POWER EQUIPMENT EXPERIMENT（1）

动力设备实验

（一）

廖和德　闵桂兰　郑国杰　刘建华　编著

陈景锋　主审

- 船舶柴油机实验
- 轮机维护与修理实验
- 船舶管理实验（轮机）

大连海事大学出版社

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内容提要

本书三篇共十章，采用汉英双语编写。主要内容有：船舶柴油机课程实验、轮机维护与修理课程实验和船舶管理(轮机)课程实验。按照大学实验教学大纲的要求，每项实验均编写了实验目的、实验内容、实验设备、实验方法和实验报告。

本书可作为高等航海院校船舶轮机专业本科、专科学生的实验教材，也可作为有关方面技术人员的参考用书。

Abstract

This book is written in bilingual languages (in Chinese and English), consisting of 10 chapters, covering 3 courses, of which the main contents are Experimental Course of Marine Diesel Engine, Experimental Course of Marine Machinery Maintenance and Repair as well as Experimental Course of Ship Management(Marine Engineering). Based on the requirements of our university experiment teaching syllabus, the experimental contents for each course cover experiment purposes, experiment items, experiment equipment, experimental methods and experiment reports.

This book is mainly used as the textbook for the marine engineering students in colleges and universities, but also, the concerned technicians can use it as a reference book in their work.

前 言

本书是《动力设备实验》系列教材之一。书中涵盖了“船舶柴油机实验”、“轮机维护与修理实验”和“船舶管理实验”三门轮机课程实验的内容。本书是按照大学轮机工程专业本科的实验教学大纲的要求，并结合集美大学船舶柴油机实验室、轮机维护与修理实验室和船舶防污染实验室中现有的设备及有关资料进行编写的。上述三门的课程实验合编为一本，不仅丰富了教材内容，节省了成本，而且也方便了学生的学习与使用。

本书从收集资料到完稿前后历时两年多。在编写的过程中力求做到突出重点、简明扼要、图文并茂。按照大学实验教学大纲的要求，每项实验均编写了实验目的、实验内容、实验设备、实验方法和实验报告。本书主要作为大学轮机专业学生船舶柴油机实验、轮机维护与修理实验、船舶管理实验的教材，也可作为有关方面技术人员的参考用书。

本书采用汉英双语的形式编写，由廖和德、闵桂兰、郑国杰、刘建华合作编写。“船舶柴油机实验”英文初稿由郑国杰编译，中文稿是在林金田编写的原文本的基础上由廖和德改编；“轮机维护与修理实验”由郑国杰编写；“船舶管理实验(轮机)”由刘建华编写。

廖和德、闵桂兰担任《动力设备实验》系列教材的总主编。本书中英双语版的前言、目录、插图、表格等主要由廖和德、闵桂兰编写，并负责统稿以及本书中英文稿的全面修改，尤其是对英文稿件进行了逐段逐句的修改。书中部分插图由廖闵闽绘制或修改。

趁本书出版之际，感谢相关技术资料或说明书的原编者。在编写本书的过程中，得到了集美大学轮机工程学院领导、同事的支持和学生们的帮助；张天野副教授和戴乐阳副教授分别审阅了书中相关内容；陈景锋教授担任本书的主审，认真审阅了本书各章内容并提出了宝贵的意见。在出版的过程中，还得到大连海事大学出版社的支持。对此，一并表示衷心的感谢。

由于编者水平和资料有限，不当之处在所难免，恳请各位读者不吝指出。

编 者

2011 年 10 月

Foreword

This textbook is the first book of *Power Equipment Experiment* series textbook. It covers all contents about Marine Diesel Engine Experiment, Marine Machinery Maintenance and Repair Experiment and Ship Management Experiment (Marine Engineering). This book is written and compiled in accordance with the experimental teaching syllabus for the undergraduate students of the marine engineering (management), also it is written and compiled according to the related materials and the existing equipment and facilities in Marine Diesel Engine Laboratory, Marine Machinery Maintenance and Repair Laboratory, and Ship Pollution Prevention Laboratory. The above three experimental courses now are compiled into one book, which not only enriches the teaching materials, saves the cost, but also facilitates the students' learning and use.

It takes the compilers more than two years to complete this book from the collection of information to the finalization. In the writing and compilation, the compilers of the book attach great importance to the key points, trying to be brief and to the point, and also to explain the professional theoretical knowledge by means of illustrations, excellent pictures and drawings. Based on our university experiment teaching syllabus, the experimental contents for each course cover experiment purposes, experiment items, experiment equipment, experimental methods and experiment reports. This book is mainly used as the textbook for the marine engineering students in colleges and universities, but also, the concerned technicians can use it as a reference book in their work.

This book is co-compiled by Mr. Liao Hede, Ms. Min Guilan, Mr. Zheng Guojie, and Mr. Liu Jianhua. It is written in bilingual languages (in Chinese and English).

The English translation of Marine Diesel Engine Experiment is compiled by Mr. Zheng Guojie, and its Chinese text is adapted by Mr. Liao Hede from the Chinese manuscript written by Mr. Lin Jintian. Marine Machinery Maintenance and Repair Experiment is also written by Mr. Zheng Guojie, Ship Management Experiment (Marine Engineering) is written by Mr. Liu Jianhua.

It is Mr. Liao Hede and Ms. Min Guilan who are the general chief editors of the book *Power Equipment Experiment.* Both Chinese and English editions of the foreword, the table of contents, all drawings and pictures are mainly compiled by Mr. Liao Hede and Ms. Min Guilan, who are also responsible for editing the whole book and for revising both Chinese and English manuscripts, especially, they spend plenty of time reading and revising all English manuscripts from paragraph by paragraph to sentence by sentence. In addition, some of illustrations and pictures in the book are drawn or revised by Ms. Liao Minmin.

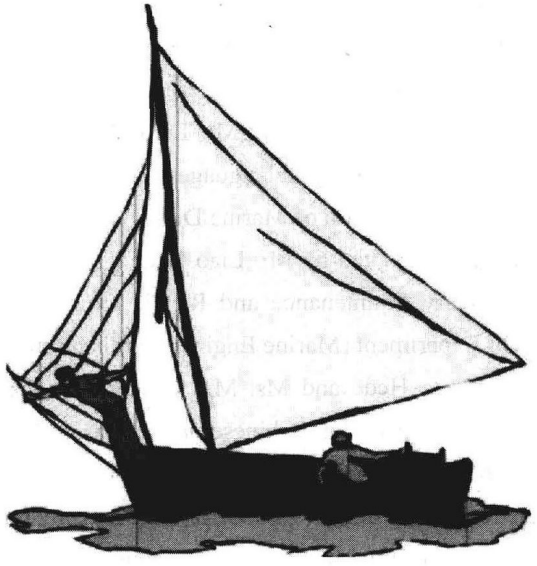
Take advantage of the occasion of the book publication, we would like to express our sincere thanks to the writers and compilers of the original technology materials or instruction books. During the compilation, we have got the help and support from the leaders, the colleagues, our students in Marine Engineering Institute of Jimei University. Associate professors, Mr. Zhang Tianye and Mr. Dai Leyang respectively read and make some revisions for some related contents of the book. Mr Chen Jingfeng has

taken time from his busy schedule to read the whole book and puts forward some valuable suggestions. To publish this book, we have also received the help and support from Dalian Maritime University Press. To all of the above people, along with many others that space does not permit us to name, we extend our most sincere thanks.

This book is of course not without its errors and oversights, due to limited materials and limitations in our human capabilities and also a hectic schedule. We sincerely hope that our readers and users will kindly share any comments and suggestions, so that we may further improve it in future revisions.

Compilers

Oct. 2011



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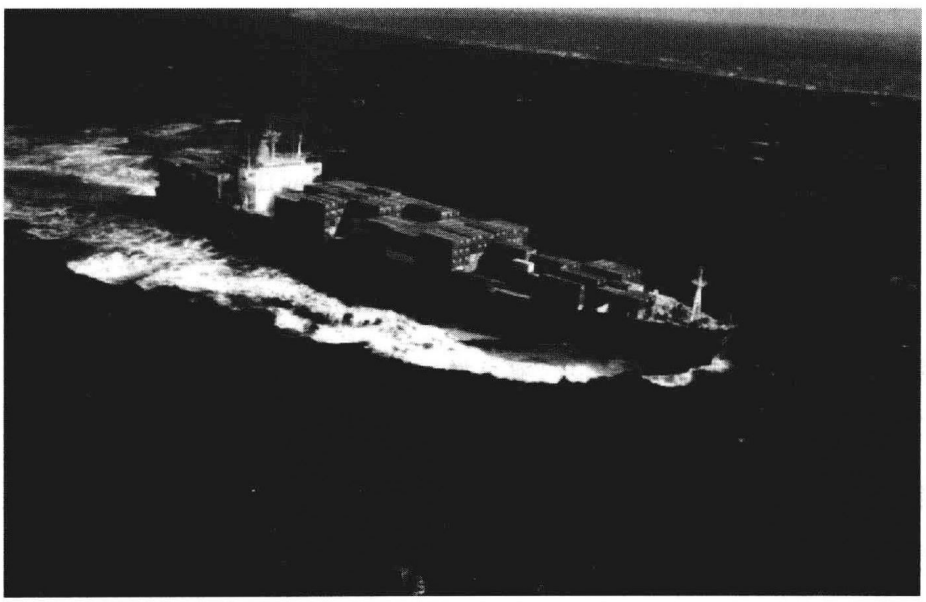

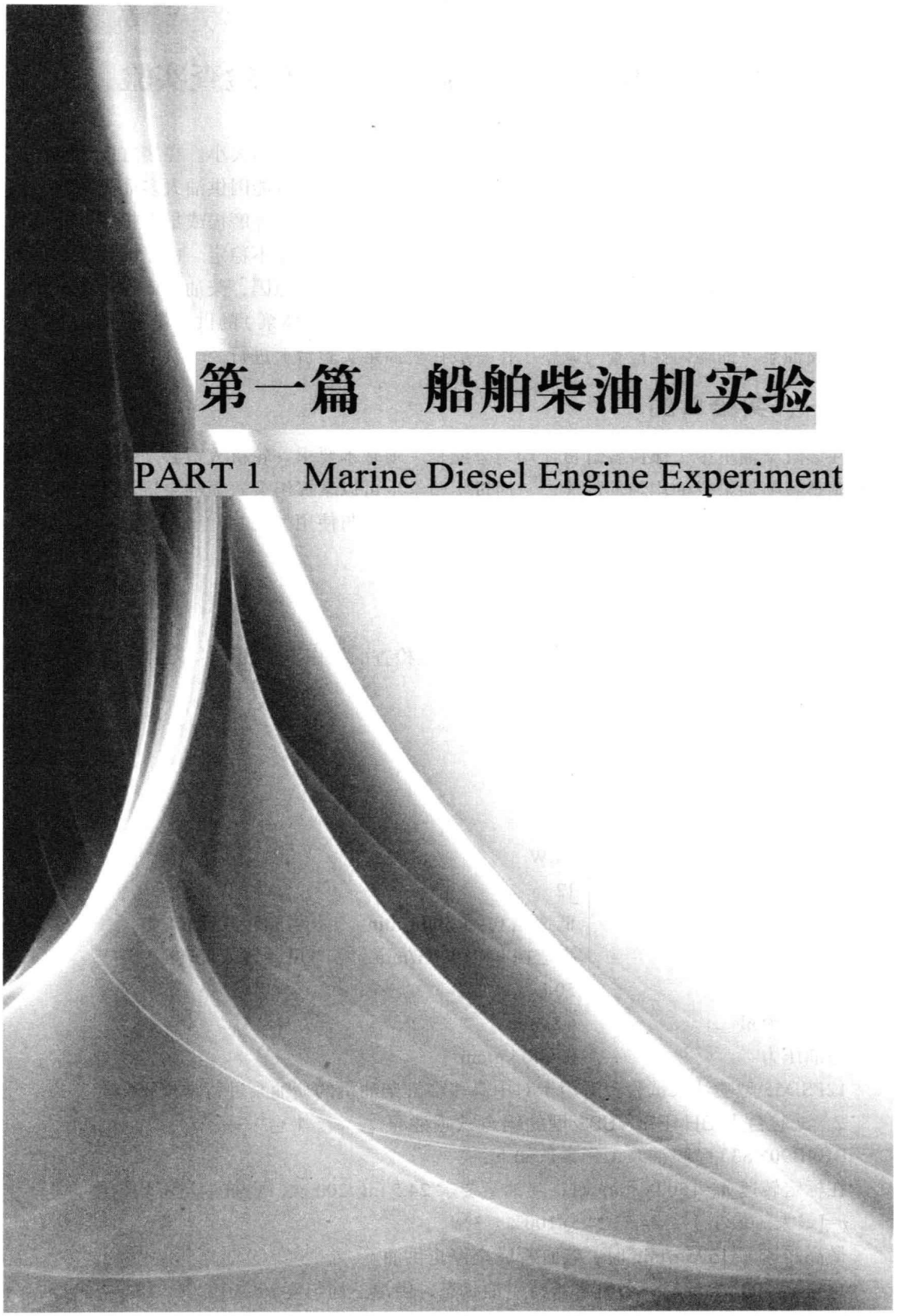

第一篇　船舶柴油机实验

PART 1　Marine Diesel Engine Experiment

第一章　柴油机喷油泵供油均匀性检查实验

柴油机每一循环中气缸中喷入的柴油量，决定于柴油机功率的大小。在多缸柴油机中，各缸供油量应该相等，否则在柴油机高负荷工作时，某些气缸可能因供油太多而超负荷，使组成燃烧室的零件和运动部件因机械负荷和热负荷增大而产生严重磨损或早期损坏；在低负荷时，某些气缸又可能因供油量太少不能发火，造成柴油机工作不稳定。由于喷油泵零件制造质量上的差别和使用中磨损程度不同以及安装调整不准确等原因，柴油机工作中各缸供油量会出现不均匀。为此需要在维修中或运行后对各分泵（或单体泵）的供油量进行检查调整。组合式喷油泵供油均匀性检查与调整工作一般在喷油泵实验台上进行。

一、实验目的

在多缸柴油机中，保持各缸负荷均匀分配是一项基本要求。轮机人员必须具有分析、测量和调整各喷油泵供油均匀性的能力。通过实验学生可以掌握组合式喷油泵供油均匀性检查与调整的一般方法，进而了解喷油泵的工作要求、维护与使用方法。

二、实验内容

（1）组合式喷油泵供油均匀性检查与调整。

（2）学会在实验台上进行喷油泵供油均匀性检查的操作步骤。

（3）掌握供油均匀性调整方法。

三、实验设备

1. 12PSD55 喷油泵试验台1 台

主要技术参数

主轴最大输出功率	4 kW	
可试缸数	12	
转速范围	低速挡 0 ~ 1 500 r/min	可顺转或反转
	高速挡 0 ~ 3000 r/min	可顺转或反转
油箱容积	50 L	
输油泵流量	6 L/min	
输油压力	0 ~ 40 kg/cm^2	

12PSD55 型喷油泵试验台适用于对中高速多缸柴油机的喷油泵进行常规校验。

2. 试验台上 BH4B90YS33 型的组合式喷油泵　　1 台

BH4B90YS33 型喷油泵工作参数如下：

在标定转速 n_b=1500 r/min 时，喷油量要求 24.5 mL/200 次，各缸油量不均匀度 ρ=[最大（最小）－24.5]/24.5×100%≤3%。

最高转速 n=1575 r/min 时，各缸都完全停止供油。

怠速 n=500 r/min 时，各缸都维持供油状态，供油不均匀度 ρ≤30%。

图 1-1 为 12PSD55 喷油泵试验台外部结构图。图 1-2 为 12PSD55 喷油泵试验台内部结构图。控制屏上有计数按钮和调速旋钮。计数器的电源开关、次数转换开关和闪光灯的电源开关等安装在控制箱的顶部。次数转换开关的前方还有一个计数计时转换开关。

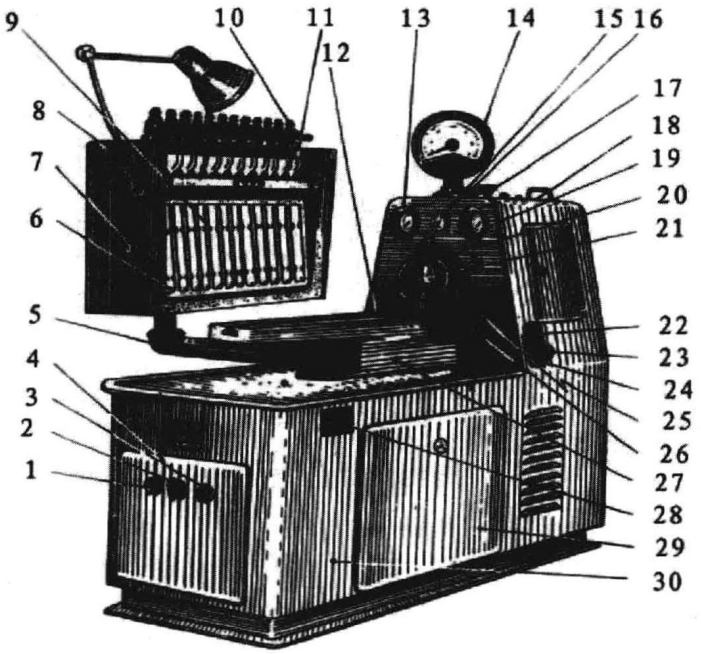

图 1-1 12PSD55 喷油泵试验台外部结构图

1－加热器开关；2－总开关；3－输油泵开关；4－强电箱；5－转臂；6－量油管；7－旋钮；8－测量机构；9－卡子；10－喷油器总成；11－消雾器罩；12－进回油接头；13－低压压力表；14－转速表；15－油温表；16－调压阀手柄；17－截止阀手柄；18－控制箱；19－高压压力表；20－刻度盘；21－万向联轴节；22－计数按钮；23－调速旋钮；24－控制屏；25－闪光插座；26－供油接头；27－导轨；28－启动按钮；29－右侧门；30－机身

四、实验步骤

组合式喷油泵供油均匀性检查与调整

（1）喷油泵试验台启动检查，喷油次数选择 200 次。根据该喷油泵的标定转速 n_b=1500 r/min，选择喷油泵试验台转速应为 750 r/min。

（2）启动试验台油泵，旋转调速旋钮使喷油泵试验台运转，推动喷油泵油门手柄至标定位置，观察各泵是否正常喷油，待正常工作时停车，并转动旋钮倒空量杯，泄放各玻璃量杯内的燃油，然后复位。

（3）重新启动运转，转速为 750 r/min，推动喷油泵油门手柄至标定位置，待各泵正常喷油后，按下计数器按钮，这时量油挡板被吸入，燃油流入量杯。喷油 200 次后挡板推出，油杯所盛燃油即 200 次喷油量，然后停车。

（4）读出各缸量杯油量，并记录。

（5）转动量筒放油手柄，泄放各玻璃量筒内的燃油并复位。重复上述测量并记录。计算两次测量值的算术平均值。

（6）以 24.5 为标准值，计算各泵供油不均匀率 ρ=[最大（最小）－24.5]/24.5×100%。对 ρ > 5%的喷油泵应进行调整。该调整只能作微量调整，否则会引起喷油泵零位的变化。

（7）调整方法：松开相应单体泵上调节齿圈的锁紧螺钉，改变齿圈在齿套上的周向位置，即可改变供油量。调整之后应重新测定各泵供油均匀性，直到满意为止。

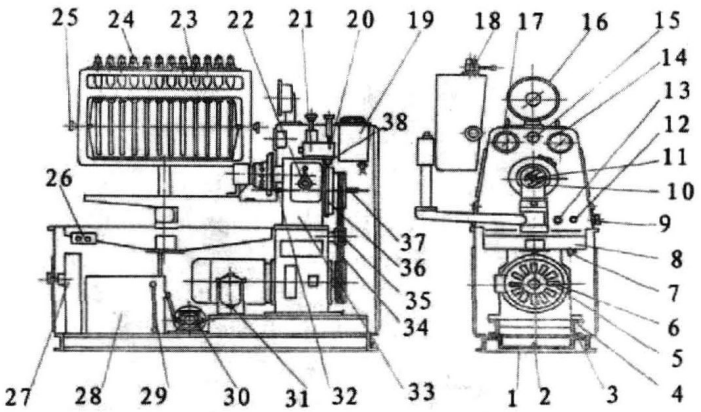

图 1-2　12PSD55 喷油泵试验台内部结构图

1－下底座；2－放油口；3－防振垫；4－上底座；5－转差离合器；6－电机；7－放油龙头；8－污油槽；9－控制屏；10－传动盘；11－万向节；12－闪光插座；13－供油接头；14－高压表；15－油温表；16－转速表；17－低压表；18－喷油器总成；19－控制箱；20－闸阀；21－调压阀；22－变速手柄；23－消雾器；24－量杯；25－量杯倒空旋钮；26－启动/停止按钮；27－强电箱；28－油箱；29－油面计；30－输油泵；31－滤清器；32－计数头；33－变速箱；34－三角带；35－张紧轮；36－测速轮；37－测速轴；38－测速头

五、实验报告

1. 组合式喷油泵供油均匀性检查与调整记录，见表1-1。
2. 对组合式喷油泵供油均匀性发生变化的原因分析。

表 1-1　标定转速 1500 r/min 时组合式喷油泵供油记录表

泵　号 / 测量次数	1	2	3	4	平均
第一次测量（mL）					
第二次测量（mL）					
平均（mL）					
供油量不均匀率(ρ)					
调整后（mL）					

Chapter 1 Experiment of Diesel Engine Injection Pump Oil Supply Uniformity Check

The amount of fuel injected into the diesel engine cylinder in each cycle depends on the engine power. With multi-cylinder diesel engine, each cylinder should be provided the same amount of fuel. If not, some cylinder will be overloaded due to too much fuel delivered when the engine operates at high load, which will make the components and the moving parts of the combustion chamber are worn out or early seriously damaged due to the increase of mechanical stress and thermal stress. And when the diesel engine works at low load, unstable running may take place because of failure ignition in some cylinders due to not enough fuel delivered. The amount of fuel injected into each cylinder appears uneven may result from the following causes of fuel injection pump parts manufacturing quality difference and different wear degrees in use, together with incorrect installation and adjustment. Therefore, it is necessary to check and adjust the amount of oil supply for each pump (monomer pump) during maintenance or after a period of running. The oil supply uniformity check and adjustment for the assembled-type injection pump is generally carried out at the fuel injection pump test-bed.

A. Experiment Purposes

As to multi-cylinder diesel engine, it is a basic requirement to maintain uniform distribution of the load to each cylinder. Engineers must have an ability to analyze, measure and adjust the oil supply uniformity of each injection pump. The experiment will enable students to know well the general methods of checking and adjusting the oil supply uniformity of the assembled-type injection pump, and then to understand the operational requirements, maintenance and usage of the fuel injection pump.

B. Experimental Contents

(1) Oil supply uniformity check and adjustment for assembled–type injection pump.

(2) Learn the operational procedures of oil supply uniformity check for the fuel pump at the test-bed.

(3) Grasp oil supply uniformity adjustment methods for the fuel pump.

C. Experiment Equipment

1. 12PSD55 fuel injection pump test–bed 1 set

The Main Technical Parameters:

Main shaft maximum output power	4 kW
Test cylinder number	12
Speed range	low gear 0 – 1500 r/min corotation or reverse
	top gear 0 – 3000 r/min corotation or reverse
Fuel tank capacity	50 liters

Fuel delivery pump flow　　6 litres/min

Fuel delivery pressure　　0 – 40 kg/m^2 (0 – 4 MPa)

12PSD55 type injection pump test-bed is suitable to regular checks of the fuel injection pump for the medium speed or the high speed multi-cylinder diesel engine.

2. BH4B90YS33 assembled–type injection pump located on the test–bed　1set

BH4B90YS33 Type Injection Pump Parameters:

At rated rotational speed n_b=1500 r/min, required amount of fuel injected: 24.5 mL/200 times; the amount of fuel injected into each cylinder's uneven degree:

$$\rho=[\text{Max}\ (\text{Min})\ -24.5]/24.5\times100\%\leqslant3\%$$

At Max rotational speed n=1575 r/min, each cylinder's fuel injection stops. At idle speed n=500 r/min, fuel is still kept injecting into each cylinder, the amount of fuel injected into each cylinder's uneven degree: $\rho\leqslant30\%$.

Fig. 1-1 is 12PSD55 injection pump external structure drawing. Fig. 1-2 is 12PSD55 injection pump internal structure drawing. On the control panel there are a count button and a speed control knob. The counter power switch, the changeover switch for counting the number and the flash lamp power switch are installed on the top of the control box. At the front of the changeover switch for counting the number, there is a count or timer changeover switch.

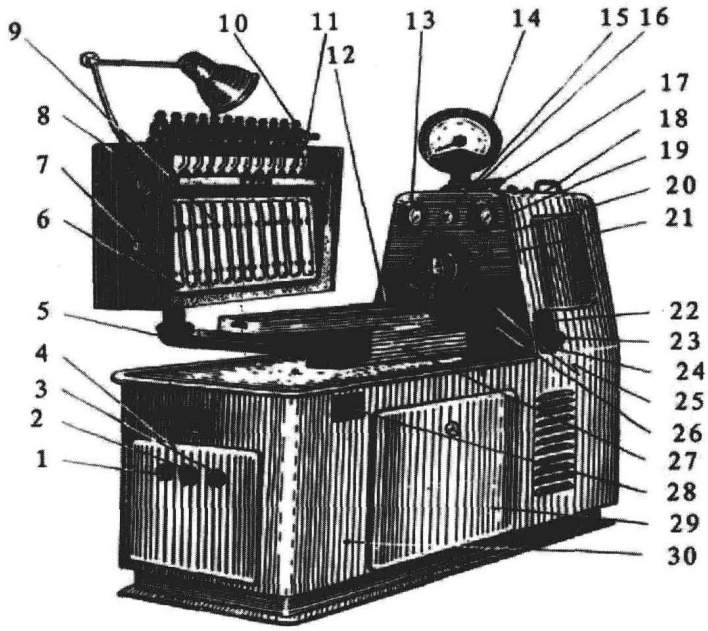

Fig. 1–1　12PSD55　Injection Pump Test–bed External Structure Drawing

1 – heater switch; 2 – main switch; 3 – fuel delivery pump switch; 4 – strong current box; 5 – turn arm; 6 – test oil tube; 7 – knob; 8 – measuring mechanism; 9 – clip; 10 – fuel injector assembly; 11 – fog dispersal device hood; 12 – oil inlet or return joint; 13 – low pressure gauge; 14 – tachometer; 15 – oil thermometer; 16 – pressure adjusting valve handle; 17 – stop valve handle; 18 – control box; 19 – high pressure gauge; 20 – dial; 21 – universal coupling; 22 – count button; 23 – speed control knob; 24 – control panel; 25 – flash socket; 26 – oil supply connecting; 27 – guide rail; 28 – start button; 29 – right side door; 30 – machine body

D. Experiment Steps

Assembled injection pump oil supply uniformity check and adjustment

(1) Check the fuel injection pump test-bed starting, setting total 200-time injection. According to the rated rotational speed of the fuel pump of 4135 diesel engine n_b=1500 r/min, setting the rotational speed of the injection pump test-bed is 750 r/min.

(2) Start the fuel pump on the test-bed. Turn the speed control knob to operate the fuel pump test-bed, move the fuel injection pump accelerator handle to the setting position, and observe whether each fuel pump injection is normal and then stop it after running normally. And turn the measuring cup emptying knob of the measuring glass to discharge the fuel in each measuring glass and then reset it.

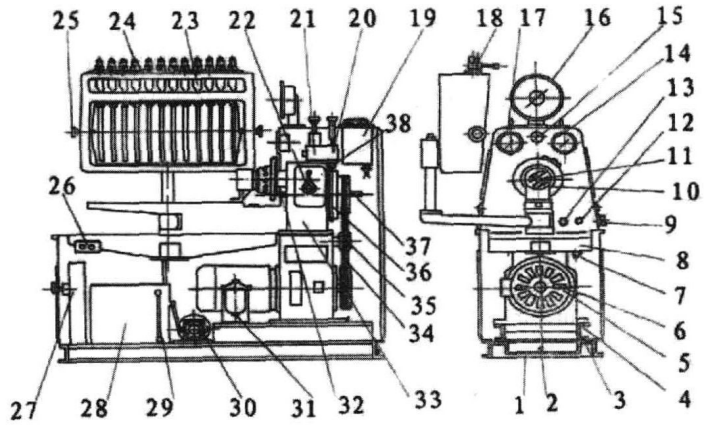

Fig. 1-2 12PSD55 Injection Pump Test-bed Internal Structure Drawing

1 – lower foundation; 2 – oil drain hole; 3 – anti – shock pad; 4 – upper foundation; 5 – slip clutch; 6 – motor; 7 – oil drain bibcock; 8 – dirt oil sump; 9 – control panel; 10 – transmission disc; 11 – universal joint; 12 – flash socket; 13 – oil supply connecting; 14 – high pressure gauge; 15 – oil thermometer; 16 – tachometer; 17 – low pressure gauge; 18 – fuel injector assembly; 19 – control box; 20 – gate valve; 21 – pressure adjusting valve; 22 – variable speed handle; 23 – fog dispersal device; 24 – measuring cup; 25 – measuring cup emptying knob; 26 – starting/stop button; 27 – strong current box; 28 – oil tank; 29 – oil level gauge, 30 – oil delivery pump; 31 – filter; 32 – head of count; 33 – gear box; 34 – V-belt; 35 – tension pulley; 36 – speed measure wheel; 37 – speed measure shaft; 38 – head of speed measure

(3) Restart, setting rotational speed is 750 r/min. Move the fuel injection pump throttle handle to the setting position, and press the counter button after running normally, baffle being sucked and fuel into the measuring glass. After 200 times of injection, the baffle will be pushed off, the amount of fuel contained in the measuring glass will be the same as the oil amount of 200-time fuel injection. And then stop the test-bed.

(4) Read out the oil amount in the measuring glass of each cylinder and record the readings.

(5) Turn the oil discharge handle of the measuring glass to discharge the fuel in each measuring glass and then reset. Repeat the above-mentioned measure and record it. And then calculate the arithmetic average of two measurements.