# Investigation of Input Signal Curve Effect on Formed Pulse of Hydraulic-Powered Pulse Machine

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**Abstract.** Well drilling machines should have as high efficiency factor as it is possible. This work proposes factors that are affected by change of input signal pulse curve. A series of runs are conducted on mathematical model of hydraulic-powered pulse machine. From this experiment, interrelations between input pulse curve and construction parameters are found. Results of conducted experiment are obtained with the help of the mathematical model, which is created in Simulink Matlab. Keywords – mathematical modelling; impact machine; output signal amplitude; input signal curve.

## Introduction

At the present day, special emphasis is placed on studying the output signal curve of drilling machines [1]. Key performance indicators of existing impact machines influence the overall impact machine efficiency; the most essential indicator is impact energy. Comparison of impact energy is always used to rate different impact machines and determine their possible applications in borehole drilling [5,7]. Impact energy value is dependent on machine type and borehole diameter [2]. Other key performance indicators are amplitude and oscillation period [4]. As well as impact energy, they have an effect on overall drilling efficiency [6]. This studying is devoted to find the interrelation between oscillation period and amplitude and to find applicable pulse curve in order to increase overall efficiency of drilling process. A series of runs are conducted on mathematical model of hydraulic-powered pulse machine, it allows investigating the effect of input signal on output characteristics of formed pulse.

In general, mathematical models describe the basic properties of an object, process or system, its parameters, internal and external communications with the help of logical-mathematical structures [10]. MATLAB software is used to conduct the experiments. Software offers a variety of methods to find solution for Cauchy problem for differential equations: ordinary differential equation (ODE) solvers, special-purpose programs for model investigation of controlled systems, SIMULINK as analog simulation tool [3, 8]. Scheme, which generated in SIMULINK, consists of units that simulate process, its properties and construction parameters.

It is possible to choose one of the following input signal by changing variable in - sine, sawtooth or square. Output frequency can be measured in hertz (Hz) or in radians per second (rad/s); it is also possible to adjust the amplitude of the input signal by changing the plunger stroke length [9]. Sample amplitude of 1 mm is applied for model calculation. Signal curve is not affected by decreasing or increasing of this parameter.

**Results & Discussion**

Mathematical model is tested for following system parameters as depicted in Table 1.

Table 1.Impact machine parameters

| | Parameter | Value |
|---|---|---|
| c | Spring stiffness | $18600\frac{N}{m}$; |
| m | Active mass | $100\,kg$ |
| Cv | High-pressure hose volume elasticity | $3,441 \bullet 10^{-9}\,\frac{m^3}{Pa}$ |
| $k_f$ | Coefficient of friction | 0,2 |

Fig.1-3 show the result of mathematical modelling for different type of input signal curve.

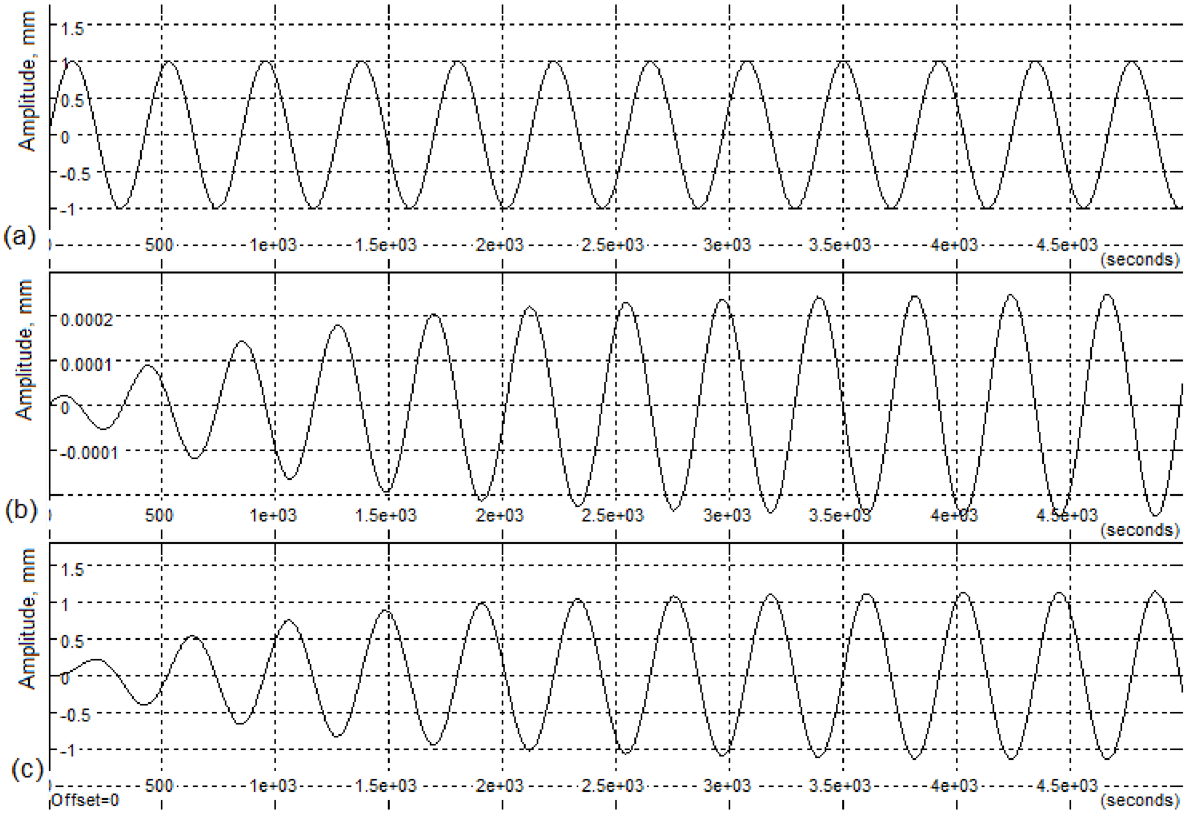


**Fig.1.** Dependence graphs of active mass displacement (b) and formed pulse (c) for sine input signal (a) on time interval, for which pulse acts

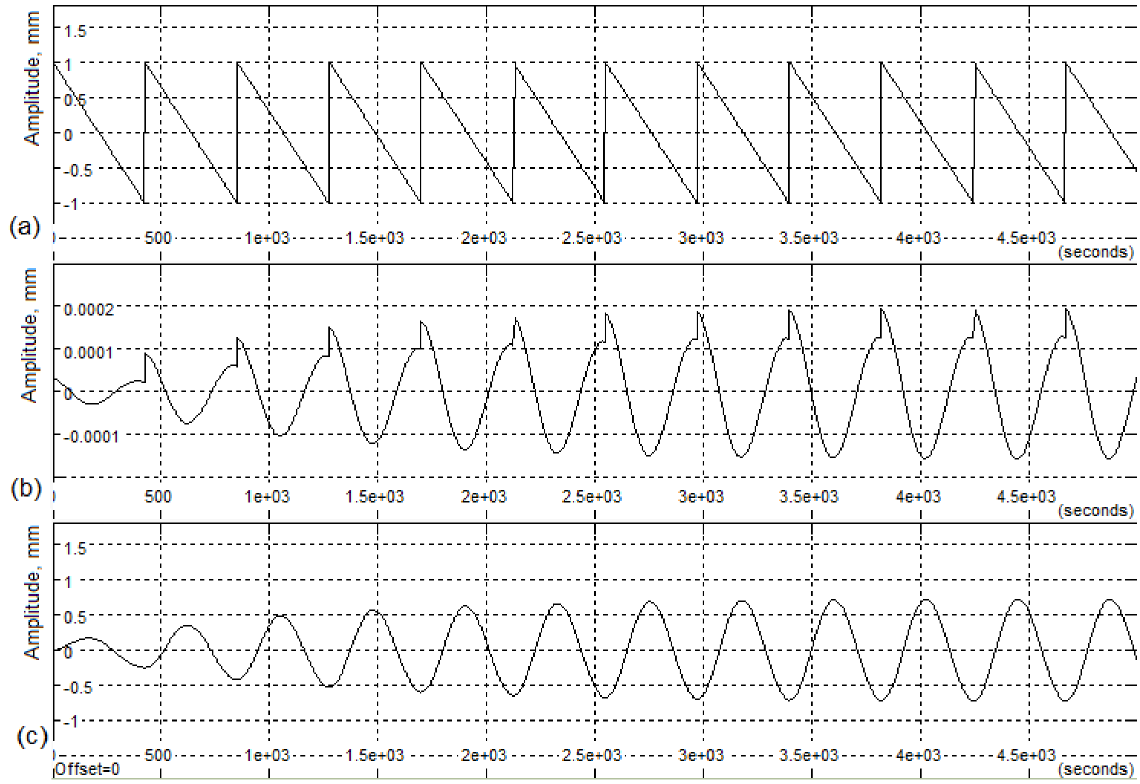


**Fig.2.** Dependence curves of active mass displacement (b) and formed pulse (c) for sawtooth input signal (a) on time interval, for which pulse acts

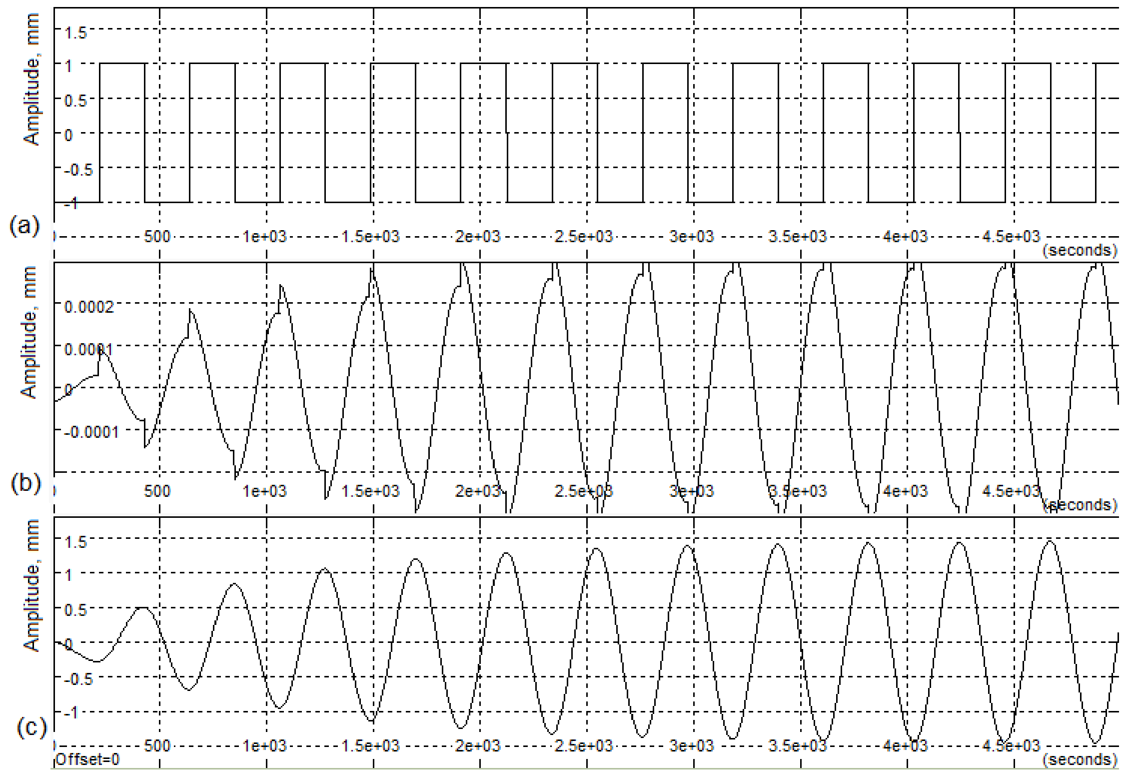


**Fig.3.** Dependence curves of active mass displacement (b) and formed pulse (c) for square input signal (a) on time interval, for which pulse acts

Formed pulse curve is sine for three experiment runs; it comes out from oscillation concept of machine operation. Output signal becomes stable after eight oscillation periods for all types of input signal curve and then reaches its maximum amplitude. Maximum amplitude is reached by modelling with usage of square input signal. It is 1.3 times higher than amplitude for sine input signal curve and 2 times higher than amplitude for sawtooth input signal curve.

Fig.4-5 show the result of mathematical modelling. Spring stiffness varies from 18600 N/m to 76000 N/m, while active mass value remains constant.

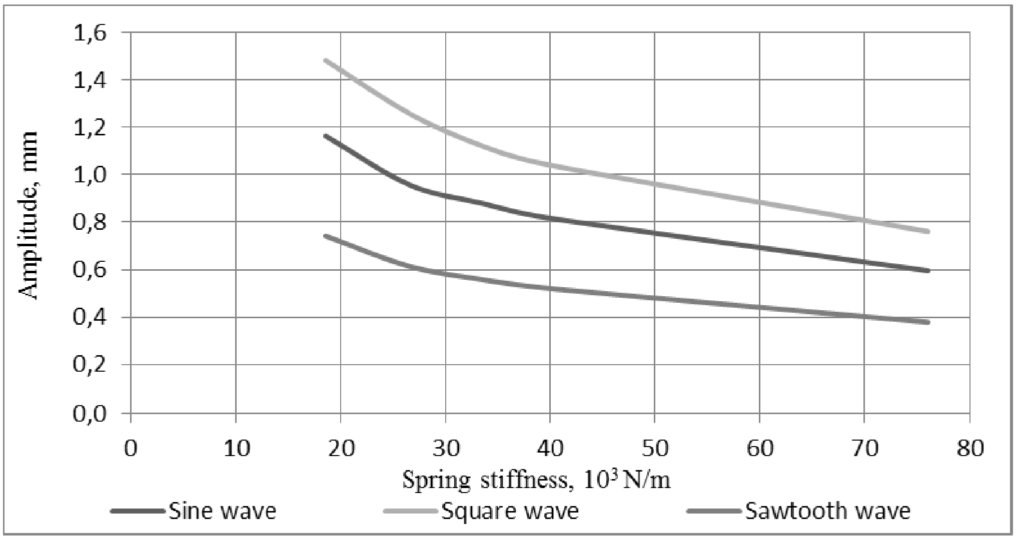


**Fig.4.** Dependence curve of formed pulse amplitude on spring stiffness

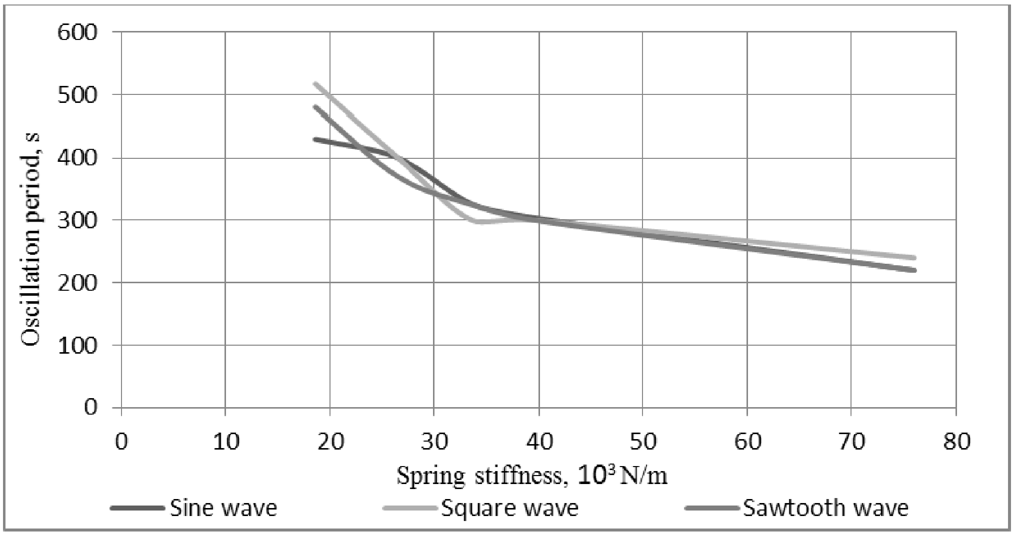


**Fig.5.** Dependence curve of formed pulse oscillation period on spring stiffness

Formed pulse oscillation period decreases with the increase of spring stiffness for all types of input signal curve. Oscillation period does not depend on type of input signal curve. Small difference for several values of spring stiffness is visible due to the measurements uncertainty. Formed pulse amplitude also decreases with the increase of spring stiffness for all types of input signal curve. Amplitude interrelation remains constant for all values of spring stiffness for different types of input curves.

Fig.6-7 show the result of mathematical modelling. Active mass varies from 100 to 800 kg, while spring stiffness remains constant.

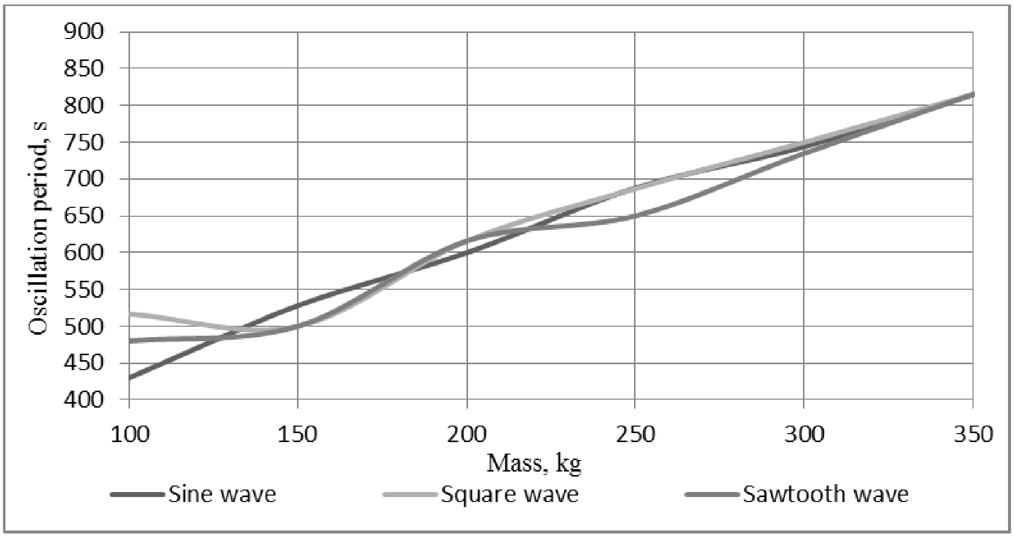


**Fig.6.** Dependence curve of formed pulse oscillation period on active mass

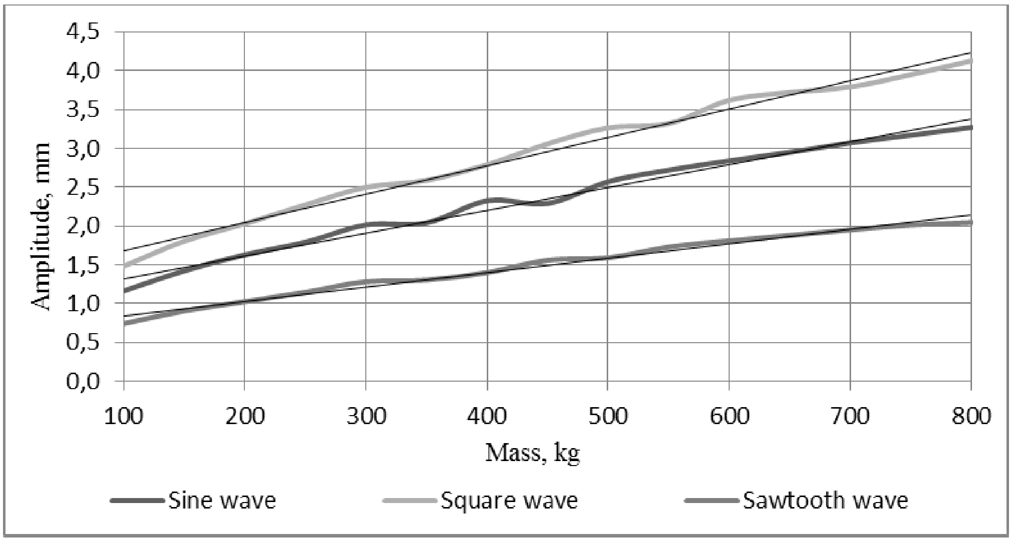


**Fig.7.** Dependence curve of formed pulse amplitude on active mass

Formed pulse oscillation period increases two times, when active mass is increased from 100 kg to 350 kg. Oscillation period does not depend on type of input signal curve. Small difference for several values of active mass is visible due to the measurements uncertainty. Formed pulse amplitude also increases with the increase of active mass for all types of input signal curve. Amplitude interrelation remains constant for all values of spring stiffness for different types of input curves. Amplitude increases two times, when active mass is increased from 100 kg to 500 kg.

**Conclusion**

Results of conducted experiment show that input signal curve has an effect on amplitude, while oscillation period value is not dependent on curve. Oscillation period is affected by construction parameters, such as spring stiffness and active mass. Regardless of construction parameters, amplitude is also affected by input pulse curve. Square input pulse curve allows reaching the maximum possible value of amplitude. It is 1.3 times higher than amplitude for sine input signal curve and 2 times higher than amplitude for sawtooth input signal curve. Further studying will be on finding interrelationship between construction parameters, which have an effect on formed pulse, including parameters that are not covered in this article.

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