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Preliminary identification of gasdynamic processes in exhaust gas channel of pulsatory supercharging system of a marine diesel engine

SUMMARY

In the paper preliminary results are presented of experimental investigations of exhaust gas flow through the delivery channel to the pulsatory supercharging system of Sulzer 6AL20/24 marine four-stroke diesel engine. On the basis of the recorded measurements two diagnostic measures were proposed. Further investigations are under way.

INTRODUCTION

In diagnostic investigations of the pulsatory supercharging systems of ship engines it is necessary to identify changeable course of disposed energy of pressure impulses of the exhaust gas delivered to the turbocompressor during one working cycle. On the basis of measurements of exhaust gas pressure in some characteristic control cross-sections of the delivery channel to the turbocompressor the propagation velocity of exhaust gas pressure waves occurring after opening successive cylinder outlet valves of the engine, is determined. This makes it possible to elaborate the so-called energy characteristics of the delivery channel, which becomes stratified along with developing degradation (mainly due to wearing and fouling) of engine elements. Degree of stratification of the energy characteristics can be deemed an important source of diagnostic information on technical state of the load exchange system and turbocompressor of the engine.

In this paper preliminary results of the experimental investigations of exhaust gas flow through the delivery channel of the pulsatory supercharging system of Sulzer 6AL20/24 marine four-stroke diesel engine are presented. The investigations were aimed at identification of gasdynamic processes occurring in the delivery channel, necessary for diagnosing technical state of the load exchange systems and turbocharging system of such ship engines. Measuring and recording the flow parameters were carried out in two different states of the engine : the so-called reference state, i.e. the state of full serviceability – at nominal setting of control elements, and the state of partial serviceability – at one shut-down cylinder system.

THEORETICAL BACKGROUND OF EXHAUST GAS FLOW THROUGH DELIVERY CHANNEL TO TURBOCOMPRESSOR

Course of disposed energy of pressure impulses of the exhaust gas delivered to the turbocompressor during one working cycle of the engine is influenced by many structural and operational factors. From the available domestic literature sources [2,3,4,8,9,12] it results that the crucial structural factor determining character of the pressure wave system of exhaust gas in the delivery channel to the turbocompressor is an optimum value of the ratio of the active flow cross-section field of the turbine nozzle and the diameter and length of the delivery channel.

Also, the way of shaping the branches and inlets to particular cylinders is important because it decides on possible occurence of an undesirable phenomenon of generating reflected waves of different velocities, which disperse energy of exhaust gas pressure impulses and disturbe scavening process of the engine cylinders [4,6,11].

In analysis of influence of the operational factors on the exhaust gas pressure wave system it is necessary to take into account changes of engine load, its rotational speed as well as control changes of opening and closing angles of inlet and outlet valves.

Instantaneous energy values of the impulses oscillate around the mean value constant in a given load range, in accordance with a composite periodic function, at 1st harmonic frequency which can be expressed by the following relationship [5] :

$$f_1 = 2\frac{i\omega}{s} \qquad (1)$$

An enthalpy value of exhaust gas pressure impulse, averaged within one engine working cycle, in the characteristic control cross-sections of the flow channel to the turbocompressor, can be determined by means of the following expression :

$$\dot{H}_{imp} = \int_0^\tau \dot{m} c_p T d\tau \tag{2}$$

Changes of enthalpy flow distribution determined for given representative loads of the engine, related to reference (standard) values, recorded in their initial operation phase, can be a valuable source of diagnostic information on technical state of the turbine and of the load exchange system as well, sea a.o. [7].

The most often used method of elaborating the energy characteristics of the delivery channel in question consists in determination of instantaneous values of gasdynamic parameters of exhaust gas flow within a separated control volume of the channel, based on measurements of propagation velocity of the exhaust gas pressure wave generated after opening of the outlet valve. It propagates through the collective channel towards the turbine nozzle with velocity of sound whose value mainly depends on exhaust gas temperature. The propagation velocity of the peak pressure wave amplitude, V_{pw}, is the sum of the instantaneous sound velocity V_s and the exhaust gas flow velocity in the channel, V_c :

$$V_{pw} = V_s + V_c \tag{3}$$

As the sound velocity in the exhaust gas is expressed by the formula :

$$V_s = \sqrt{\chi R T} \tag{4}$$

and the exhaust gas flow velocity in the channel, V_c, is a function of the Mach number :

$$V_c = V_s Ma \tag{5}$$

hence :

$$V_{pw} = \sqrt{\chi R T}\,(Ma + 1) \tag{6}$$

Finally the following expression can be obtained to calculate instantaneous value of the exhaust gas temperature T :

$$T = \frac{V_{pw}^2}{\chi R (Ma+1)^2} \tag{7}$$

The velocity V_{pw} and Mach number Ma appearing in (7) can be determined by measuring instantaneous values of the swelling pressure p_1^* and of statical pressures p_1 and p_2, recorded in two control cross-sections (1 and 2) of the exhaust gas channel, located at the distance L each to other (Fig.1.).

The propagation velocity of the peak pressure wave amplitude, V_{pw}, can be determined with the use of the following expression :

$$V_{pw} = \frac{L}{\tau_{pw}} \tag{8}$$

where :

τ_{pw} – propagation time of the peak pressure wave amplitude of exhaust gas between the control cross-sections 1 and 2 of the flow channel.

Mach number is determined by using the relationship of the statical pressure p_1 and swelling pressure p_1^* as well as the equations of isentropic change assumed to be realized at exhaust gas flow ramming in the control cross-section 1 of the flow channel :

$$\frac{p_1^*}{p_1} = \left(1 + \frac{\chi - 1}{2} Ma^2\right)^{\frac{\chi}{\chi-1}} \tag{9}$$

hence :

$$Ma = \sqrt{\frac{2\left[\left(\frac{p_1^*}{p_1}\right)^{\frac{\chi-1}{\chi}} - 1\right]}{\chi - 1}} \tag{10}$$

The above presented method makes it possible to determine an instantaneous value of exhaust gas temperature, which is the mean value averaged over the time τ and valid for the channel volume li-

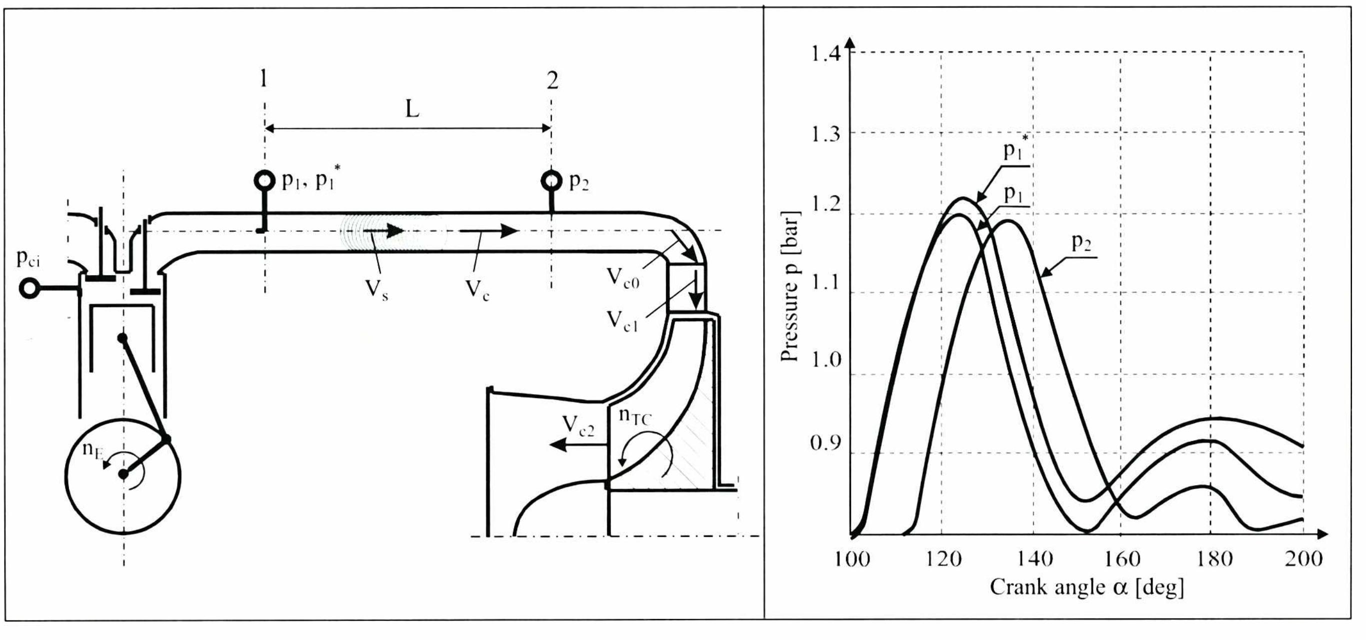

Fig.1. *Measurement scheme of instantaneous pressure values in the exhaust gas delivery channel to the turbocompressor*

mited by the control cross-sections 1 and 2. Therefore the length L should be as small as possible provided a required measurement accuracy of propagation time of the peak exhaust gas pressure wave amplitude through the control volume, is maintained.

In a similar way an instantaneous value of exhaust gas mass flow rate in the control volume can be determined by making use of the measurements of the pressure impulse propagation velocity :

$$\dot{m} = FV_c\rho \tag{11}$$

where an instantaneous value of the exhaust gas flow velocity V_c is defined as follows :

$$V_c = Ma\frac{L}{\tau_{wc}(Ma+1)} \tag{12}$$

and an instantaneous value of the exhaust gas density ρ - by the relationship :

$$\rho = \frac{p_1}{RT} \tag{13}$$

The exhaust gas pressure impulse amplitude in particular control cross-sections of the delivery channel to the turbocompressor, hence also the exhaust gas energy and turbine power output, vary due to flow drag between the outlet valve and turbine nozzle, and also as a result of interference and reflection of pressure waves coming from the remaining cylinders working together to a given channel.

The presented computation algorithm makes it possible to perform a changeability analysis of the disposed enthalpy flow of the exhaust gas delivered to the compressor, considered as an averaged value within the control volume of the delivery channel, restricted by the control cross-sections 1 and 2.

INVESTIGATION OBJECT

The investigation object is the turbocharging system of Sulzer 6AL20/24, four-stroke, six-cylinder diesel engine earlier described in the author's paper [1]. In that paper a detail scope of the measured control parameters of the engine together with their measurement points was also given, as well as the measurement system itself and the course of exhaust gas pressure variation in the delivery channel before the turbine were characterized.

MEASUREMENT INSTRUMENTS

For the investigations in question high-class measurement and recording instruments were selected :

- SEFRAM 8416 digital recorder which makes it possible to simultaneously measure and automatically record 16 control paramenters at the sampling frequency up to 250 kHz – (Fig.2)
- Two OPTRAND C11294-Q lightwave gauges of 0-7 bar measurement range and 1.0 accuracy class were applied to pressure measurements in the exhaust gas collective channel to the engine turbocompressor – (Fig.3a)
- One OPTRAND C31294-Q lightwave gauge of 0-200 bar measurement range and 1.0 accuracy class was applied to indicate pressure inside the combustion chambe of cylinder 6 – (Fig.3b)
- Engine rotational speed was measured by means of an inductive gauge of the measurement range up to 800 rpm and 0.1 accuracy class, cooperating with the flywheel marker
- Measurements of the turbocompressor rotor speed were performed by means of a magnetoelectric gauge of the measurement range up to 4000 rpm and 0.5 accuracy class, using two impulses of markers installed on the compressor shaft.

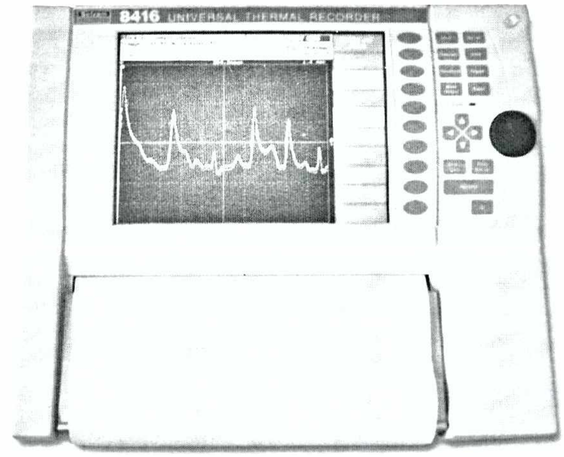

Fig.2. *SEFRAM 8416 digital recorder used for recording the course of exhaust gas pressure changes in the delivery channel to the turbocompressor*

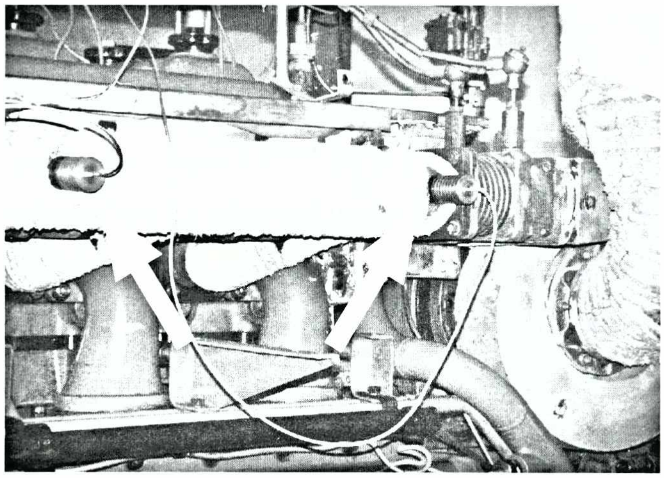

Fig.3a. *Place of fixing the exhaust gas pressure gauges in the delivery channel to the turbocompressor*

Fig.3b. *Place of fixing the inside-cylinder pressure gauge*

COURSE OF INVESTIGATIONS

To analyze gasdynamic processes occurring in the delivery channel of the pulsatory turbocharging system in question it is necessary to know character of variability of appropriate parameters of exhaust gas flow from the engine cylinders. On the basis of the above given theoretical considerations it can be stated that an important assessment parameter is the propagation velocity of the peak pressure wave amplitude of exhaust gas between the selected control cross-sections of the flow channel, determined by means of the simultaneous measurement of static pressure in these sections.

The experimental investigations were carried out on the mentioned Sulzer 6AL20/24 diesel engine installed on the engine test bed of the Technical Institute of Ship's Maintenance, Polish Naval University.

The investigations were aimed at preliminary assessment of influence of technical state changes of the engine on the propagation velocity of exhaust gas pressure wave in the delivery channel to the turbocompressor.

The experiment consisted in disturbing the steady operation of the engine at 0.4 P_{nom} output by shutting down one cylinder, at blocked fuel charging bar. In this way the engine operation in the state of its partial serviceability was simulated. The following gasdynamic parameters were similtaneously measured (at 20 kHz sampling frequency) :

- the cylinder interenal pressure p_{ci} of the cylinder system 6
- the dynamic pressure in the control cross-section 1 of the delivery channel, p_{1dyn}
- the static pressure in two control cross-sections 1 and 2, 0.583 m distant each to other along the delivery channel, p_1, p_2
- the engine rotational speed n_E
- the turbocompressor rotor speed n_{TC} .

The measurements were performed
in two different technical states of the engine :

1st - of full technical serviceability, i.e. the reference state, at rated setting of control elements
2nd - of partial technical serviceability – at shut down one cylinder.

GASDYNAMIC ANALYSIS OF THE RECORDED COURSES

As a result of the performed investigations courses of the measured gasdynamic parameters in function of time, in response to shutting down one cylinder, were obtained. The recorded courses of the exhaust gas pressures showed some deformations due to measurement errors and disturbances connected mainly with pressure wave reflection and interference, work of the engine's speed governor etc [4].

In order to reliably reproduce the courses it was necessary to minimize influences of the deforming factors by averaging the results in the domain of the crankshaft revolution angle. Therefore one averaged course was formed from an arbitrary number of four-stroke engine working cycles (each of them contained two crankshaft rotations) and an averaged time of propagation of the growing slope of the exhaust gas pressure wave was determined for each of the cylinders, and this parameter was assumed a substitute of the peak amplitude propagation time of the appropriate exhaust gas pressure wave. In Fig.4 and 5. courses of cylinder internal pressure changes of the system 6 as well as of pressure in the exhaust gas outlet channel before the turbine of the engine in question are presented in function of time.

From the recorded courses it results that the shutting down of one cylinder causes quantitative and qualitative changes of exhaust gas pressure pulsation in the delivery channel to the turbine : exhaust gas pressure impulses connected with the cylinders 4 and 5 changed their character. It was supposedly caused by worsening conditions of fuel injection and combustion in these cylinders. In order to quantitatively assess the changes it was necessary to perform harmonic analysis of the recorded courses, and then to evaluate changes of amplitude values, and possible phase shifts of selected harmonic components.

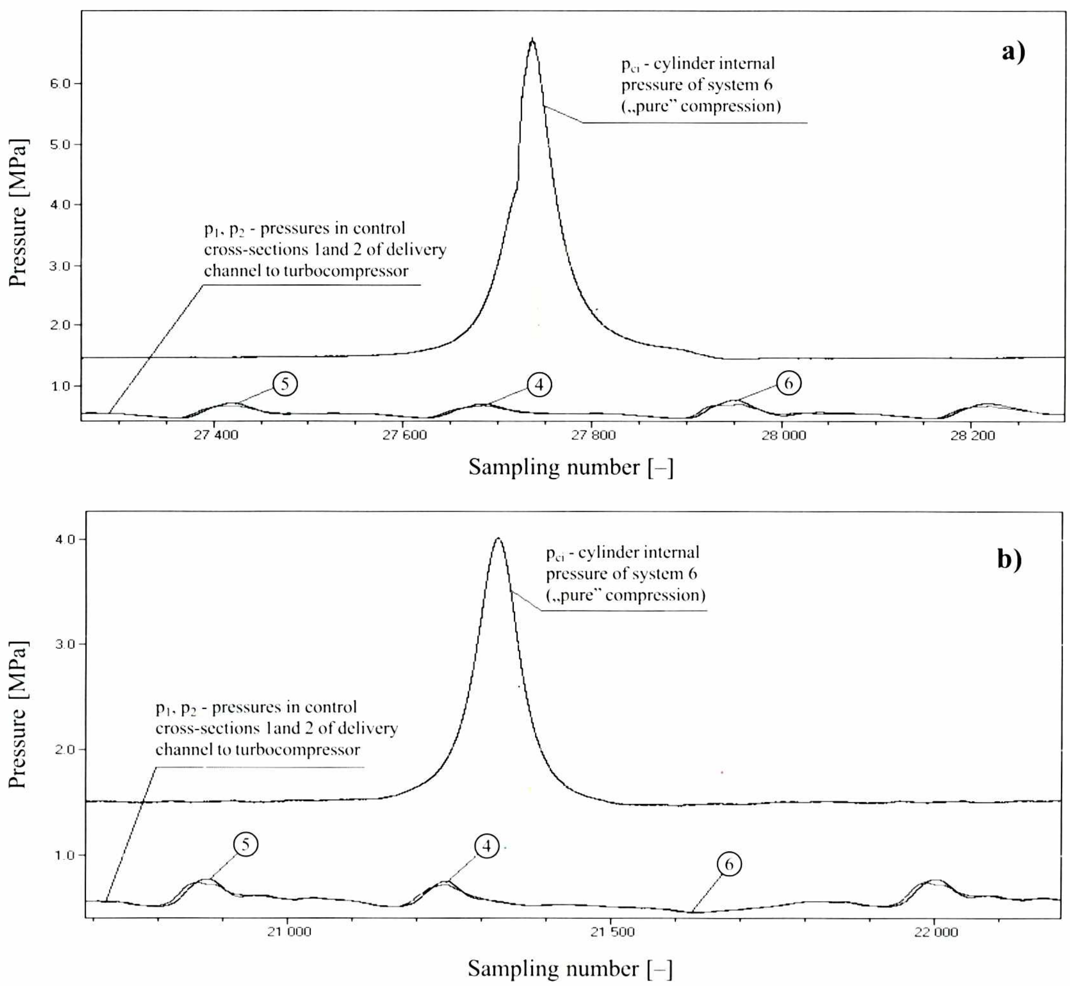

Fig.4. *Courses of cylinder internal pressure changes of the cylinder system 6 as well as of pressure in the exhaust gas channel before the turbine of Sulzer 6AL20/24 engine in function of sampling number*
a) *for the engine in full serviceability state* ***b)*** *for the engine in partial serviceability state – at shut - down cylinder 6*

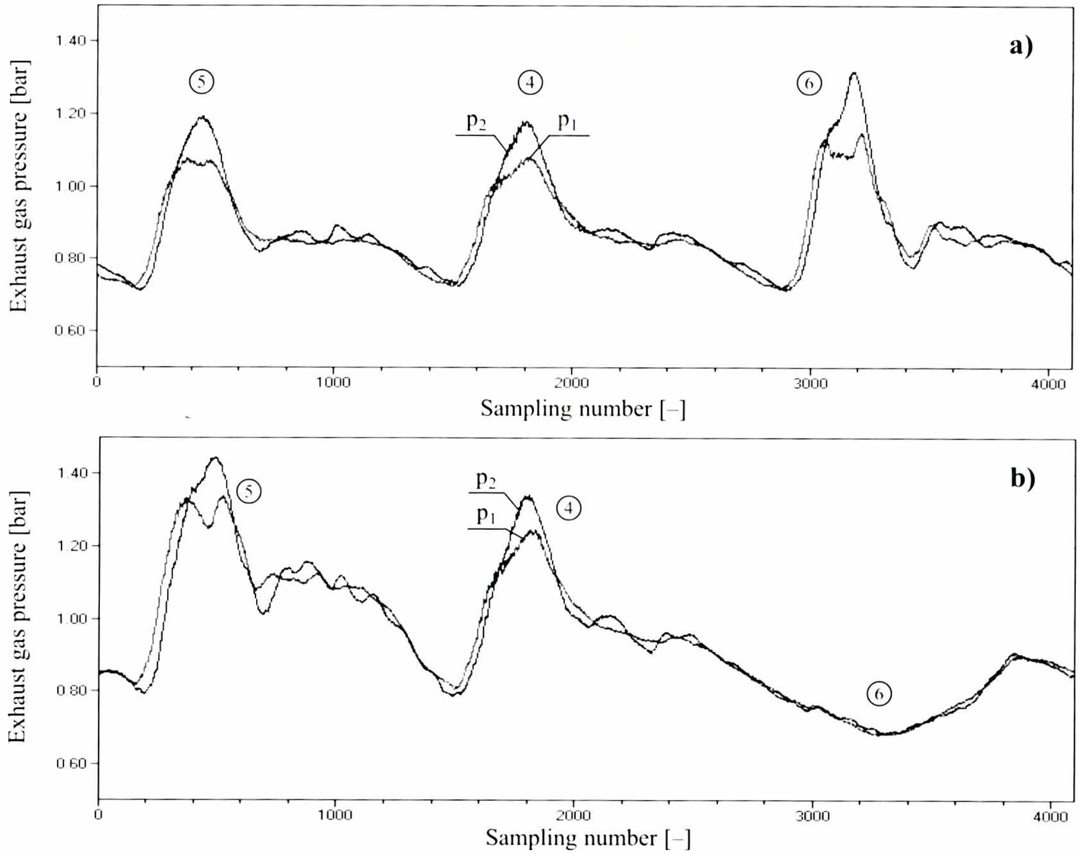

Fig.5. *Courses of exhaust gas pressure changes in the conrol cross-sections 1 and 2 of the delivery channel to the turbocompressor of Sulzer 6AL20/24 engine in function of sampling number*
a) *for the engine in full serviceability state* ***b)*** *for the engine in partial serviceability state – at shut - down cylinder 6.*

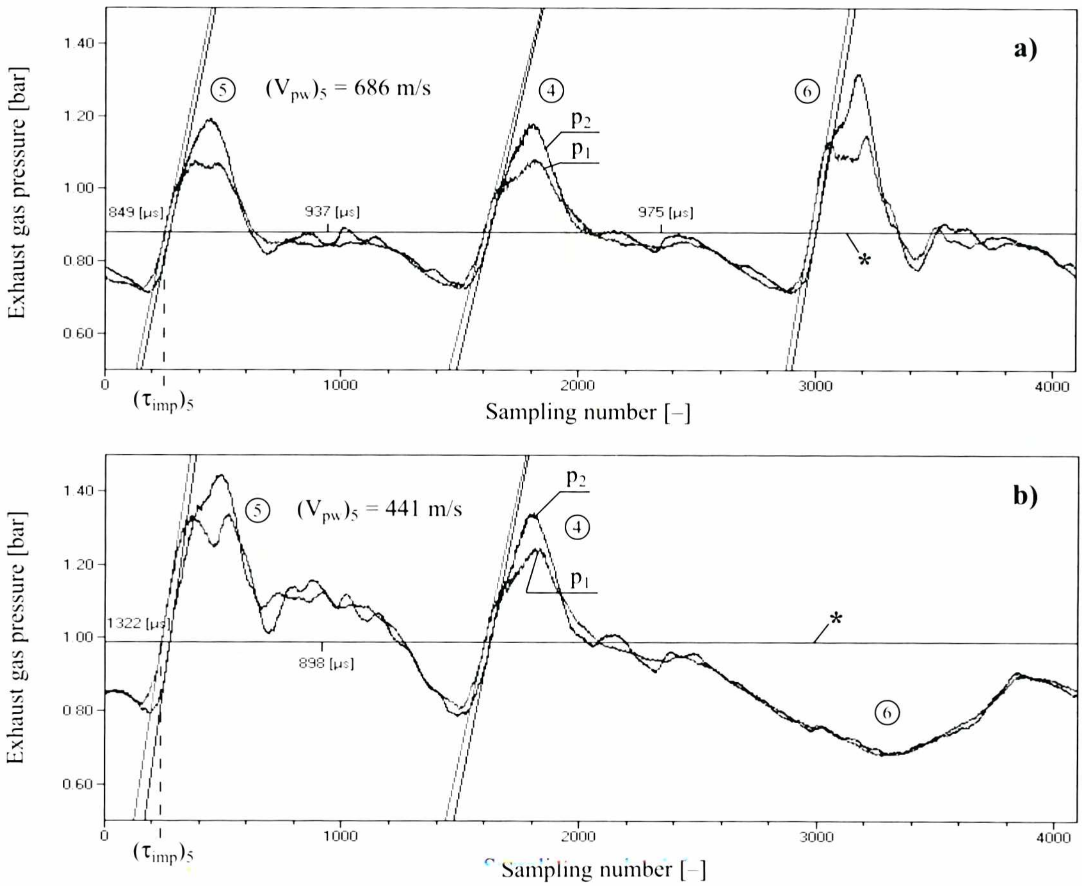

Fig.6. *Courses of exhaust gas pressure changes in the control cross-sections 1 and 2 of the delivery channel to the turbocompressor of Sulzer 6AL20/24 engine in function of sampling number – the way of determining of propagation time of exhaust gas pressure wave in the channel*
a) *for the engine in full serviceability state* ***b)*** *for the engine in partial serviceability state at shut - down cylinder 6.*
**** – Basis for determination of distance of tangents***

It could make it possible to define diagnostic measures describing technical state of the considered turbocharging system of the engine.

From the records it also results that a correlation occurs between the fuel charge to a given cylinder system and the amplitude of relevant (coupled with it) exhaust gas pressure impulse in the channel. The observed phenomenon of „subsidence" of pressure impulse amplitude in cylinder 6 (Fig.5b) is most probably caused by exhaust gas reversion to the cylinder during the opening period of outlet valves as well as by interference of primary pressure waves and those reflected from the turbine nozzle [4,11].

Assessing influence of the simulated defect on the propagation velocity of exhaust gas pressure wave in the channel one can conclude that it resulted in almost 70% drop of value of the velocity. As the kinetic energy of exhaust gas delivered to the turbine decreased, the turbocompressor rotor speed also dropped and the compressor's efficiency decreased. Obviously, it had very large influence on the supercharging air parameters and conditions of load exchange in the engine cylinders, as it can be observed in the diagrams of pressure courses of the exhaust gas delivered to the turbine (Fig.5a,5b).

To better understand the pulsatory flow process in question instantaneous values {determined at the time instant $(\tau_{imp})_5$} of the gasdynamic parameters which characterize propagation of the exhaust gas pressure impulse connected with cylinder system 5, occurring within the control volume of the delivery channel to the turbocompressor, are presented in Tab.2.

Tab.2. *Instantaneous values of the gasdynamic parameters which characterize propagation of the exhaust gas pressure impulse connected with cylinder system 5, occurring within the control volume of the delivery channel to the turbocompressor (averaged over the channel length)*

Parameter / Work range	τ_{pw}	V_{pw}	p_1	p_1^*	Ma	T	V_c	V_s	ρ	$\dot{m}$	h	$\dot{H}_{imp}$
	s^{-3}	m/s	bar	bar	[-]	K	m/s	m/s	kg/m^3	kg/s	kJ/kg	kW
$0.4P_{nom}$	0.849	686.7	1.20	1.21	0.1097	1238.2	67.8	618.8	0.622	0.212	1007.6	213.6
$0.25P_{nom}$ (shut down cyl. 6)	1.322	441.0	1.43	1.44	0.1048	683.6	41.8	399.2	1.243	0.261	428.6	111.8

These are the values averaged over the channel length and determined in accordance with the above described calculation algorithm. However its realization is difficult because it is very hard to determine precisely and fully automatically phase shift of the investigated pressure impulses propagating between the control cross-sections of the flow channel. It was proposed to use the distance between tangents to compared curves of changeable courses of exhaust gas pressure in the points determined for one and the same value of the pressure (Fig.6).

Attempts to improve the measurement technique and processing method of measurement results are under way. The change of propagation time of the pressure wave impulses along the exhaust gas channel before the turbine nozzle are deemed an appropriate diagnostic parameter for assessing technical state of the cylinder systems and turbocharging system of the engine in question.

SPECTRAL ANALYSIS OF RECORDED COURSES

The exhaust gas outlet of the considered engine is split into two flow channels directly connected to the turbocompressor. 1st channel contains cylinders 1, 2 and 3, and 2nd channel – cylinders 4, 5 and 6.

Taking into account the firing sequence of the engine in question (1-4-2-6-3-5) and its four-stroke cycle one can observe that the exhaust gas pressure impulses from the particular cylinders of a group, directed to the flow channel, occur at equal interval values of the crank angle α :

$$\Delta\alpha = \frac{2}{3}\pi \qquad (14)$$

or in the general case :

$$\Delta\alpha = \frac{s}{i}\,\frac{\pi}{2} \qquad (15)$$

The recorded courses of exhaust gas pressure pulsation in question were analyzed in frequency domain. As the measurement data from the experiment have been obtained at equal time intervals, and they are periodical and continuous therefore they satisfy the Dirichlet's conditions of permissibility for carrying out spectral analysis with the use of the fast Fourier transform (FFT) [10]. In such analysis the smallest frequency is called the *fundamental frequency* and the larger ones which are integer multiples of that fundamental – the *harmonic frequencies*.

The course of exhaust gas pressure pulsation in question can be described as a periodic signal of the period $P = 2\pi$ and angular frequency $\omega = 2\pi/P$ by means of the following trigonometric series :

$$y(\tau) = A_0 + \sum_{k=1}^{\infty}\left[A_k \cos\left(k\frac{2\pi}{P}\tau\right) + B_k \sin\left(k\frac{2\pi}{P}\tau\right)\right] \qquad (16)$$

where :

A_0 - constant component of the signal

A_k, B_k - amplitude of real part and imaginary part of k-th harmonic frequency of the periodic signal, respectively.

The following harmonic distribution scheme of the analyzed pressure pulsation in question was assumed :

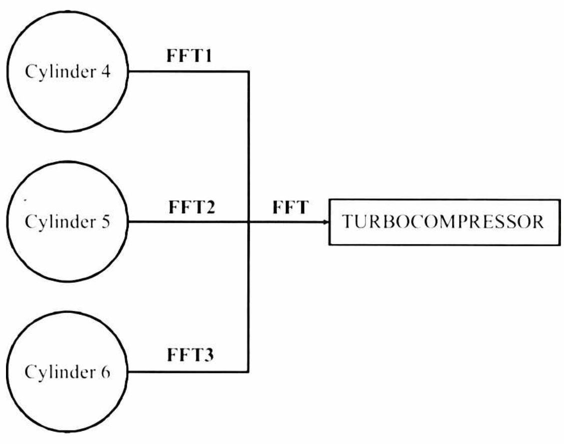

Fig. 7. *The assumed harmonic distribution scheme of the analyzed exhaust gas pressure pulsation in the delivery channel*

Notation :

FFT1, FFT2, FFT3 – harmonic components of pressure impulses from particular cylinders
FFT – summary harmonic distribution

The harmonic components of the pressure pulsations from particular cylinders can be added together with taking into account phases of their occurence.

On assumption of the following notation :

A_{xy} - amplitude of real part of k-th harmonic frequency of exhaust gas pressure

B_{xy} - amplitude of imaginary part of k-th harmonic frequency of exhaust gas pressure,

where indices :

$x = 1, 2, 3,..i$ - number of a considered cylinder
$y = 1, 2, 3,..k$ - harmonic order

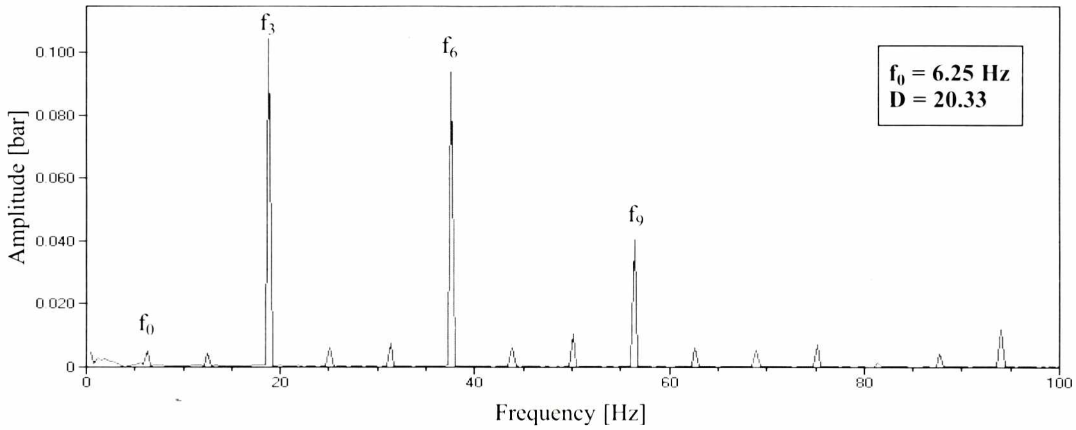

Fig.8. *Amplitude spectrum of the exhaust gas pressure pulsations in the delivery channel to the turbocompressor of Sulzer 6AL20/24 diesel engine in the full serviceability state. D – proposed diagnostic measure acc.(22)*

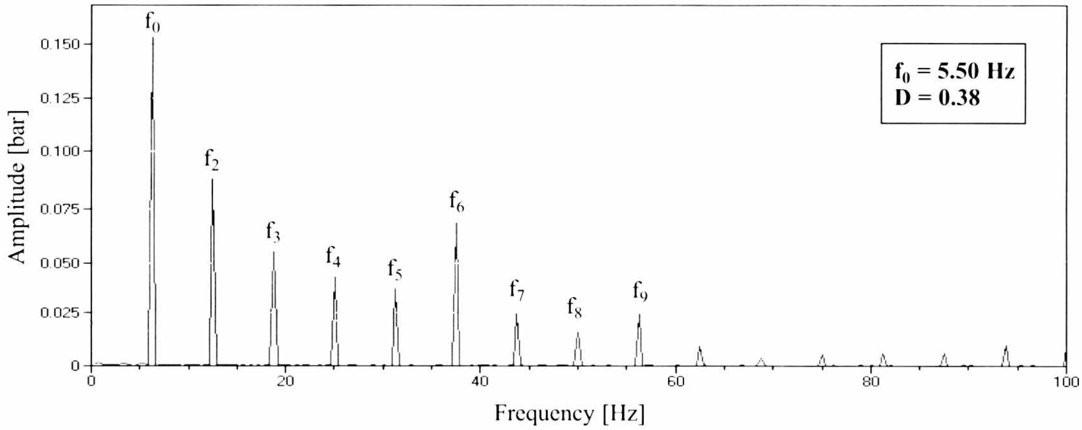

Fig.9. *Amplitude spectrum of the exhaust gas pressure pulsations in the delivery channel to the turbocompressor of Sulzer 6AL20/24 diesel engine in the partial serviceability state – at shut down cylinder 6. D – proposed diagnostic measure acc.(22)*

the Fourier series for the course of exhaust gas pressure pulsation from 1st cylinder take the form as follows (at neglected constant component) :

$$\begin{aligned} y_1(\tau) = {} & A_{11}\cos(\frac{2\pi}{P}\tau) + B_{11}\sin(\frac{2\pi}{P}\tau) + \\ & + A_{12}\cos(2\frac{2\pi}{P}\tau) + B_{12}\sin(2\frac{2\pi}{P}\tau) + \\ & + A_{13}\cos(3\frac{2\pi}{P}\tau) + B_{13}\sin(3\frac{2\pi}{P}\tau) + \\ & + A_{14}\cos(4\frac{2\pi}{P}\tau) + B_{14}\sin(4\frac{2\pi}{P}\tau) + \cdots \end{aligned} \tag{17}$$

the relevant series for 2nd and 3rd cylinder, $y_2(\tau)$, $y_3(\tau)$, are of the same form but different only by their respective indices.

Hence the series for the summary exhaust gas pulsation in the collective channel is :

$$y(\tau) = y_1(\tau) + y_2(\tau) + y_3(\tau) \tag{18}$$

It can be demonstrated by making use of basic trigonometric functions that for equal amplitudes :

$$A_{1y} = A_{2y} = A_{3y} \tag{19}$$

$$B_{1y} = B_{2y} = B_{3y} \tag{20}$$

the resulting frequency spectrum will contain only harmonic frequencies being multiples of the number of the cylinders working to the same delivery channel to the compressor. In the considered case these are harmonics : 3, 6, 9...etc. If the signal amplitudes are different each to other the remaining frequencies will appear in the spectrum.

Amplitude spectra of the exhaust gas pressure pulsations in question resulting from the performed FFT analysis for the considered operational states of the engine are presented in Fig. 8 and 9.

The fundamental frequency of vibration generated by gas forces, f_0, related to the number of working cycles of particular cylinder systems can be determined from the following relationship :

$$f_0 = \frac{n_E}{60r} \tag{21}$$

where : r – number of revolutions per one working cycle of the engine (in the considered case: $r = 2$).

From the frequency characteristics it results that the engine's work disturbance which consists in shutting down one cylinder makes the amplitude spectrum of the exhaust gas pressure pulsation in question undesirably dense. Additionally, it can be observed that the fundamental frequency amplitude dominates in the spectrum which shows that the gas forces in the engine cylinders are markedly unbalanced ; they act, on one hand, onto the crankshaft system, on the other hand – onto the cylinder head and cylinder block. Moreover the unbalanced gas forces heighten destructive influence of unbalanced inertia forces (due to mass of rotating elements and of those in to-and-fro motion) on the engine structure.

In order to quantitatively assess the phenomenon the following diagnostic measure is proposed for the considered solution of the turbocharging system of the marine diesel engine (i.e.three cylinders delivering exhaust gas to the turbocompressor through the common channel) :

$$D = \frac{A_3}{A_0} \tag{22}$$

where :

A_0 - fundamental frequency amplitude due to engine working cycles
A_3 - 3rd harmonic frequency amplitude due to engine working cycles.

It is expected that by monitoring changes of value of the so defined diagnostic parameter during operation of the engine it would be possible to assess technical state of elements of the *PRC* (piston – – ring – cylinder) system and turbocharging system.

CONCLUSIONS

- It was possible to indirectly assess the course of gasdynamic processes in the engine cylinders on the basis of the presented preliminary experimental investigations of the exhaust gas flow process in the delivery channel to the pulsatory supercharging system of the considered marine four-stroke diesel engine, and results of processing of recorded measurements.
- The elaborated method of spectral identification of course of gasdynamic processes in the exhaust gas channel to the turbocompressor, can be alternatively used for diagnosing ship diesel engines (and not only) in the case of lack of indicator valves in the engine cylinders.
- Two diagnostic measures were proposed for assessing technical state of cylinder systems and turbocharging system of the engine of the considered kind, namely :
  1st - the exhaust gas pressure wave propagation velocity in the channel (in the case of gasdynamic analysis) and
  2nd - the ratio of 3rd harmonic frequency amplitude and that of the fundamental frequency due to engine working cycle (in the case of spectral analysis).
- The presented results encourage to undertake the experimental investigations on influence of regulation of the admission system and timing gear of the engine, as well as of some structural changes of the turbine nozzle, on the proposed diagnostic measures.

Appraised by Stefan Szczeciński, Prof.D.Sc.

NOMENCLATURE

A, B		amplitude
c_p	–	mean specific heat of exhaust gas at constant pressure
f	–	frequency
F	–	surface area
h	–	exhaust gas specific enthalpy
H	–	exhaust gas enthalpy
$\dot{H}$	–	enthalpy flow of exhaust gas
i	–	number of cylinders connected to one exhaust gas outlet channel
k	–	order of harmonic component
L	–	length
$\dot{m}$	–	mass flow rate of exhaust gas
Ma	–	Mach number
n	–	rotational speed
p	–	exhaust gas pressure
P	–	period
PRC		piston – ring – cylinder system
r		number of crankshaft revolutions per one working cycle of the engine
R		gas constant of exhaust gas
s		number of strokes per one working cycle of the engine
T	–	exhaust gas temperature
V	–	velocity
α	–	rotation angle
χ		isentrope exponent of exhaust gas
ρ		density of exhaust gas
τ	–	time
τ_{pw}		propagation time of the peak amplitude of exhaust gas pressure in the channel
τ_{wc}	–	realization time of one working cycle of the engine
ω		angular velocity

Indices

c		in the chanel	nom	–	rated (nominal)
ci		of cylinder inside	pw	–	of pressure wave
dyn	–	dynamical	s	–	of sound
E	–	of engine	TC		of turbocompressor
imp		of impulse	wc	–	of working cycle

( )* – of swelling parameters

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Conference

International tutorial course

On 23-24 June 2002, on the occasion of 6th European Conference on Underwater Acoustics (see page 30), the International Tutorial Course for Young Acousticians from European Countries on :

Underwater Acoustics and Remote Sensing Technologies for Exploration and Sustainable Exploitation of Marine Ecosystems

was organized by Gdańsk University of Technology under auspices of European Commission and its financial support in the frame of 5th Outlined Program.

The main aim of the Course was to broaden and deepen knowledge of 40 young scientists (of M.Sc. degree and candidates for doctor's degree) from 17 countries, especially in the area of better understanding important problems connected with propagation and dissipation of sound in marine environment. The participants were also acquainted with many practical applications of up-to-date hydroacoustic systems in exploration and exploitation of marine ecosystems.

The Course was also an occasion for exchange of thoughts and experience between its participants as well as for triggering new contacts both professional and private.

The inaugurating lecture was devoted to presentation of new initiatives of European Commission in the frame of 6th Outlined Program. Six special lectures dealt with novel technologies in the area of hydroacoustics and remote sensing in exploration of marine environment resources. One of them on

Acoustical Oceanography of the Baltic Sea

was prepared and presented by Prof. Zygmunt Klusek, Institute of Oceanology, Polish Academy of Sciences.