PHOTOGRAMMETRIC METHOD OF DETERMINING VIBRATIONS OF MULTIVASCULAR STRIPPER

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ABSTRACT

The results of mono-photogrammetric examinations of the vibrations of Orenstein and Koppel Sch RS 900 and KWK 1400 multivascular strippers are presented. Special light net with time relay was used to signal vibration. The method was applied to determine the amplitude and frequency of vibrations of the chosen element of the stripper. The technology of field and laboratory measurements was prepared on using dynamic characteristic on photographs. An analitic method was elaborated basing on the Vogl method.

INTRODUCTION

In modern open cast mines winning is performed mainly by means of continuously-operating machines, i.e., bucket wheel excavators. The basic working motion is the rotary motion of the bucket wheel in XOY plane. During this motion the bucket separates chips of undisturbed soil along the face and sides. For the next in line bucket to separate another chip, it must be moved forward by the distance equal to the width of the previously cut chip. This is executed by the motion of the travelling gear of the excavator. Other motions, that is : slewing of the boom, travelling of undercarriage are treated as manoeuvring motions.

The mode of operation of such a bucket wheel excavator generates different vibrations such as: transverse, torsional, longitudinal, in horizontal and vertical planes, vibrations of particular elements, units or of the whole structure. These vibrations generate in the supporting structure one of the most complex state of streses.

From among the methods used to determine the strength of the supporting structure of the machine the most often used one is that of strain gauge measurements. This method provides a very precise static characteristic of the structure tested and permits a complete spectral analysis of the dynamic surves obtained. Yet this method does not enable a direct estimation of static and dynamic deflections (especially of the bucket wheel boom) which considerably affect the cross section of the separated chip i.e., the value of the input force. The deflection measured at the end of the boom is treated here as the geometrical response of the whole system to a given type of load. The value of this deflection can be best determined from the dynamic photo-grammetry method. The application of this method to examine the vibrations generated in bucket wheel excavators completes perfectly the commonly used strain gauge measurementes.

In some cases where the knowledge of only most basic parameters of vibrations is required, the photogrammetric method may entirely replace costly and time-consuming strain gauge measurements.

METHOD OF TESTING

The course of vibrations of supporting structures of bucket wheel excavators was registered from photogrammetric stands with still camera. In this way negative images of space-time changes in signalled elements of excavators winning the undisturbed soil were obtained. Special light net (with pulsating and continuous lights) with time delay was used to signal vibrations. (Fig. 1).

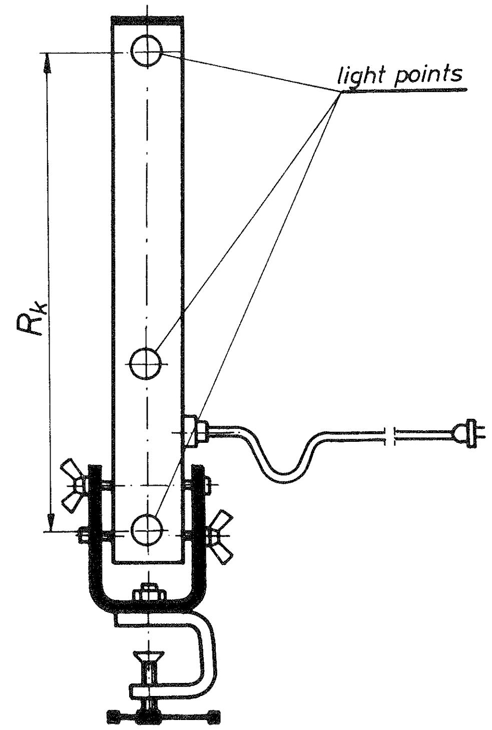

Fig. 1. Light net.

Photographs were taken at night using Photheo Zeiss camera with TO1 photographic plates. An example of a contact print from picture negative showing the course of vibrations is presented in Fig. 2.

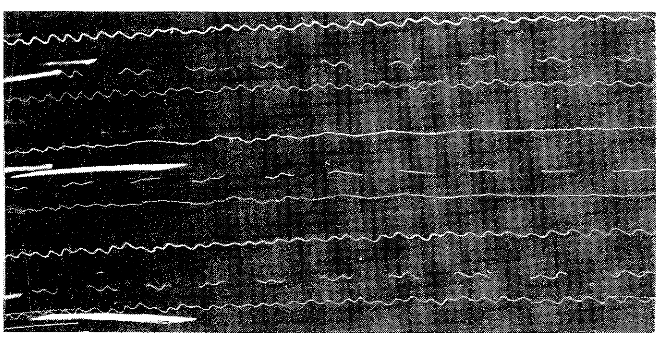

Fig. 2. Vibrations pattern of excavator's structure.

Measurements methodology and interpretation of the results obtained from the measurements of photogrammetric models were based mainly on the Vogl method

(1979, 1981).

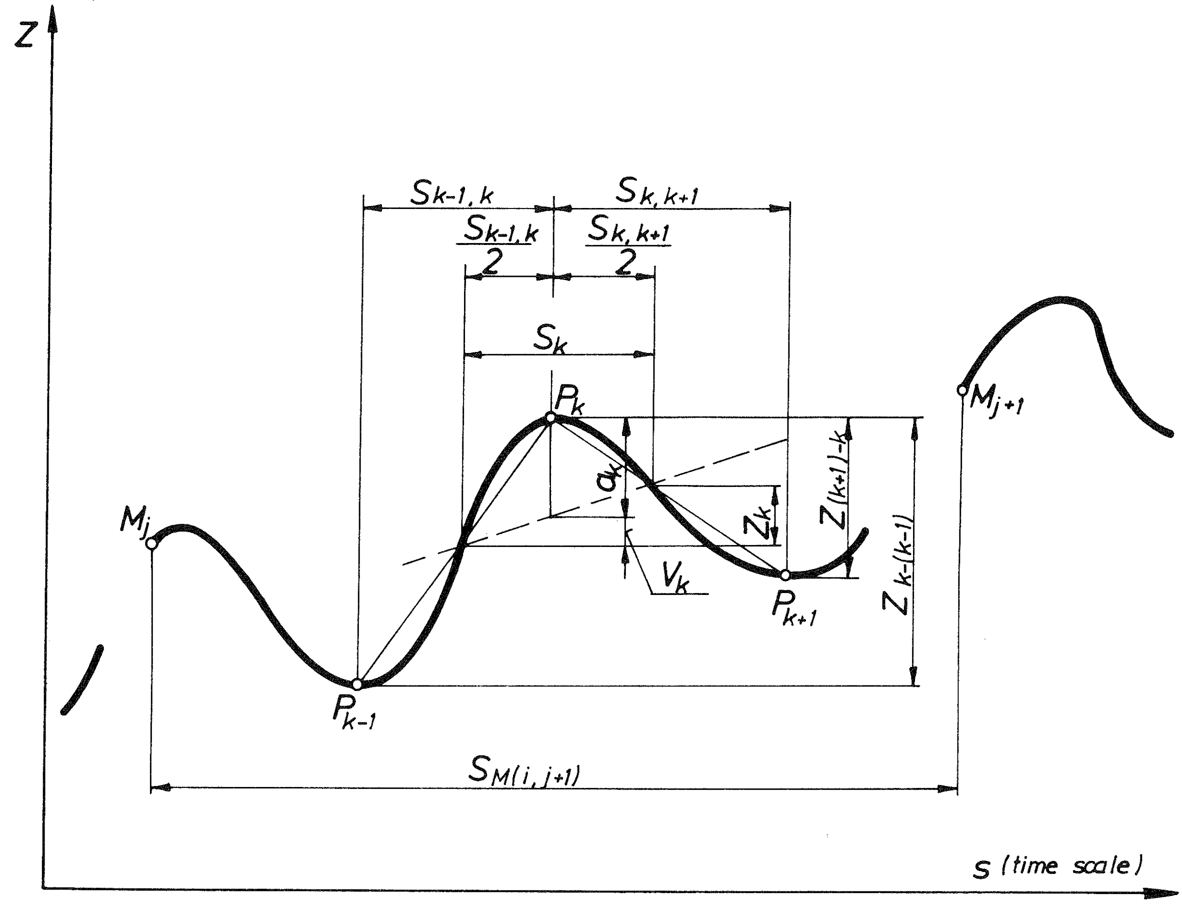

Fig. 3. Analytic relations of vibration characteristics.

On the basis of the measured photogrammetric coordinates, the amplitude and freguency of vibrations for a given element of the excavator are determined:

$$A_k = M_k \cdot a_k$$

$$M_k = \frac{L}{l_k}$$

$$a_k = \frac{\Delta Z_{(k-1)-k}}{2} - V_k$$

$$V_{a_k} = \frac{\Delta Z_k}{\Delta S_k} \cdot \frac{\Delta S_{(k-1)-k}}{2}$$

$$S_k = \frac{\Delta S_{(k-1)-k} + \Delta S_{k-(k+1)}}{2}$$

$$\Delta Z_k = \frac{\Delta Z_{k-(k-1)} + \Delta Z_{(k+1)-k}}{2}$$

$$\Delta t_k = \frac{T_M}{\Delta S_{M\,(j,\ j+1)}} \cdot \Delta S_k$$

$$V_k = \frac{1}{2\ \Delta t_k}$$

where: A_k is the vibrations amplitude at point k,
M_k is the scale of mapping,
a_k is the amplitude of vibrations to scale,
V_k is the freguency of vibrations,
T_M is the light pulsation intervals.

RESULTS OF MEASUREMENTS

Vertical deflections of the end of bucket wheel boom during vertical chip working were measured. The vertical components of amplitudes and freguencies of vibrations were determined from the above equations using MERA 400 digital computer.

The results obtained from the photogrammetric and tensometric measurements were tabulated and presented in a graphical form. Fig. 4 shows the results of the harmonic analysis of the strain gauge measurements made for a chosen strain characteristic across the bucket wheel boom of the SchRS 900 excavator

The above figure also shows the results of the photogrammetric measurements representing the number of observed points in particular frequency ranges concerning the vertical components of boom's vibrations. The strain gauge measurement system was built for measuring boom's vibration in horizontal plane within the frequency range of 1.1 to 1.2 Hz.

Since the results obtained by the photogrammetric and strain gauge methods showed a good compatibility for Sch RS 900 excavator it was decided to determine the basic vibration parameters for KWK 1400 excavator using only the photogrammetric method. A wide frequency range (0.45 do 0.85 Hz) testifies, similarly as for Sch RS 900 excavator, to the occurrence of excited frequency vibrations and natural eigenfrequency vibrations (Fig. 5).

Table 1 lists the results of the measurements of vibration frequencies determined by means of both photogrammetric and strain gauge methods and the maximum amplitudes of vibrations determined from the photogrammetric method.

Comparing the results obtained by the two methods it is evident that the photogrammetric method is sufficienty accurate for the determination of basic parameters of vibrations generated in bucket wheel excavators.

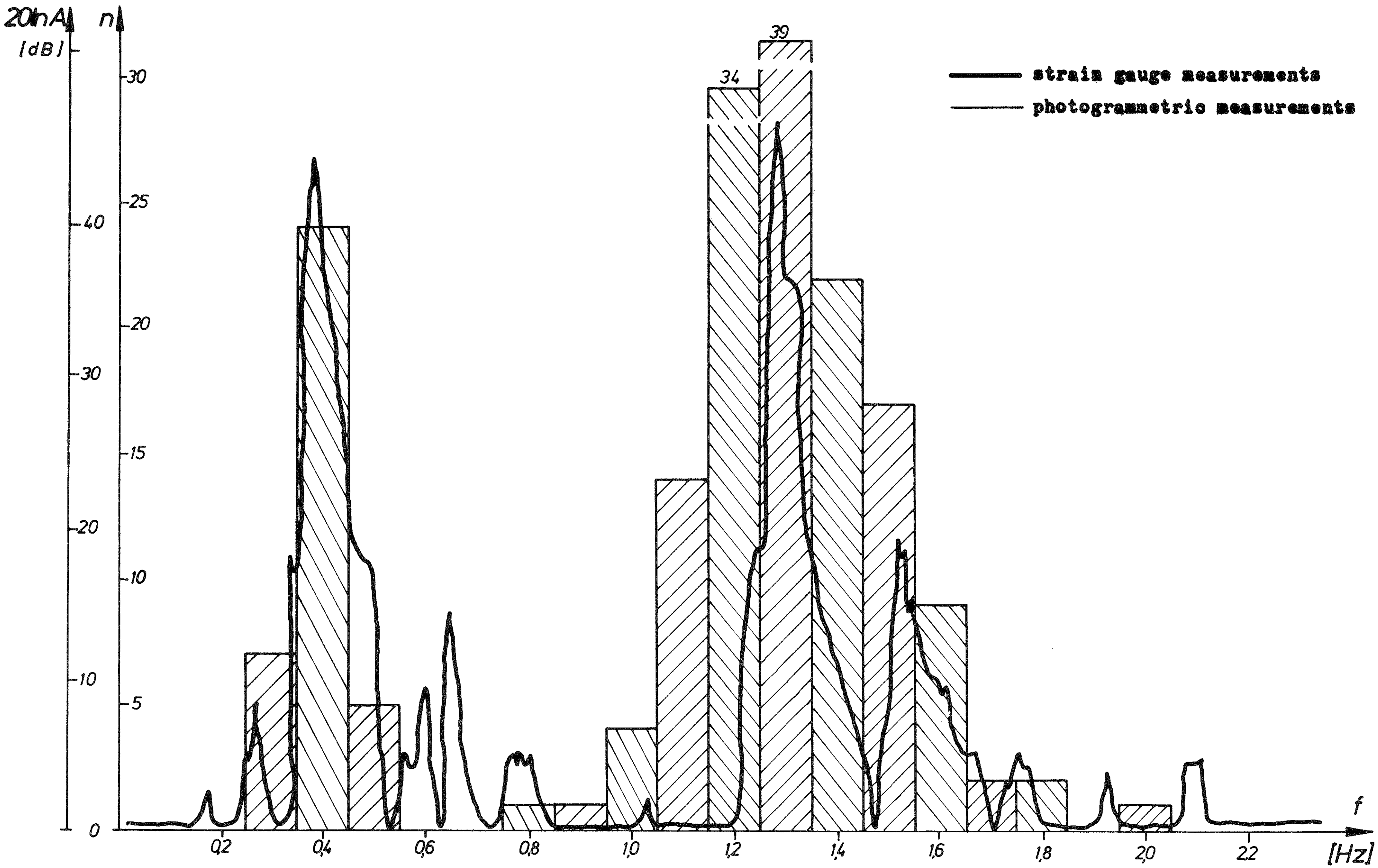

Fig. 4. Photogrammetric and tensometric measurements results for a Sch RS 900.

Table 1.

Measurement results of Sch RS 900 and KWK 1400 excavators.

Excavator		Eigenfrequence		Eigenfrequence		Input	Input
		Photogram.	Tensom.	Photogram.	Tensom.	Photogram.	Tensom.
Sch RS 900	f [Hz]	0,4	0.38	1.3	1.28	1.2 - 1.4	1.33
	A_{max} [mm]	34	-	31	-	29	-
KWK 1400	f [Hz]	0.6	-	-	-	0.6 - 0.7	-
	A_{max} [mm]	40	-	-	-	40	-

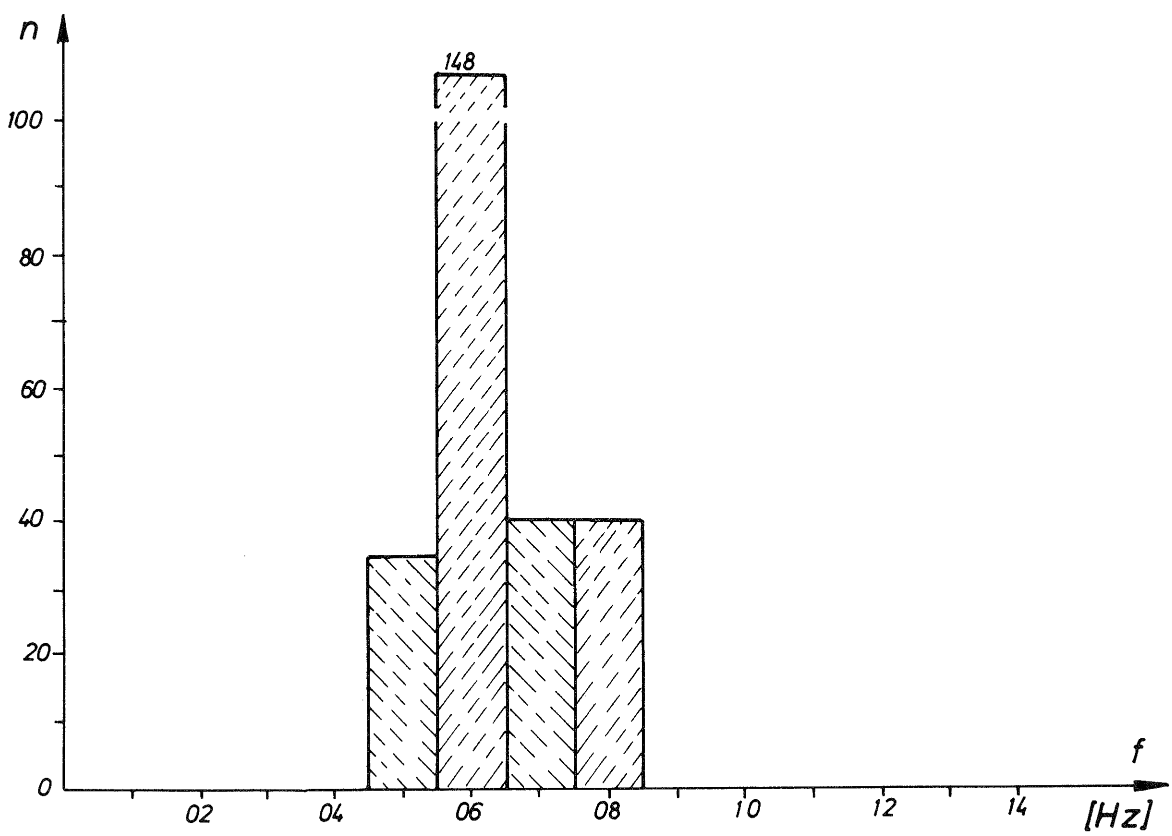

Fig. 5. Photogrammetric measurement results for a KWK 1400.

From the analysis of the results presented in Figs. 4 and 5 and in Tab.1 we can conclude that in the investigations of excavators the photogrammetric method completes the strain gauges measurements and when determining the basic parameters of the vibrating motion this former method can successfully replace the traditional, time-consuming strain gauge measurements.

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