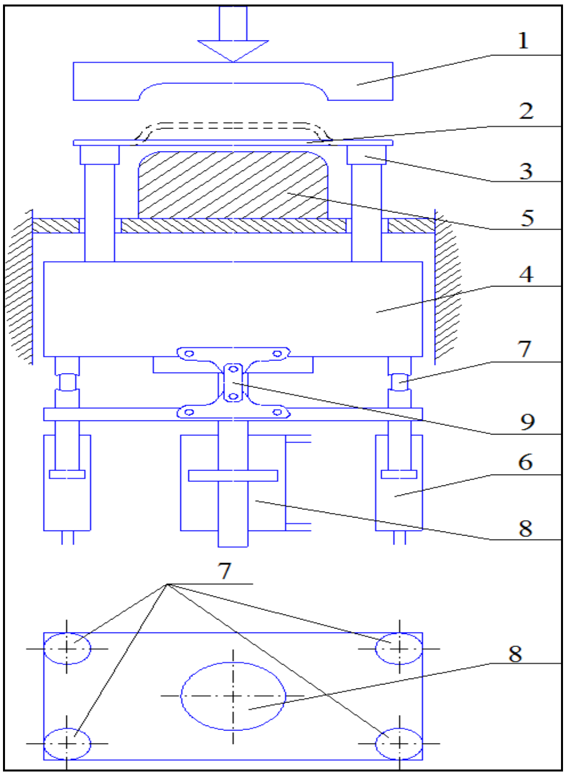

Fig 2: 1- Sliding bar; 2 - Billet sheet; 3 – Supports; 4 – Bottom plate; 5 – Counterpart; 6 – Extraction cylinders; 7 – End-thrust bearings; 8 – Central cylinder; 9 – rod.

2. MATERIALS AND METHOD

2.1 Analysis of vibroacoustic interaction in the pipeline systems

The curvilinear pipeline bending vibration genesis was first described in the article.[2] The pipeline vibration is linked to the apparition of the non-steady unbalanced stresses, caused by the pulsing flow dynamic pressure losses in the knee-shaped elements. The described bending vibration genesis mechanism is typical for pipeline systems with relatively low fluid flow speeds. This model is commonly used to define the cause of vibration increase in the booster stations piping. The articles[3,4] link the pipeline vibration phenomenon with the hydro-torque of mechanical pipeline subsystem flexible elements. This kind of vibration appears in the high velocity pipelines, specific to the fuel mains of a carrier rocket with liquid-propellant engine or gas-turbine engines fuel systems.

Anyway, the pulsating flow energy may cause significant mechanical oscillations of piping, attached equipment and bearing structure due to its interaction with the piping itself. The fluid supply units operation, self-excited oscillations, caused by the actuating of flow regulators and valves, and water-hammer processes are the main causes of the hydraulic mains power fluid pulsations.

2.2. Experimental study of the press-forge unit hydraulic pipeline dynamics

Experimental study data analysis[1] demonstrated the apparition of two intense water-hammer processes in the drain piping (Fig. 3). The first process at the time period is caused by t he power fluid draining during the downward motion of the billet sheet. The upward motion of the billet sheet starts at the time period. Therefore the second hydraulic impact, caused by the a utomation valves actuations which slow down the billet movement, occurs in the end of the mot ion at the time period. The peak pressure value amounts from 0.6 to 0.8 MPa, the minimum val ue amounting to 0.2 MPa with mean level of 0.39 MPa.

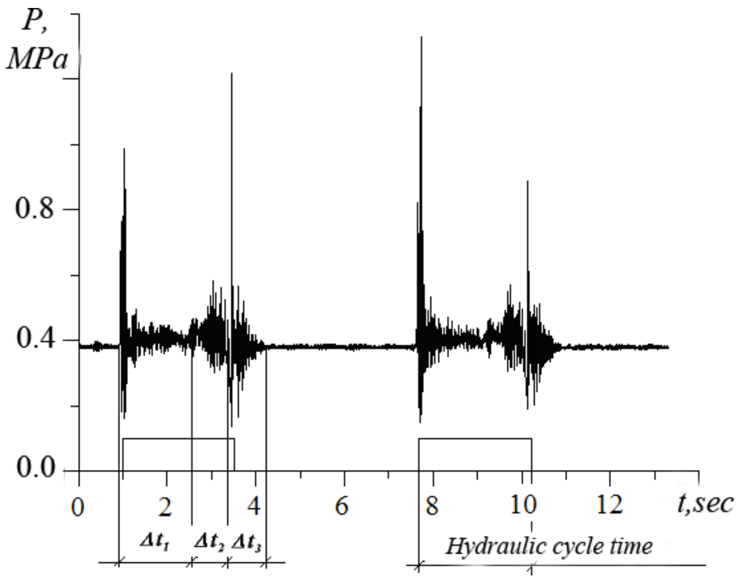

Fig 3: Sprectrum analysis graph.

The spectrum analysis of the first hydraulic impact showed the presence of two resonant zones (Fig. 3): the interval of 12 to 60 Hz with maximum at 45 Hz and the interval of 70 to 120 Hz with maximum at 93 Hz. The intensity of the resonant peaks in the second zone is 4.5 times lower than in the first one. Spectrum analysis of the second hydraulic impact (Fig. 4)

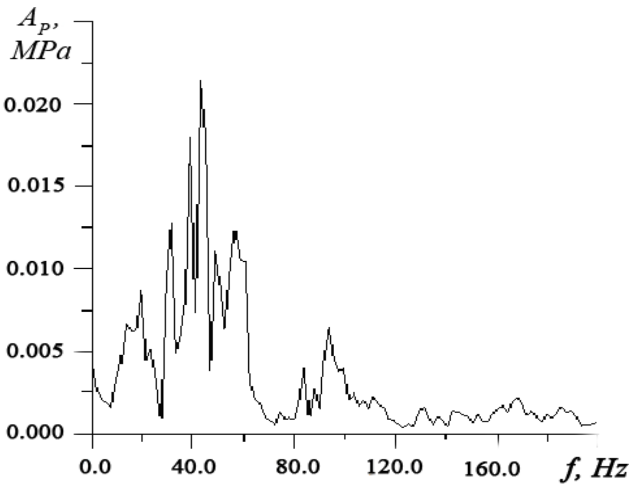

Fig 4: Intensive resonance graph shows the most intensive resonance in the interval of 15 to 88 Hz with maximum at 45 Hz.

The three-dimensional system vibration activity analysis was performed simultaneously with the piping pressure pulsation analysis. The following locations of vibration sensors installation were chosen:

X. Junction points of the main drain line and drain piping of central cylinder and each of extraction cylinders;

X. Piping breakdown locations. The figure 4 represents the vibro-acceleration oscillogram of the drain piping under the central cylinder manifold.

3. RESULT AND DISCUSSIONS

The following measures can be recommended:

X Long pipeline sections should be avoided by means of additional supports installation and overall pipeline system length reduction; x The probability of water-hammer effect occurrence should be pre-calculated; x The approximate computation of modal pipeline frequencies and water-hammer effect fluid pulsation frequencies should be performed. The research was based on vibration velocity spectral analysis of hydraulic system key points and pressure pulsation spectral analysis. This study method is unable to categorically define the cause of elevated vibration. It is worth noticing that this method complicates the formulation of the defect genesis hypothesis. In this case, the hypothesis formulation depended mostly on researcher's experience. The cross-correlation experimental data analysis methods appear to be the most promising.

4. CONCLUSION

The performed study allows drawing the following conclusions. The vibration of the pipeline system, leading to its failure, is caused by the water-hammer effect resulting from the valve actuation of the press unit automatic control system. The excessive vibration is caused by the coalescence of pipeline system modal frequency and power fluid water-hammer frequency. In this case the failures result from the hydraulic system flaws, implemented during the design stage.

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