# VALUES IDENTIFICATION OF KINEMATIC QUANTITIES DURING A MECHANICAL SHOCK

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Abstract

The paper deals with current problems of signal processing during measurement of nonstationary mechanical processes. A special case of them are shocks which impose demanding requirements on the measuring equipment as well as on processing methods of measured data heavily. Usually, acceleration is measured by acceleration transducers. If these data are integrated consequently, the time behavior of velocity or displacement will be acquired. During mechanical shocks the measured signal includes spurious components which belong to damped natural oscillations of the measured object surface and transducer as well. In the article there are mentioned concrete examples of the measured data and their evaluation of signal processing methods which are based on mathematical and mechanical filtering of high-frequency vibration components.

## 1. Introduction

Measurement of kinematic quantities during mechanical shocks is a very current issue at the present time because production technologies based on impact forces are spreading. That is why impact tests of products are performed very often. According to behaviour of kinematic quantities during and after shocks, it is possible to conclude about efficiency of the production process or the accuracy of design. The measurement is obviously performed by means of acceleration transducers which have low self-weight and small dimensions; thereby they have little demands for build-up area. Therefore, they do not unfluence the obtained results.
A contact between a transducer and a measured object is usually created by a rigid binding e.g. a glued joint or screwed joint.
During a mechanical shock, the measured signal includes spurious components, which belong to the damped natural oscillations of micro-movement of the measured object surface and the transducer as well. These components are characterized by high-frequency oscillations and high amplitudes. It is not a simple mathematical task to separate components from the signal, which represents a variety of kinematic quantities of the measured object as a rigid body with its significantly lower values of frequency and amplitudes. That is why the mechanical filtering of high-frequency vibration was used.

## 2. Methods of measurement

Design and producing of the measurement stand enabling sufficiently true repeatability of the process (Fig. 1), these were the first two background tasks to be dealt with when preparing for the quantification of kinematic quantities of an impacted object during a mechanical shock.
Measurement of acceleration was made by tensometer transducers, which were fastened via various types of compliant binding. This binding was represented by foam rubber and its rigidity by means of various relevant thickness. Recordings were gained through a high-speed camera scanning the surface of the impacted object with the frequency of 2 kHz, they were used for subsequent check of the measured data.

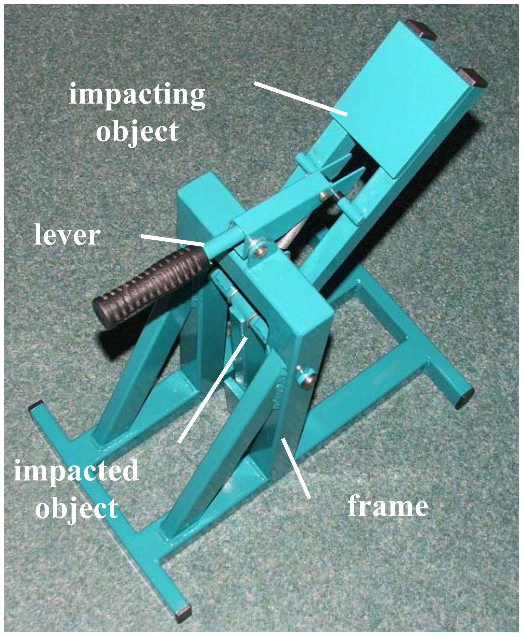


**Fig. 1 Measurement stand**

## 3. Results of measurement

The initial configuration of acceleration measurement during a mechanical shock appears from the present condition which rests in a rigid binding between the transducer and the impacted object (see Fig. 2).

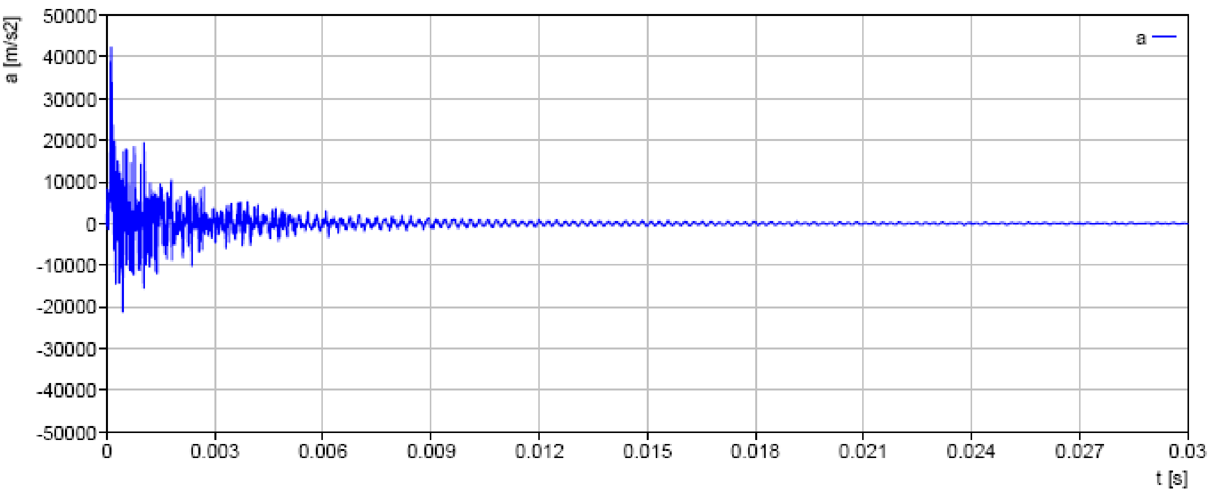


**Fig. 2**

The time behavior of acceleration mentioned above shows the presence of considerable spurious components, which belong to micro-movement; these must be filtrated. To do this, some mathematical procedures based on so-called Butterworth filters are commonly used. In the case of short-term, deadbeat and impact processes, these methods malfunction.
That is the reason why authors of this paper used the mechanical filtering of high-frequency vibration. This procedure rests in creation of an elastic damping binding between the transducer and the measured object with very low values of the transmission function in the high-frequency range.

The subsequence acceleration measurement results of the same mechanical shock for a lower compliance of binding is mentioned in Fig. 3, as well as in Fig. 4 for a higher compliance of binding.

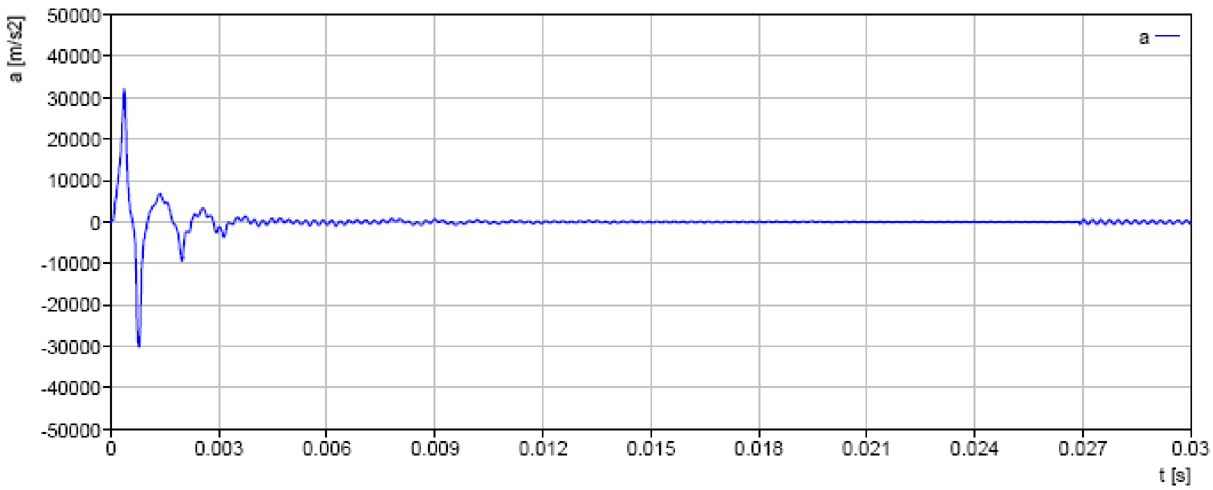


**Fig. 3**

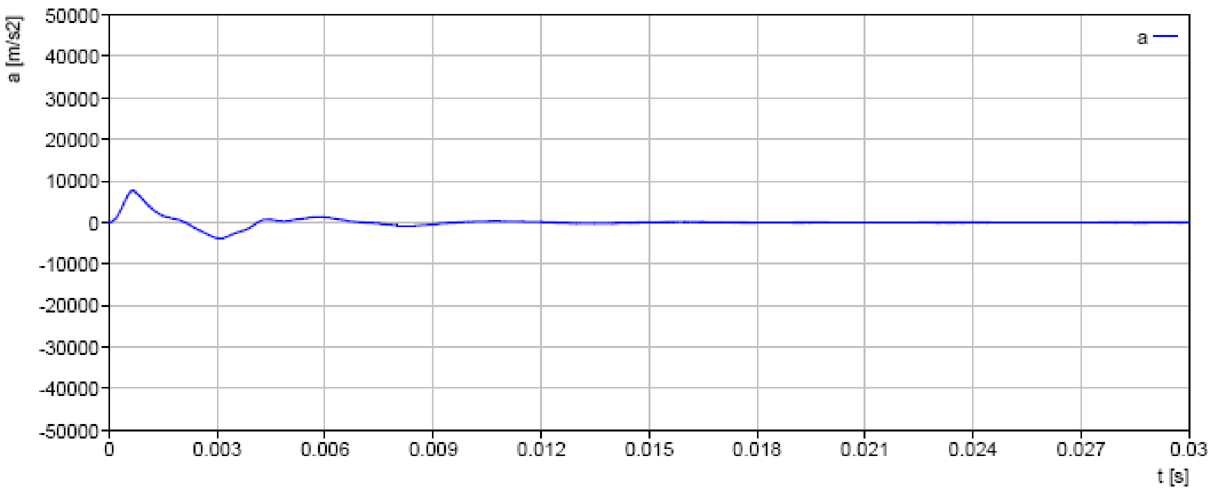


**Fig. 4**

The measured time behavior of the acceleration of the impacted object was in both cases characterized by a lower rate of spurious component, which the amplitude as well as the frequency of the damped oscillations declined. The rate of declination increases with the compliance of binding between the transducer and the measured object. To evaluate the process of a mechanical shock, the velocity values of the impacted object in the defined time intervals are very important.

An integration of the time behavior of the acceleration in both cases of the compliance of the elastic damping binding between the transducer and the measured object gives almost the same values of velocity (see Fig. 5 and also Fig. 6). It is possible to claim that if a compliance of binding between the transducer and the measured object is low, then a subsequent integration of the measured time behavior of the acceleration starts to approach the proper value. The rigid binding does not warrant this advantage evidently according to the practical experience.

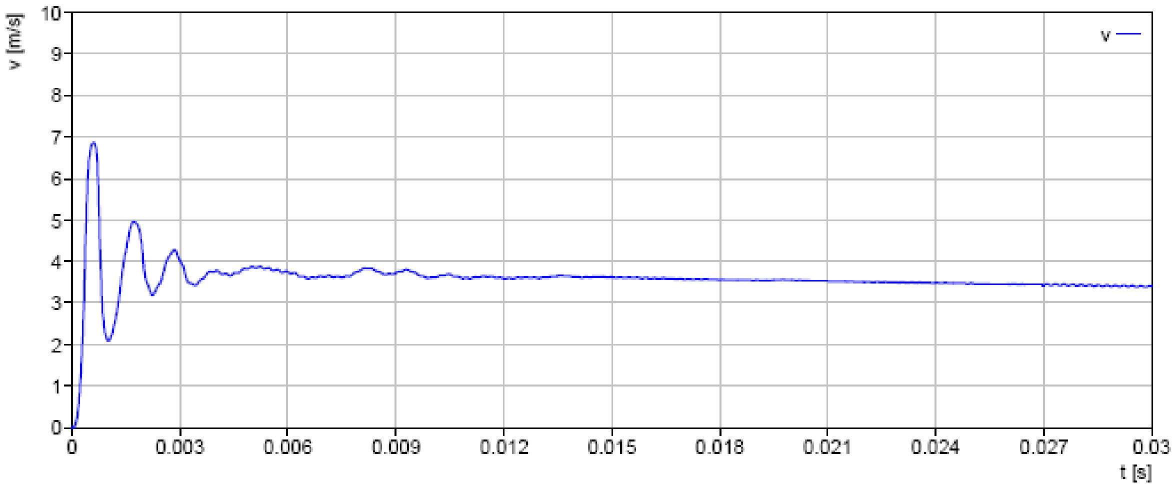


**Fig. 5**

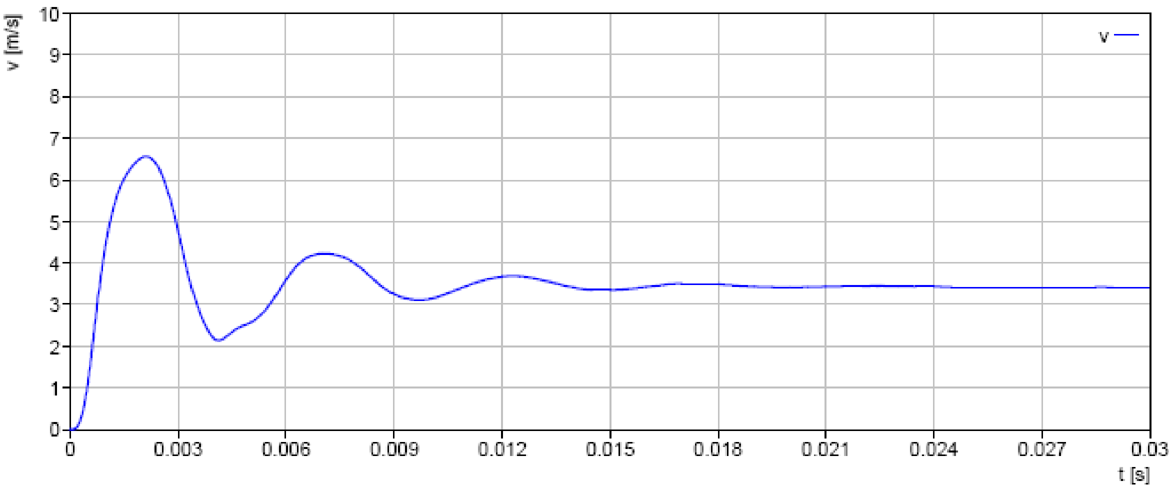


**Fig. 6**

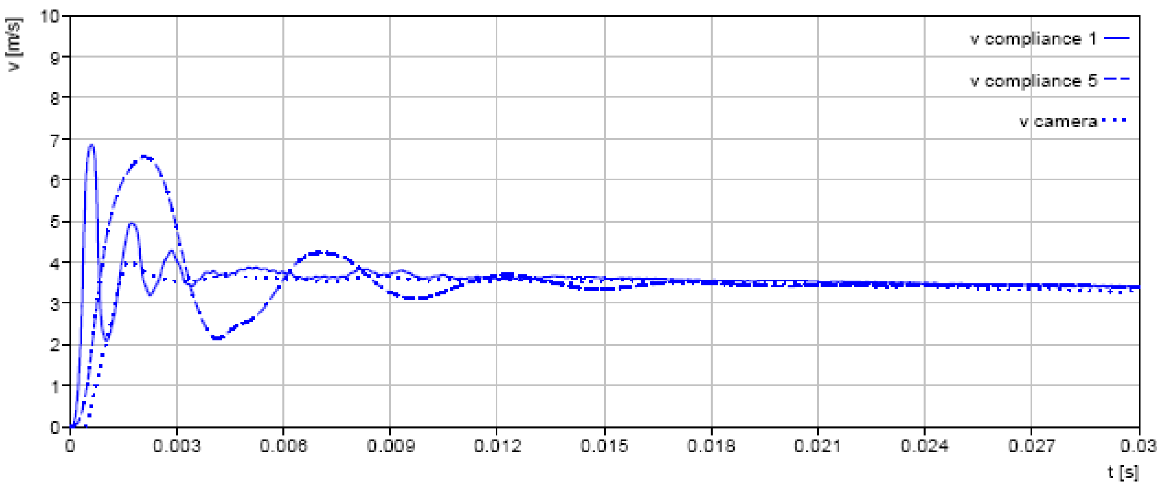


**Fig. 7**

The check of correctness of the measurements was performed by a comparision of the calculated values of velocity by the integration of the measured acceleration and also of the values of velocity acquired through the high-speed camera (Fig. 7). Differences between the results are in the range of the statistical error and the transducer error.

## 4. Conclusion

Mechanical signal filtering using measurement of the impacted object during mechanical shocks bears a significant advance in troubleshooting of velocity determination. That consists of creating elastic damping binding between transducers and measured objects. When the compliance of the binding is increasing, oscillation frequency and amplitude of micro-movement are decreasing, as well as the spurious signal. If the compliance of the binding between transducers and measured objects is sufficient, the velocity of the measured object approaches the common and proper value.

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Literature

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## IDENTIFIZIERUNG DER WERTE VON KINEMATISCHEN GRÖSSEN BEI MECHANISCHEN STÖSSEN

Der Beitrag befaßt sich mit aktueller Problematik von einer Verarbeitung der Meßsignale nichtstationärer Vorgänge. Besondere Fälle sind mechanische Stöße, die sehr große Ansprüche an die Meßtechnik als auch an die Verarbeitung von Meßergebnissen stellen. Üblich werden Beschleunigungen gemessen die nach ihrer Integrierung in zeitliche Verläufe der Geschwindigkeiten bzw. der Wege übergehen. Im gemessenen Signal erscheinen im Verlauf des Stoßes auch parasitäre Komponente, die den gedämpften Eigenschwingungen der Oberfläche des gemessenen Objektes und selbst des Aufnehmers gehören. Im Beitrag werden auf konkreten Beispielen Ergebnisse der Verarbeitung und Auswertung der Signale mit Hilfe von Methoden gezeigt, die auf mathematischer oder mechanischer Ausfiltierung beruhen.

## IDENTIFIKACJA WARTOŚCI WIELKOŚCI KINEMATYCSNYCH PRZY UDERZENIU MECHANICNYM

Artykuł dotyczy aktualnych zagadnień w zakresie przetwarzania sygnałów w pomiarach niestacjonarnych zjawisk mechanicznych. Szczególnymi przykładami są mechaniczne uderzenia, które stawiają bardzo wysokie wymagania zarówno w stosunku do urządzeń pomiarowych, jak i do przetwarzania wyników pomiarów. Zazwyczaj mierzy się przyspieszenie, a na wskutek jego integracji pozyskiwane są dane nt, kształtowania się prętkości lub toru w czasie. W uzyskanym w wyniku pomiarów sygnale pojawiają się jednak również elementy „pasożytnicze", powodowane stłumionymi drganiami powierzchni mierzonego obiektu i samego urządzenia pomiarowego. Artykuł przedstawia, na podstawie konkretnych przykładów, wyniki przetworzenia i analizy sygnałów przy pomocy metod, bazujących na matematycznym lub mechanicznym wyfiltrowaniu elementów o wysokich częstotliwościach.

## IDENTIFIKACE HODNOT KINEMATICKÝCH VELIČIN PŘI MECHANICKÉM RÁZU

Článek se zabývá aktuální problematikou zpracování signálů při měření nestacionárních mechanických dějů. Zvláštní případem jsou rázy, které kladou jak na měřící aparaturu, tak na metody zpracování naměřených hodnot velmi vysoké nároky. Obvykle se měří zrychlení a jeho integrací se získávají údaje o časovém průběhu rychlosti, případně dráhy. V naměřeném signálu se však v průběhu rázu objevují parazitní složky, které příslušejí vlastním tlumeným kmitům povrchu měřeného objektu a snímače samotného. V příspěvku jsou na konkrétních případech uvedeny výsledky zpracování a vyhodnocení signálů metodami založenými na matematickém a mechanickém odfiltrování vysokofrekvenčních složek.