data are effected to the TDC correction to be calculated. For Diesel Propulsion Engines indicator diagrams TDC correction the ME indirect values measurement readings to be taken, recorded & output data are effected to the TDC correction to be calculated.

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ОСОБЕННОСТИ ИСПОЛЬЗОВАНИЯ ЭЛЕКТРОННОГО ИНДИКАТОРА LEUTERT «DPI50 MIP CALCULATOR» ДЛЯ СУДОВЫХ ГЛАВНЫХ ДВИГЕТЕЛЕЙ ВНУТРЕННЕГО СГОРАНИЯ

А.Г. Таранин, кандидат технических наук

Настоящая публикация освещает следующие вопросы: правильное использование электронного индикатора при индицировании двухтактных двигателей внутреннего сгорания (ДВС); правильный перенос индикаторных диаграмм и результатов индицирования на ПК; корректировка верхней мёртвой точки ВМТ индикаторной диаграммы и корректный расчёт выходных значений характеристик двигателя, таких как P_{MI} – средне–индикаторное давление, P_{ME} – средне–эффективное давление, N_{IND} – индикаторная мощность и N_{EFF} – эффективная мощность для каждого цилиндра и двигателя в целом.

USAGE FEATURES OF THE LEUTERT «DPI50 MIP CALCULATOR» FOR SHIP'S PROPULSION DIESEL ENGINES

A.G. Taranin

The present publication illuminate the tasks as follows: Electronic indicator proper usage at two–stroke internal combustion engines (diesel engines) indication; Indication results & diagram proper transfer to PC; indicator diagram top dead center TDC correction and engine performance data output values such as P_{MI}–mean indicated pressure, P_{ME}–mean effective pressure, N_{IND}–indicated power and N_{EFF}–effective power proper calculations for each cylinder and engine total.

Keywords: Engine indication, performance data, electronic indicator, mean–indicated pressure, mean–effective pressure, indicated power, effective power.

Introduction

Currently on the worldwide fleet motor–vessels and shore diesel power plants for internal combustion engines–diesel engines indication and performance data measurement readings carrying–out the micro–processing gauging and systems, such as Doctor–Engine, Diesel–Doctor and Electronic indicators (different kind of brands and manufacturers) are used in most of cases. However, actually they are not carrying–out the functions of the engines technical condition (cylinder tightness, fuel injection equipment condition and turbocharger system condition) diagnostic and analysis, overload/download analysis and load distribution between the cylinders analysis, but they are electronic gauges for compression pressures P_{COM}, maximum combustion pressures P_{MAX} measurement by open indicator diagrams (Figures 1÷3) and closed indicator diagrams for each cylinder and for engine speed measurement at each cylinder indication. All others values are required for the engine technical condition diagnostic and analysis has determined by calculation from indicator diagrams or entered manually to the electronic equipment tables.

Examine the engine indication results from **«LEUTERT DPI50» MIP CALCULATOR (GMBH, Germany)**:

1) The values are measured by MIP calculator (Figure 3):
   - Cylinders maximum combustion pressure (bar) (Figure 3);
   - Cylinders pressure at TDC (compression pressure) (bar) (Figure 3);
   - Engine speed (rpm) (Figure 3);
2) The values are calculated from the indicator diagrams:
   - Cylinders indicator diagrams area AD (mm2);
   - Cylinders mean–indicated pressure PMICYL (bar) – by MIP calculator (Figure 3);
   - Cylinders mean–effective pressure PMECYL (bar);
   - Cylinders indicated power NINDCYL (IKW) – by MIP calculator (Figure 3);
   - Cylinders effective power NEFFCYL (EKW);
   - Engine average mean–indicated pressure PMIENG (bar) – by MIP calculator (Fig.3);
   - Engine average mean–effective pressure PMEENG (bar);
   - Engine indicated power NINDENG (IKW) – by MIP calculator (Figure 3);
   - Engine effective power NEFFENG (EKW);
   - Engine mechanical efficiency ηMEC (%).
3) The values are entered manually to the electronic equipment tables (Figure 3):
   - Scavenging air pressure after scavenging air cooler P_{SC}^{AC} (bar);
   - Cylinders exhaust gas temperatures T_{EXH}^{CYL} (^{O}C);
   - Cylinders fuel rack position FRP (fuel pump index FPI) (mm);
   - Cylinders VIT index (variable injection timing) (index);

Note: However, the mentioned above values are not enough for the engine technical condition full diagnostic and analysis (cylinder tightness, fuel injection equipment condition and turbocharger system condition).

In completion of indication data entering to the PC without TDC correction the engine average mean–indicated pressure & indicated power calculation can give tolerance up to ±10%, while the same values calculation from indicator diagrams are taken by mechanical indicator with usage of computerized technology gives tolerance up to ±0.5% only.

The engine average mean–indicated pressure and indicated power calculation tolerance up to ±10% is not satisfactory for the engine technical condition (cylinder tightness, fuel injection equipment condition and turbocharger system condition) diagnostic and analysis, overload/download analysis and load distribution between the cylinders analysis.

Thereby we suggest the engine (2–stroke engine) indicated power accurate calculation procedure, afterwards it is possible a TDC accurate correction for each cylinder, and then a cylinders mean–indicated pressure P_{MI}^{CYL}, cylinders indicated power N_{IND}^{CYL} & engine average mean–indicated pressure P_{MI}^{ENG} same accurate calculation within tolerance ±0.5%.

Work object

The high accuracy obtaining in the indicator diagram treatment and as results high accuracy in the cylinder power calculation, determination of load distribution between cylinders and cylinders/engine condition diagnostic & analysis without engine disassembling.

Ways of investigation

Investigations has carried out on the vessel's (with effective power from **436 EKW** up to **11915 EKW**) with different kind of micro-processing gauging and systems (Doctor–Engine, Diesel–Doctor and Electronic indicator) & with mechanical indicators.

Investigation results and discussion about

1. LEUTERT «DPI50 MIP CALCULATOR» (GMBH, Germany) introduction:
   1) In previous publication «USAGE FEATURES OF THE ELECTRONIC INDICATORS FOR SHIP'S AND SHORE POWER SUPPLY FOUR–STROKE INTERNAL COMBUSTION ENGINES (DIESEL ENGINES) we have introduced the **«HLV–2005 MK» MIP Calculator** (Praezisionsmesstechnik Beawert GMBH, Germany) (Picture 1), which has the cylinders TDC correction tolerance within 0.5^{O} CA.
   2) Presently we introduce the **«LEUTERT DPI50» MIP Calculator** (GMBH, Germany) with the cylinders TDC correction tolerance within 12.5^{O} CA (Picture 1).

HLV–2005 MK MIP CALCULATOR

TDC correction tolerance is 0.5° CA

Two sensor connections.

1. One pressure sensor with pressure transmitter, connected to the indicator cock.
2. One RPM peak–up sensor, connected to the fly-wheel frame

LEUTERT «DPI50 MIP CALCULATOR»

TDC correction tolerance is 12° CA

One sensor connections.

1. One pressure sensor with pressure transmitter, connected to the indicator cock.

Picture 1

2.The indicator diagrams TDC correction and each cylinder/total engine output data calculation after the 2–stroke Diesel Propulsion Engine MITSUI MAN–B&W type 6S50MC indication by the LEUTERT «DPI50 MIP CALCULATOR».

1) The Diesel Propulsion Engine performance data some measurement readings are taken during the indication (table 1):

Table 1

M/T. HAFID				UNIT NO:	1	GE RH:	85484.4	DATE:	27-Nov-17
MAIN ENGINE PERFORMANCE DATA (INDICATION)									
ENG.MAKER	MITSUI MAN-B&W	ENG.TYPE:	6S50MC (MCR 11640 BHP x 127 RPM)					SER No:	3866
DRAFT COND.	LADEN	FWD (M):	6.8	AFT (M):	8	MDL (M):	7,4	TRIM (M):	1,2
DISPLACEM.COND:	32,249	SEA CONDITION:			SMOOTH	ATMOS.PRESSURE (kg/cm^2)			1,0421
SEAWATER TEMPERAT (°C):	25	E/R TEMPERAT (°C):			34	WIND DIRECTION / FORCE:			A / 4 knts
		12,09	W 4knts C 0.2knts			8,70			
PROPELLER PITCH (M):	3,31	REDUCTION RATIO (-):			1	INDIC.TIME (MIN):			36
DISTANCE BY ENGINE (MLS):	7,25	DISTANCE BY OBSERV (MLS):			5,22	SLIP (%):			28,04
TIME(HR): 8	(MIN): 54	M/E REV.COUNT:			23801482	M/E F.O. FLOWMETER (KG):			7592742
TIME(HR): 9	(MIN): 30	M/E REV.COUNT:			23805033	M/E F.O. FLOWMETER (KG):			7593363

ENGINE SPEED		RPM	98,64	TURBOCHARGER		No.	LOC	REM
REMOTE / LOCAL			REM/LOC	TURBOCHARGER SPEED		RPM	11550	11550
GOVERNOR POSITION		UNIT	5,4	SCAVEN. AIR PRESSUR	DROP AT FILTER	mm.WC	20	
VIT INDEX SET AIR		kg/cm^2	4,9		DROP AT COOLER	mm.WC	191	
FPI INDICATION		MM	62		IN SCAV. MANIF.	kg/cm^2	[illegible]	1,78
FUEL OIL PRESSUR	BEFORE FILTER	kg/cm^2	7,4	EXHAUST GAS PRESSUR	EXH. MANIFOLD	kg/cm^2		
	AFTER FILTER	kg/cm^2	7.1		TURBINE INLET	kg/cm^2		
LUB.OIL PRESSUR	PISTON COOLING	kg/cm^2	2.543 / 2.8		TURBINE OUTLET	kg/cm^2		
	BEARINGS	kg/cm^2	2.497	SCAVEN AIR TEMPER	AIR FILTER INLET	°C	26	
	CAMSHAFT	kg/cm^2	3.313 / 3.6		AIR COOLER IN	°C	144	
	TURBOCHARGER	kg/cm^3	2.35 / 2.5		AIR COOLER OUT	°C	47	
WATER PRESSUR	HT FRESH WATER	kg/cm^2	3.463		IN SCAV.MANIFOLD	°C	45	47,5
	LT FRESH WATER	kg/cm^2	1 707	EXH.GAS TEMPER	TURBINE IN	°C	380	387,7
FUEL OIL TEMPER	ENGINE INLET	°C	118		TURBINE OUT	°C	259	262
	FL.METER INLET	°C	118	FR.WAT TEMPER	AIR COOLER IN	°C	22	
FUEL OIL DATA	SPEC.GRAV.@15	kg/ltr	0,9895		AIR COOLER OUT	°C	32	
	EXP. FACTOR	kg/ltr.C	0,000529	FR.WAT TEMPER	T / CHARGER IN	°C		
	SG AT FL METER	kg/ltr	0,9350		T / CHARGER OUT	°C	72	72
	SULPH. CONTENT	%	2,69	AIR COOLER DATA	TERMOEFFICIENCY	%	79,51	
	LOW. CAL.VALUE	kcal/kg	9580		EFF. POWER RATIO		0,99110	
FUEL OIL	VOLUME - Qfo	ltr/hr	1106,916	DATA	POWER COR.FACT.		0,99074	
FUEL OIL CONSUM	VOLUME - Qfo	ltr/hr	1106,916	DATA	POWER COR.FACT.		0,99074	
	MASS - Gfo	kg/hr	1035.000	INDICATOR SPRING FACTOR		mm/kg/cm	0,3	

CYLINDER No.		1	2	3	4	5	6	7	8
FRESH WATER	°C	81 / 80	80 / 82	80 / 82	79 / 80	79 / 80	79 / 82	REM/LOC	
TEMPERATURE	°C	IN	70					AVERAG	#ЗНАЧ!
PISTON COOLING	°C	49	48	48	49	48	48	REM	
TEMPERATURE	°C	IN	41					AVERAG	48,3
EXHAUST GAS	°C (REM)	346	344	318	335	320	333	AVERAG	332,7
TEMPERATURE	°C (LOC)	287	300	310	355	287	345	AVERAG	314,0
FUEL PUMP INDEX	mm	62	67,5	69	69,5	68	67,1	AVERAG	67,2
VIT INDEX	mm	7,75	7,81	7,79	7,78	7,7	7,7	AVERAG	7,76
SC.AIR PRESSURE	kg/cm^2	1,78	1,78	1,79	1.79	1,77	1,8	AVERAG	1,785
SC.AIR BOX TEMP.	°C	52	53	51	50	50	51	AVERAG	51,2

2) The Diesel Propulsion Engine ambient (reference) conditions and FO data from shop trial test results (table 2):

Table 2

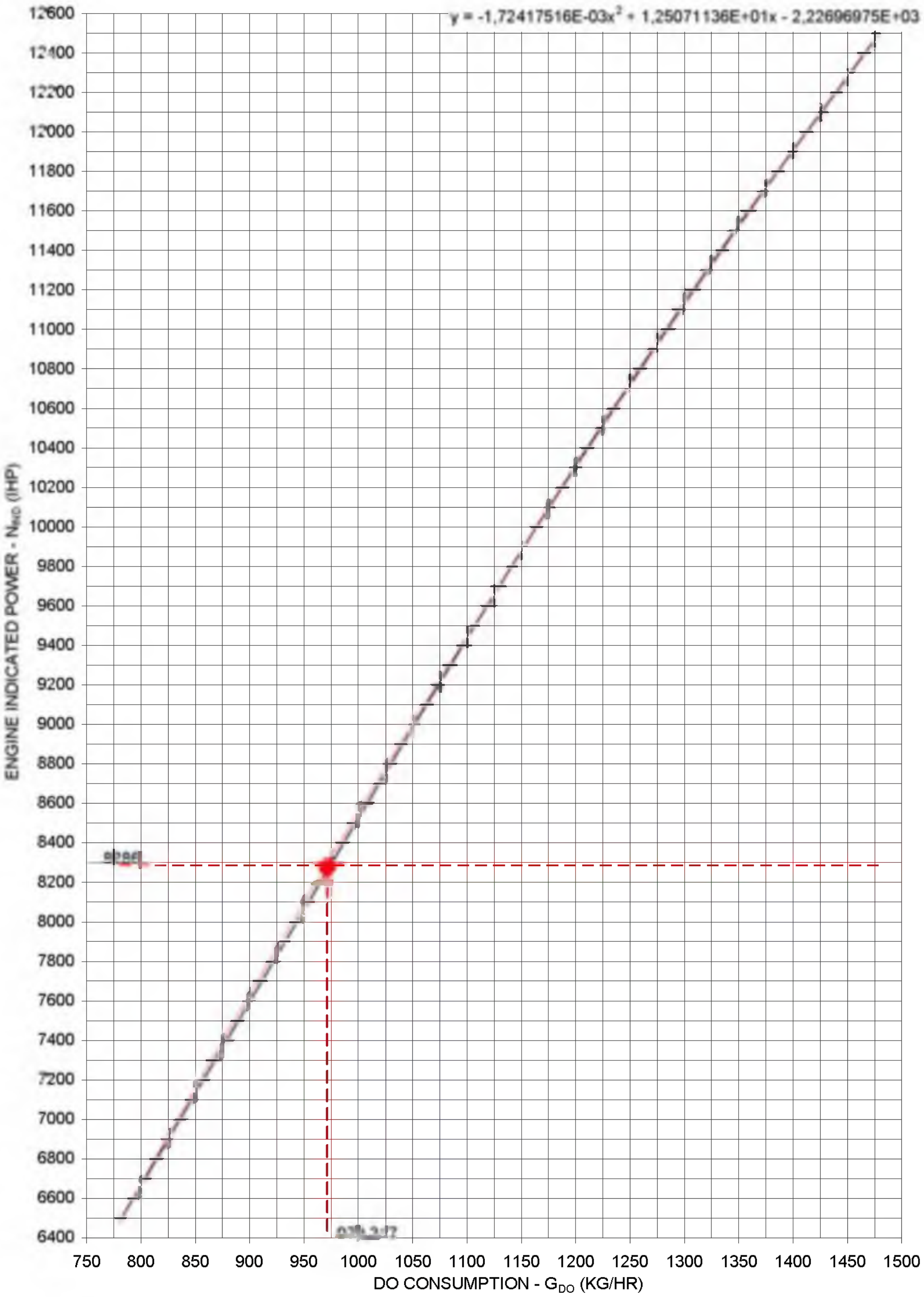
FUEL OIL STAND	SG AT 15^{o}C	EXPANS FACTOR	SG AT FLOWM	SULPHUR CONTENT	LOW CAL VALUE	BAROM PRESSUR	BAROM PRESSUR	AMB.AIR TEMPER	SEA WAT TEMPER	ENG / R TEMPER
BUNKER	kg / ltr	kg / ltr.C	kg / ltr	%	kcal / kg	BAR	kg / cm^2	^{o}C	^{o}C	^{o}C
A	0,8686	0,000688	0,8664	0,41	10124	1,02475	1,0449	15,25	12	18,2

3) The Diesel Propulsion Engine FO consumption G_{FO} correction to the shop trial test reference conditions:

$$G_{DO} = \frac{F_{PC} \cdot G_{FO} \cdot LCV}{LCV_{ST}} = \frac{0.99074 \cdot 1035 \cdot 9580}{10124} = 970.317 \text{ kg / hr}$$

4) Draw the diagram of the engine indicated power dependence of FO consumption from shop trial test results table and found its dependence function by the trend line (Diagram 1):

Diagram 1



5) The engine calculated indicated power by the function is founded from the diagram 1:

$$N^1_{IND} = -1.72417516\cdot10^{-3}\cdot G^2_{DO} + 12.5071136\cdot G_{DO} - 2226.96975 =$$

$$= -1.72417516\cdot10^{-3}\cdot970{,}17^2 + 12.5071136\cdot970{,}17 - 2226.96975 = 8286 \text{ IHP}$$

6) The Diesel Propulsion Engine turbocharger speed N_{TC} correction to the shop trial test reference conditions:

$$N^{ST}_{TC} = N_{TC}\cdot\sqrt{\frac{(273+T_{INL})}{(273+T_{ER})}} = 11550\cdot\sqrt{\frac{(273+18.2)}{(273+26)}} = 11398 \text{ rpm}$$

7) Draw the diagram of the engine indicated power dependence of turbocharger speed from shop trial test results table and found its dependence function by the trend line (in the same way as Diagram 1):

8) The engine calculated indicated power by function is founded from the diagram in item (7):

$$N^2_{IND} = 8.8575327095\cdot10^{-8}\cdot N^{ST3}_{TC} - 2.996666216\cdot10^{-3}\cdot N^{ST2}_{TC} + 35.095114098\cdot N^{ST}_{TC} -$$

$$-132825.59199 =$$

$$= 8.8575327095\cdot10^{-8}\cdot11398^3 - 2.996666216\cdot10^{-3}\cdot11398^2 + 35.095114098\cdot11398 -$$

$$-132825.59199 = 9038 \text{ IHP}$$

9) The Diesel Propulsion Engine multiply FRP $\cdot$ n_{ENG} correction to the shop trial test reference conditions:

$$FRP_{ST}\cdot n_{ENG} = \frac{F_{PC}\cdot FRP\cdot n_{ENG}\cdot LCV\cdot\rho_{FO}{}^T}{LCV_{ST}\cdot\rho_{ST}{}^T} = \frac{0.99074\cdot67.2\cdot98.64\cdot9580\cdot0.935}{10124\cdot0.8664} =$$

$$= 6705 \text{ mm}\cdot\text{rpm}$$

10) Draw the diagram of the engine indicated power dependence of multiply $FRP_{ST}\cdot n_{ENG}$ from shop trial test results table and found its dependence function by the trend line (in the same way as Diagram 1):

11) The engine calculated indicated power by function is founded from the diagram in item (10):

$$N^3_{IND} = 2.2980478332\cdot10^{-8}\cdot(FRP_{ST}\cdot n_{ENG})^3 - 5.59619123\cdot10^{-4}\cdot(FRP_{ST}\cdot n_{ENG})^2 +$$

$$+ 5.758496945\cdot(FRP_{ST}\cdot n_{ENG}) - 11287.324114 =$$

$$= 2.2980478332\cdot10^{-8}\cdot6705^3 - 5.59619123\cdot10^{-4}\cdot6705^2 + 5.758496945\cdot6705 -$$

$$-11287.324114 = 9092 \text{ IHP}$$

12) The Diesel Propulsion Engine scavenging air pressure correction to the shop trial test reference conditions:

$$P^{ST}_{SC} = P_{SC} + 0.002856\cdot(T_{INL} - T_{ER})\cdot(P_{ATM} + P_{SC}) - 0.00222\cdot(T^{BC}_{FW} - T^{BC}_{SW})\cdot(P_{ATM} + P_{SC}) =$$

$$= 1.785 + 0.002856\cdot(26 - 18.2)\cdot(1.042 + 1.785) - 0.00222\cdot(22 - 12)\cdot(1.042 + 1.785) =$$

$$= 1.785 \text{ kg/cm}^2$$

13) Draw the diagram of the engine indicated power dependence of scavenging air pressure from shop trial test results table and found its dependence function by the trend line (in the same way as Diagram 1):

14) The engine calculated indicated power by function is founded from the diagram in item (13):

$$N^4_{IND} = -99.5049482\cdot P^{ST2}_{SC} + 4301.15896\cdot P^{ST}_{SC} + 1909.04582 =$$

$$= -99.5049482\cdot1.785^2 + 4301.15896\cdot1.785 + 1909.04582 = 9270 \text{ IHP}$$

15) The engine average indicated power is calculated by the indirect values:

$$N^{AVR}_{IND} = \frac{N^1_{IND} + N^2_{IND} + N^3_{IND} + N^4_{IND}}{4} = \frac{8286 + 9038 + 9092 + 9270}{4} = 8921 \text{ IHP} = 6562 \text{ IKW}$$

16) Enter the engine indication and performance data to the PC (Fig.1, Fig.2).

Conclusion: As we have seen from the Fig.1 the engine all cylinders indicator diagrams compression lines are in different position (arrow 1), that is not to be for the same designed cylinders. They to be in one line that is supposed to be adjusted by cylinders TDC correction individually **(But in the LEUTERT «DPI50 MIP CALCULATOR» attached computerize program this particular correction is possible within tolerance 12.5^{O} that is not acceptable for future analysis)**. As we have seen from the Fig.3 the engine indicated power is 5432 IKW instead of calculated in item (15) 6562 IKW, that is become «–20.8%» tolerance, which is not acceptable for the engine technical condition diagnostic and analysis. We have to correct the engine cylinders TDC totally.

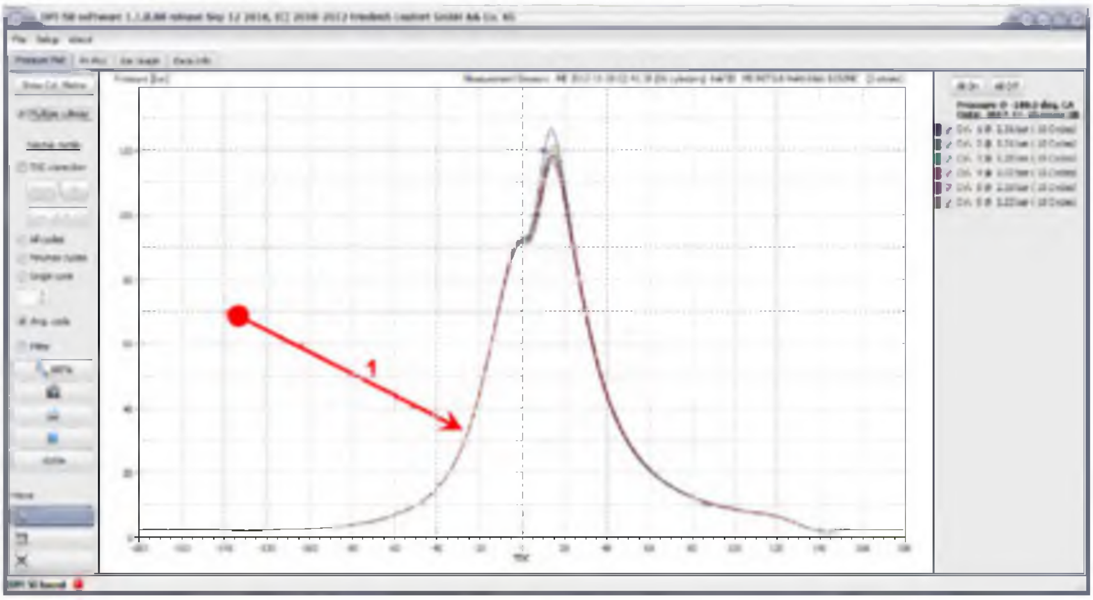


Figure 1 – Cylinders open type indicator diagrams before TDC correction

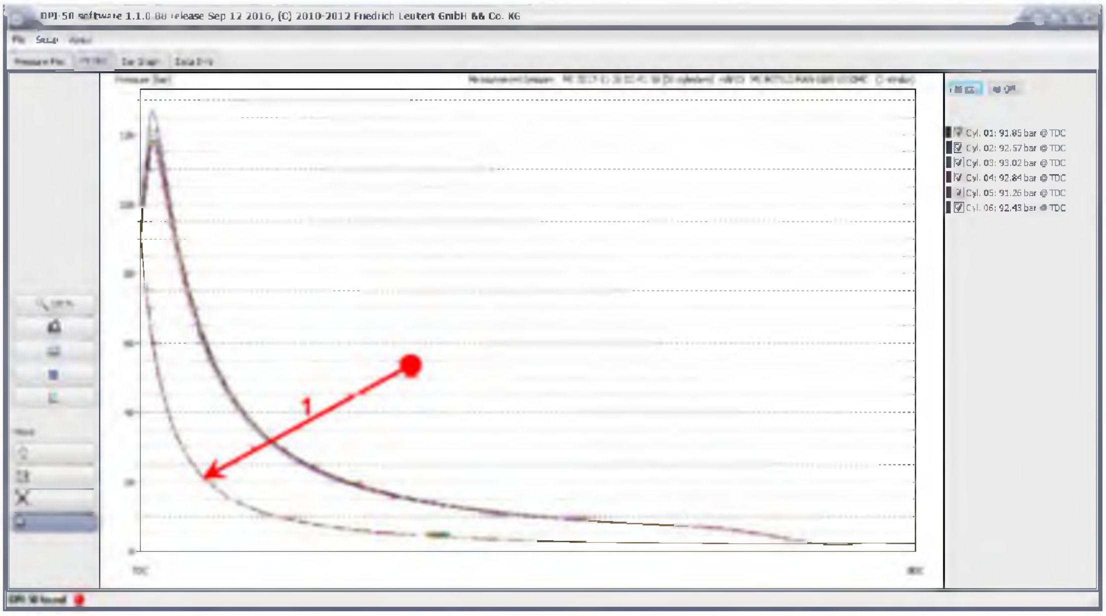


Figure 2 – Cylinders closed type indicator diagrams before TDC correction

DPI-50 software 1.1.0.88 release Sep 12 2016, (C) 2010-2012 Friedrich Leutert GmbH && Co. KG

File Setup About

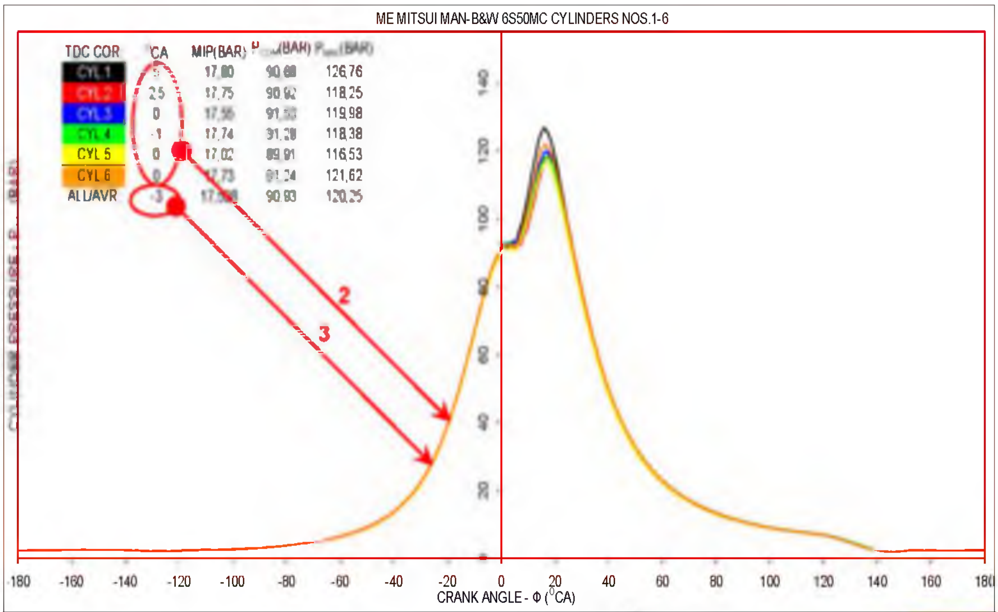
Pressure Plot | PV Plot | Bar Graph | Data Info

Measurement Session: ME 2017-11-28 02:41:38 (06 cylinders) HAFID ME MITSUI MAN-B&W 6S50MC (2-stroke)

	Cyl. 1	Cyl. 2	Cyl. 3	Cyl. 4	Cyl. 5	Cyl. 6	Mean	Total
Date	2017-11-27	2017-11-27	2017-11-27	2017-11-27	2017-11-27	2017-11-27		
Time	09:25:28	09:26:56	09:28:47	09:31:01	09:33:04	09:34:38		
Average cycles	10	10	10	10	10	10		
Pmax_av [bar]	126.76	118.25	119.98	118.38	116.53	121.62	120.25	—
Pmax_max [bar]	129.63	120.78	120.90	120.52	119.10	122.95	122.31	—
Pmax_low [bar]	122.93	116.54	118.11	115.97	114.61	119.95	118.02	—
MIP [bar]	15.07	14.69	14.53	14.57	14.22	15.02	14.68	—
Deviation [bar]	6.51	-2.00	-0.27	-1.87	-3.72	1.37	0.00	—
Ptdc [bar]	91.85	92.57	93.02	92.84	91.26	92.43	92.33	—
RPM [1/min]	99.29	98.54	98.55	98.19	97.49	99.67	98.62	—
Ind. power [kW]	935.10	905.03	894.92	894.45	866.42	935.98	905.32	5431.90
Boost pressure [bar]	1.75	1.75	1.75	1.75	1.75	1.75		
Exhaust gas temp. [deg. C]	0	0	0	0	0	0		
Fuel rack setting	62.00	67.50	69.00	69.50	68.00	67.10		
VIT setting	7.75	7.81	7.79	7.78	7.70	7.70		
Additional information								

Export to Excel

Figure 3 – Cylinders indication & performance data table before TDC correction



MEAN INDICATED	kg/cm²	18,27	18,21	18,01	18,20	17 47	18,19		
PRESSURE	kg/cm²							AVERAG	18,06
INDICATED POWER	IHP	1501,4	1496,4	1480,1	1495,9	1435,9	1494,9		
	IHP	TOTAL	8905	IKW	6549			AVERAG	1484,1
MEAN EFFECTIVE	kg/cm²	17,21	17,15	16,96	17,15	16,42	17,14		
PRESSURE	kg/cm²							AVERAG	17,00
EFFECTIVE POWER	BHP	1414,8	1409,9	1393,6	1409,4	1349,3	1408,4		
	BHP	TOTAL	8386	LOAD (%)	71,02	EF-CY (%)	94,17	AVERAG	1397,6

Figure 4 – Cylinders open indicator diagrams after TDC correction by developed program

17) As it is mentioned above in item (16) that by the «LEUTERT DPI50» MIP CALCULATOR attached computerize program cylinders TDC correction is possible within tolerance 12.5° and that is not acceptable for future analysis, we have to develop the correction program (Figure 4).

18) Engine cylinders TDC correction program development (Figure 4).

19) Correct the engine cylinders TDC individually at first for making the diagrams compression lines in one line (arrow 2), then totally for making the engine indicated power same as calculated in item 15 (arrow 3), (Figure 4):

Cylinder 1 TDC = 5°CA; Cylinder 2 TDC = –2.5°CA; Cylinder 3 TDC = 0°CA;

Cylinder 4 TDC = – 1°CA; Cylinder 5 TDC = 0°CA; Cylinder 6 TDC = 0°CA;

All Cylinders TDC = –3°CA;

Conclusion: As we have seen from the figure 4 the engine all cylinders indicator diagrams compression lines are in one line after TDC correction (arrow 2), that is what to be for the same designed cylinders. As we have seen from the same figure the engine indicated power is 6550 IKW and almost the same with calculated in item (15) 6562 IKW, that – is become «–0.2%» tolerance, which is perfect for the engine technical condition diagnostic and analysis.

20) The Diesel Propulsion Engine mechanical loss pressure calculation:

a) ME Turning Gear technical data from instruction manual (Table 3):

Table 3

Turning gear electromotor amperage	I^{ELM}	A	from turning gear technical data	4.9
Turning gear electromotor voltage	U^{ELM}	V	from turning gear technical data	440
Turning gear electromotor phases Nos	m	-	from turning gear technical data	3
Turning gear electromotor active load	P^{ELM}	HP	from turning gear technical data	3
Turning gear electromotor total load	S^{ELM}	HP	$S^{ELM} = 1.3596 \cdot m^{0,5} \cdot U^{ELM} \cdot I^{ELM} / 10^3$	5.077
Turning gear electromotor power factor	$\cos\varphi^{ELM}$	-	$\cos\varphi^{ELM} = P^{ELM} / S^{ELM}$	0.59088
Turning gear electromotor frequency	F^{ELM}	Hz	from turning gear technical data	60
Turning gear electromotor pole's pairs No	p	-	from turning gear technical data	3
Turning gear electromotor speed	n^{ELM}	rpm	$n^{ELM} = 60 \cdot F^{ELM} / p$	1200
Turning gear electromotor speed	n^{ELM}	rpm	from turning gear technical data	1155
Turning gear speed	n^{TG}	rpm	from turning gear technical data	1.04
Turning gear angular velocity	ω^{TG}	1/sec	$\omega^{TG} = \pi \cdot n^{TG} / 30$	0.10891
Turning gear output shaft torque	M^{TG}	N · mtr	from turning gear technical data	15696
Turning gear output shaft power	N^{TG}	HP	$N^{TG} = 1.3596 \cdot M^{TG} \cdot \omega^{TG} / 1000$	2.32414
Turning gear mechanical loss power	$N_{MEC}{}^{TG}$	HP	$N_{MEC}{}^{TG} = P_{ELM} - N^{TG}$	0.67586
Turning gear mechanical efficiency	η_{MEC}	-	$\eta_{ME}{}^{TG} = N^{TG} / P^{ELM}$	0.7747

b) ME mechanical loss pressure calculation by the turning gear operation data at ME opened indicator cocks (Table 4):

Table 4

Turning gear electromotor amperage	I	A	by observation	2,75
Turning gear electromotor voltage	U	V	by observation	446
Turning gear electromotor active load	P	HP	$P = 1.3596 \cdot m^{0,5} \cdot U \cdot I \cdot \cos\varphi / 10^3$	1,707
Turning gear output shaft power	N	HP	$N = P - N_{MEC}^{TG}$	1,031
ME turning time for 1 rev.by turning gear	t	sec	by observation	298
ME speed by turning gear	n^{ME}	rpm	$n^{ME} = 60 / t$	0,20134
ME mechanical loss pressure	P_{MEC}^{ME}	kg / cm^2	$P_{MEC} = N / (K \cdot n^{ME} \cdot i)$	1,024
ME mechanical loss pressure	P_{MEC}^{ME}	bar	$P_{MEC}^{BAR} = P_{MEC} / 1.0197$	1,004

21) The Diesel Propulsion Engine mean–effective pressure calculation:

$$P_{ME} = P_{MI} - P_{MEC} = 18.06 - 1.024 = 17.04 \text{ kg / cm}^2$$

where: P_{MI} = 18.06 kg/cm² – from the engine performance data results table (figure4);

P_{MEC} = 1.024 kg/cm² – from item (20), sub–item (b).

22) The Diesel Propulsion Engine effective power calculation:

$$N_{EFF} = k \cdot P_{ME} \cdot n \cdot i = 0.833238 \cdot 17.04 \cdot 98.64 \cdot 6 = 8905 \text{ BHP} = 6550 \text{ EKW}$$

where: $k = 1.745 \cdot D^2 \cdot S \cdot m = 1.745 \cdot 0.5^2 \cdot 1.91 \cdot 1 = 0.833238$ – cylinder constant;

D = 0.5 mtr – cylinder diameter;

S = 1.91 mtr – piston stroke;

m = 1 – stroke factor (four–strike engine m = 2, two–stroke engine m = 1).

Conclusion

As we have seen from mentioned above information for Diesel Propulsion Engines indicator diagrams TDC correction the ME indirect values measurement readings to be taken, recorded & output data are effected to the TDC correction to be calculated.

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