内河和近海船舶排放测试
Emission Test On Offshore Fishing Boats

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目录 Contents

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简　介 Introduction

- 国内尚未系统开展船舶的排放测试研究，目前的一些研究结果均是以国外的排放数据作为依据进行的。因此，有必要对通过测试获得本地船舶的排放因子，从而为了解和掌握我国船舶污染现状提供借鉴和参考；

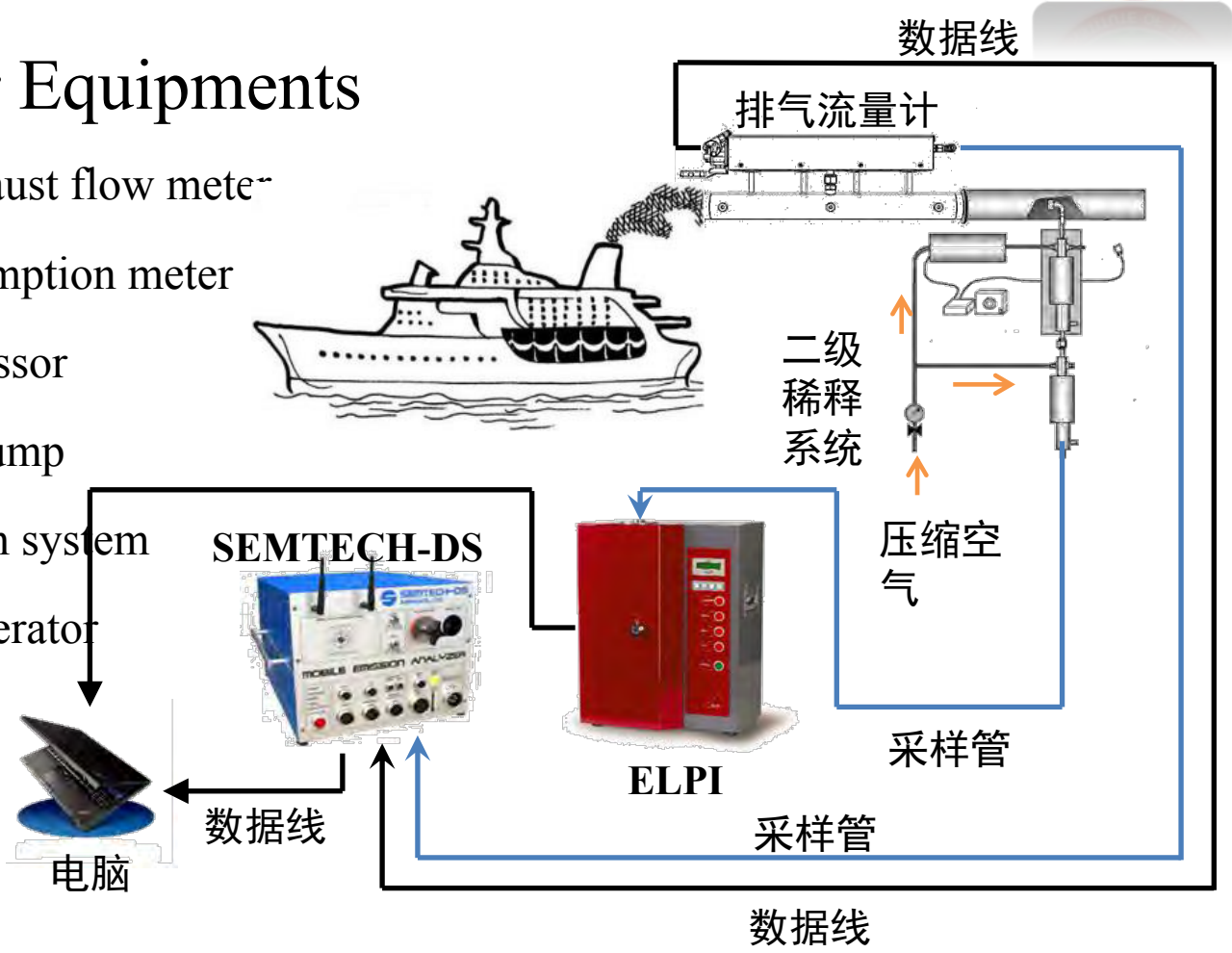
  There is no test research on vessel emission in china yet, some research results are based on emission data from abroad. So it is necessary to obtain native emission factors by testing.

- 利用PEMS（*Portable Emission Measurement System*）排放测试系统对我国内河航运和近海渔船进行实际航行条件排放特点研究。

  Some researches on emission characteristics of offshore fishing boats have been done using PEMS.

测试仪器 Equipments

- 其他设备 Other Equipments
  - 排气流量计 exhaust flow mete
  - 油耗仪 fuel consumption meter
  - 空压机 air compressor
  - 真空泵 Vacuum Pump
  - 稀释系统 Dilution system
  - 发电机 Power generator
  - 蓄电池 Battery



测试仪器连接示意图

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测试仪器 Equipments

采样管 Sampling Tube

烟囱chimney

颗粒物采样稀释系统 Dilution System Of PM Sampling

SEMTECH-DS

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测试仪器 Equipments

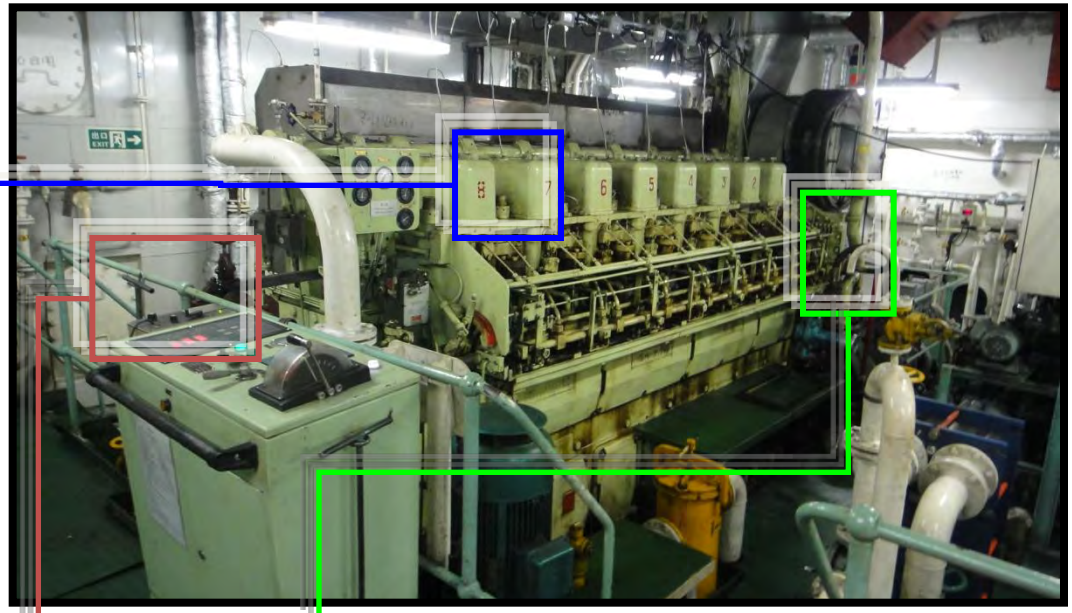
- 油耗仪：将其串联在发动机进油管路，可以实现对发动机燃油消耗量的实时测量。

  Fuel Consumption Meter : Connecting with engine oil inlet pipe, it can measure the real-time fuel consumption.

测试船舶动力舱 Engine Cabin Of Testing Vessels

实际船舶排放测量的例子-传感器安装

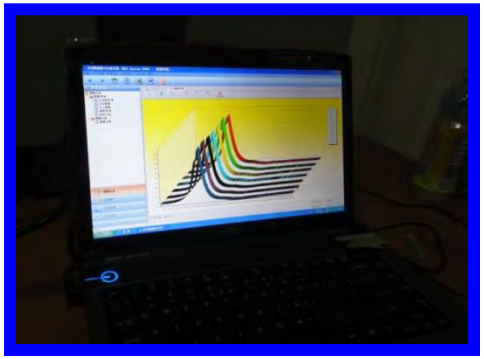
Pressure Sensor



Marine Engine

Fuel Meter

Crankshaft Position Sensor



Data monitor

大型船舶实验（近海）

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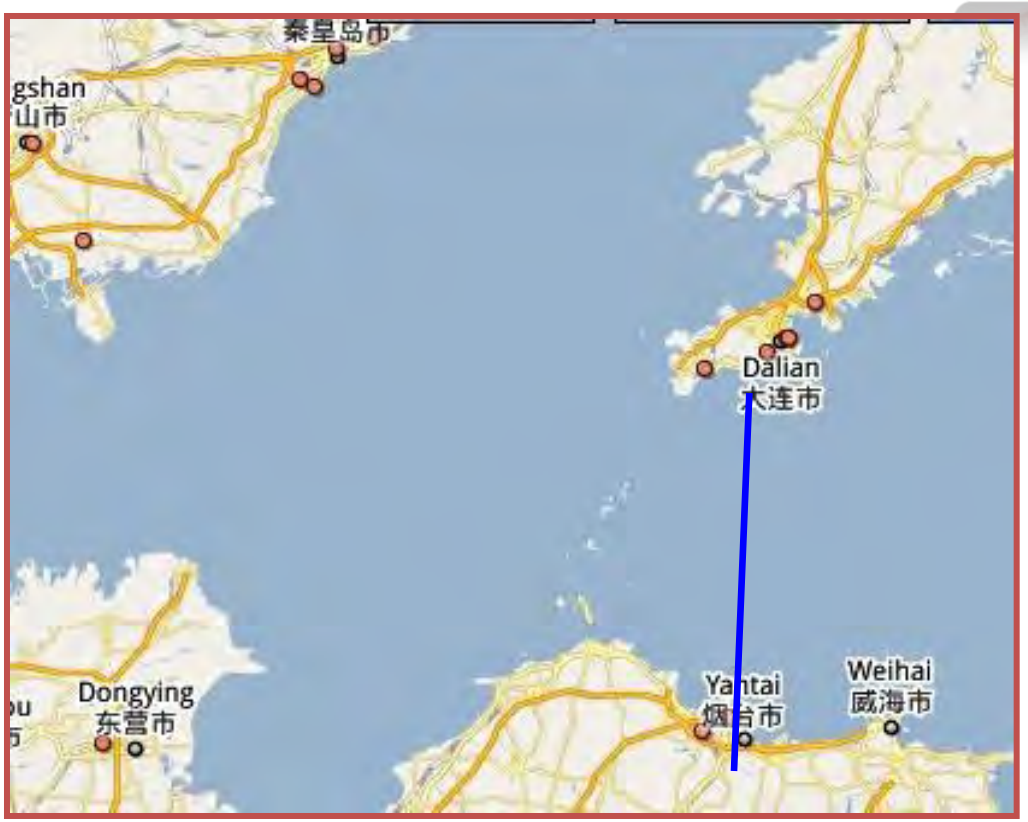
实际测试行程


Changchun
长春
Shenyang
沈阳
Hohhot
呼和浩特
Beijing
北京
North Korea
Seoul
서울
대한민국
South Korea
日本
Japan
Nagoya
名古屋
Shijiazhuang
石家庄
Taiyuan
太原
Jinan
济南
Daejeon
대전
Busan
부산
Gwangju
광주
Osaka
大阪
Zhengzhou
郑州
Nanjing
南京
Fukuoka
福岡
Wuhan
武汉
Hefei
合肥
Hangzhou
杭州
East China Sea
Changsha
Fuzhou
Naha
More...
Yingkou
营口市
Dandong
丹东市
Beijing
北京市
Tangshan
唐山市
Langfang
廊坊市
Dalian
大连市
Tianjin
天津市
Weihai
威海市
Dezhou
德州市
Binzhou
滨州市
Dongying
东营市
Jinan
济南市
Zibo
淄博市
Weifang
潍坊市
Tai'an
泰安市
Laiwu
莱芜市
山东
Qingdao
青岛市
Jining
济宁市
Linyi
临沂市
Rizhao


秦皇岛市
gshan
山市
Dalian
大连市
Dongying
东营市
Yantai
烟台市
Weihai
威海市

中小型船舶排放测试（货船）

测试航线

测试路线1（镇江→丹阳）　　测试路线2（镇江→扬州）

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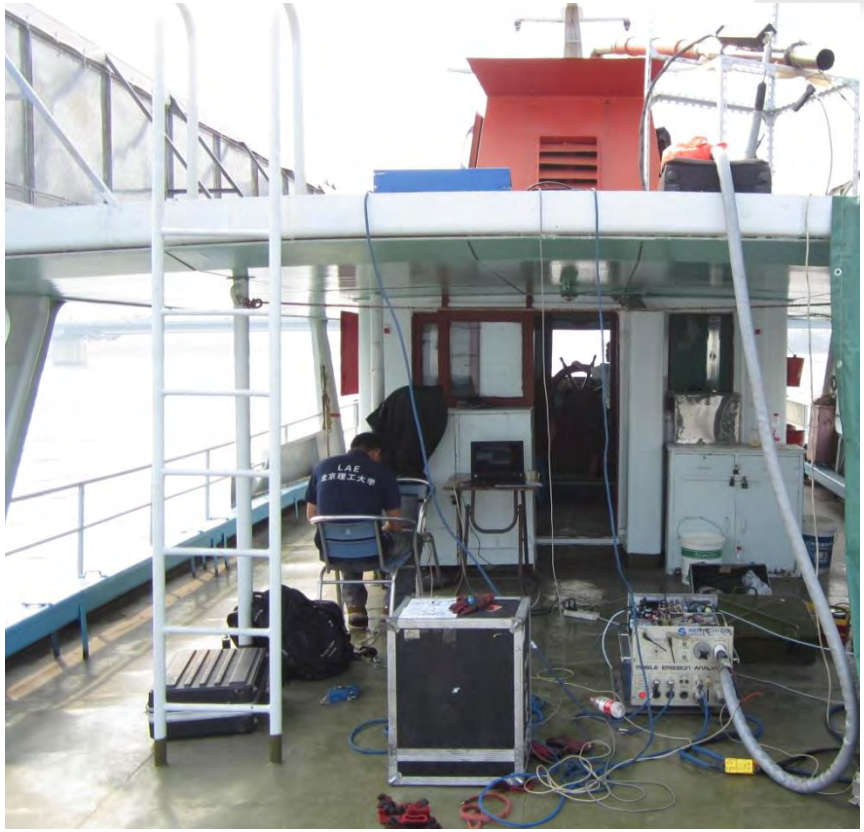
中小型珠江轮渡（客船）



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测试渔船 Test Vessels

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测试地点及航线 Location And Routes

- 近海渔船
- 辽宁大连附近海域
  - A：艾子口
  - B：郭家沟

艾子口

郭家沟

（图中蓝色线条所示为GPS测得实际测试船舶航行路线）

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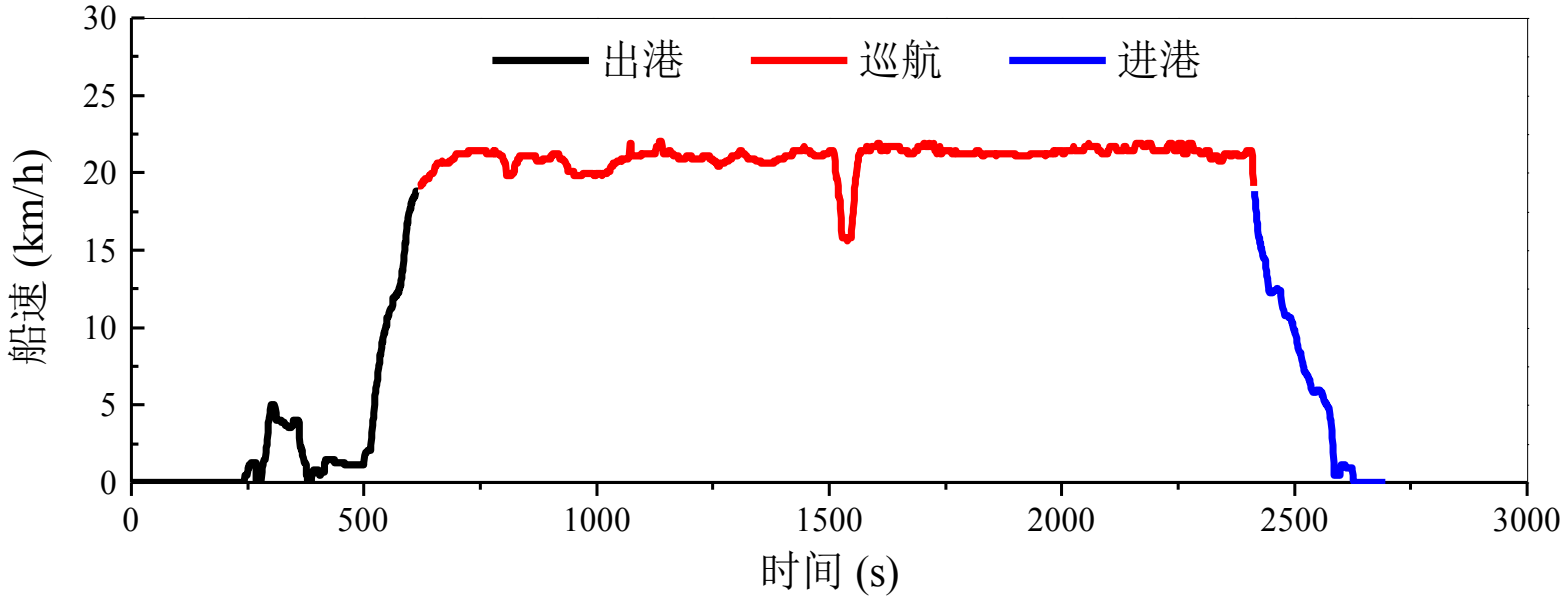
测试船舶 Test Vessels

- 近海渔船 Offshore Fishing Boats
- 大连-丹东附近海域作业的8艘渔船

编号	船号	柴油机型号	柴油机制造厂	出厂时间	标定功率（kW/ rpm）
No.1	辽丹渔23601	6190ZLCA-1	济南柴油机厂	2012-12	330/1200
No.2	辽丹渔23600	6190ZLCA-1	济南柴油机厂	2012-12	330/1200
No.3	辽丹渔3087	6190ZLCA-1	济南柴油机厂	2011-05	330/1200
No.4	辽丹渔3088	6190ZLCA-1	济南柴油机厂	2011-04	330/1200
No.5	辽丹渔3086	6190ZLCA-1	济南柴油机厂	2012-12	330/1200
No.6	辽丹渔5071	Z6170ZLC-5	淄博柴油机厂	2011-04	260/1200
No.7	辽丹渔3085	6190ZLCA-1	济南柴油机厂	2012-12	330/1200
No.8	辽丹渔5070	Z6170ZLC-5	淄博柴油机厂	2011-04	260/1200

测试工况 Operating Conditions

- 渔船的测试工况主要分为进港*(Inbound)*、离港*(Outbound)*和巡航*(cruise)*三个阶段



典型船舶测试航行速度曲线（GPS测得）

数据处理方法 Data Processing

- 基于燃料消耗的排放因子，即比燃料排放因子
  - 碳平衡方法 *Carbon Balance Method*
  - 对于气态污染物，以NO为例，计算公式为

$$NO_{fs} = \left(\frac{[NO]}{[CO] + [HC] + [CO_2] - [CO_2]_{ambient}}\right) \times \left(\frac{MW_{NO}}{MW_{fuel}}\right)$$

  - 其中，[A]为A物质的浓度，单位为ppm
  - MW_A为A物质的摩尔质量，单位为g/mol
  - 对于颗粒物，计算公式为

$$PM_{fs} = \frac{[PM]_{mc} \times 0.0224}{[CO] + [HC] + [CO_2] - [CO_2]_{ambient}} \times \frac{1}{MW_{fuel}}$$

  - 其中，$[PM]_{mc}$为颗粒物质量浓度，单位为g/m^3

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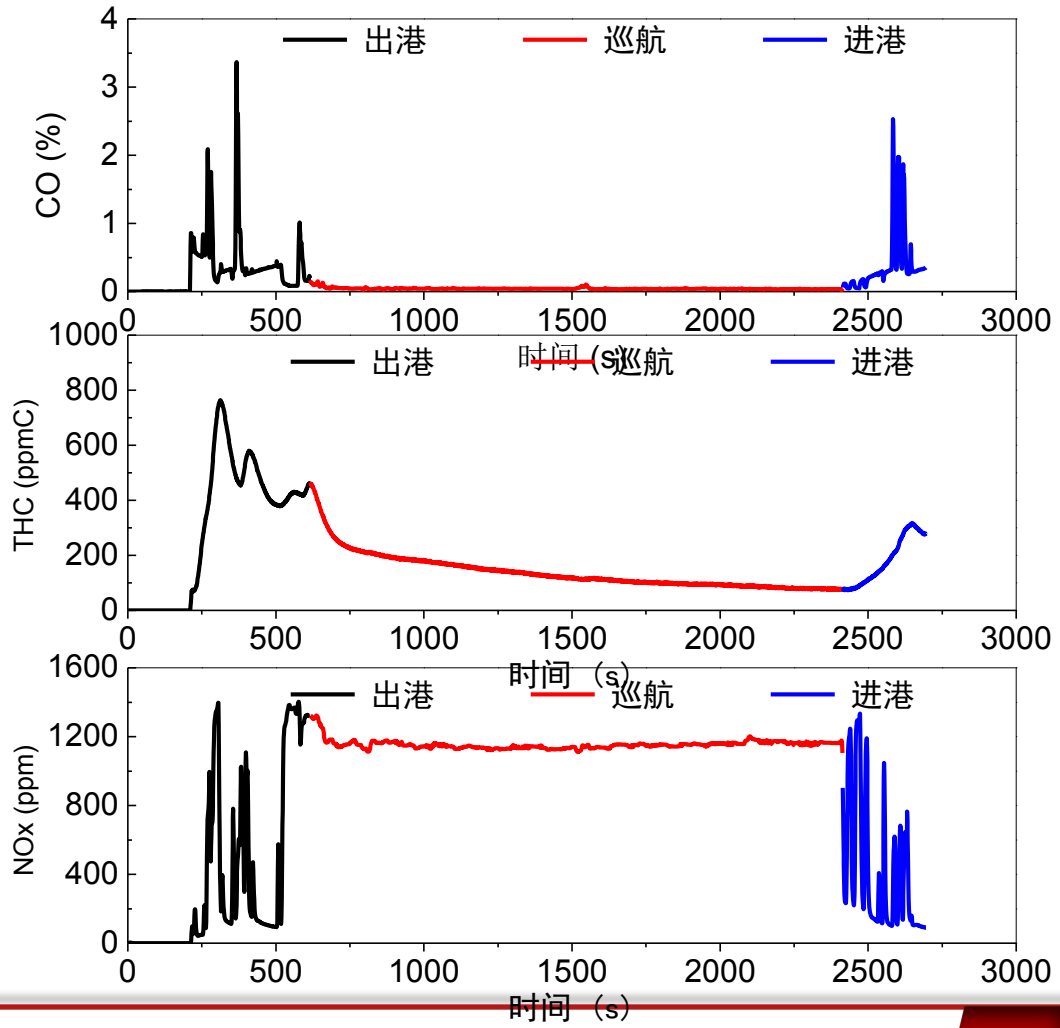
测试结果 Results

- 气态污染物排放瞬时浓度 *Instantaneous Concentration Of Gaseous Pollutants*



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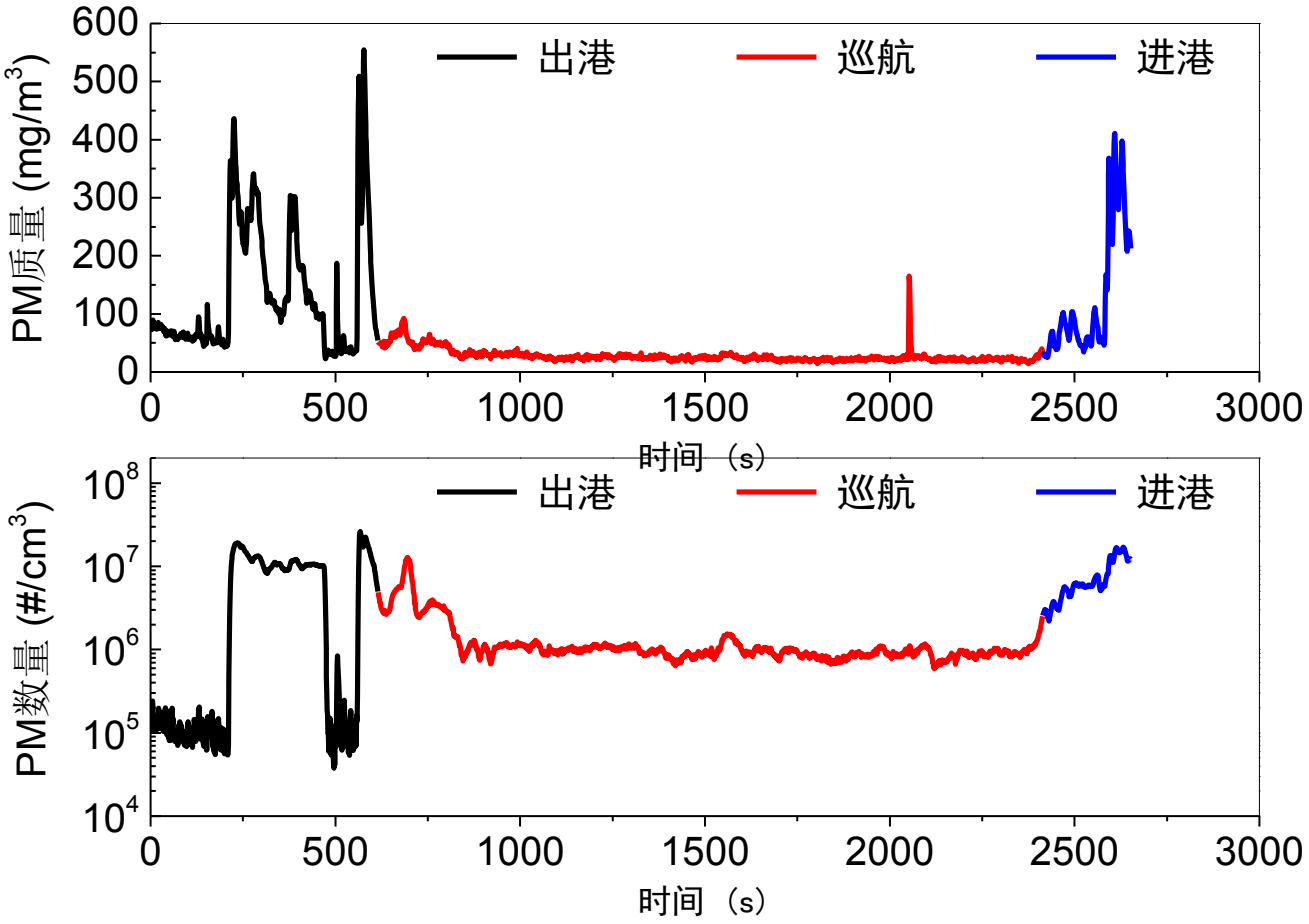
测试结果 Results

- 颗粒物排放瞬时浓度*Instantaneous Concentration Of PM*



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测试结果 Results

- 巡航工况下的船速和CO、HC、NOx和PM的排放浓度变化不大，基本保持稳定。

  The speed and concentration of the emission such as CO、HC、NOx and PM are basically stable at cruise phase.

- 在离港工况下，为避免在此过程中与周围其他船舶发生碰撞，船舶驾驶人员根据船舶的实际位置不断改变功率以调整航向和航速。当货船安全进入航道后，船舶开始加速直至达到巡航速度。

  In order to avoid collide with other vessels ,ship drivers change power constantly to adjust course and speed at outbound phase. The ships will accelerate to cruise speed after they enter waterways safely.

- 在离港工况下，发动机的负荷变化较快，燃烧条件比较恶劣，导致CO、HC、NOx和PM的排放速率波动明显，出现较多的排放浓度峰值。

  Throughout the whole outbound conditions, the rapid change of engine load and the harsh condition of combustion contribute to the fluctuation of the CO、HC、NOx and PM emission concentration apparently with lots of emission concentration peak.

测试结果 Results

- 在巡航和作业工况下，船速基本处于匀速航行状况，少有加减速过程，发动机负荷保持在平稳水平。此时各种污染物排放速率相对稳定，NOx排放浓度较高。

  The speed of the ships are basically stable at cruise phase and working conditions, so is the engine load . At the moment the emission rate of all kinds of pollutants is relatively steady, with a high NOx emission concentration.

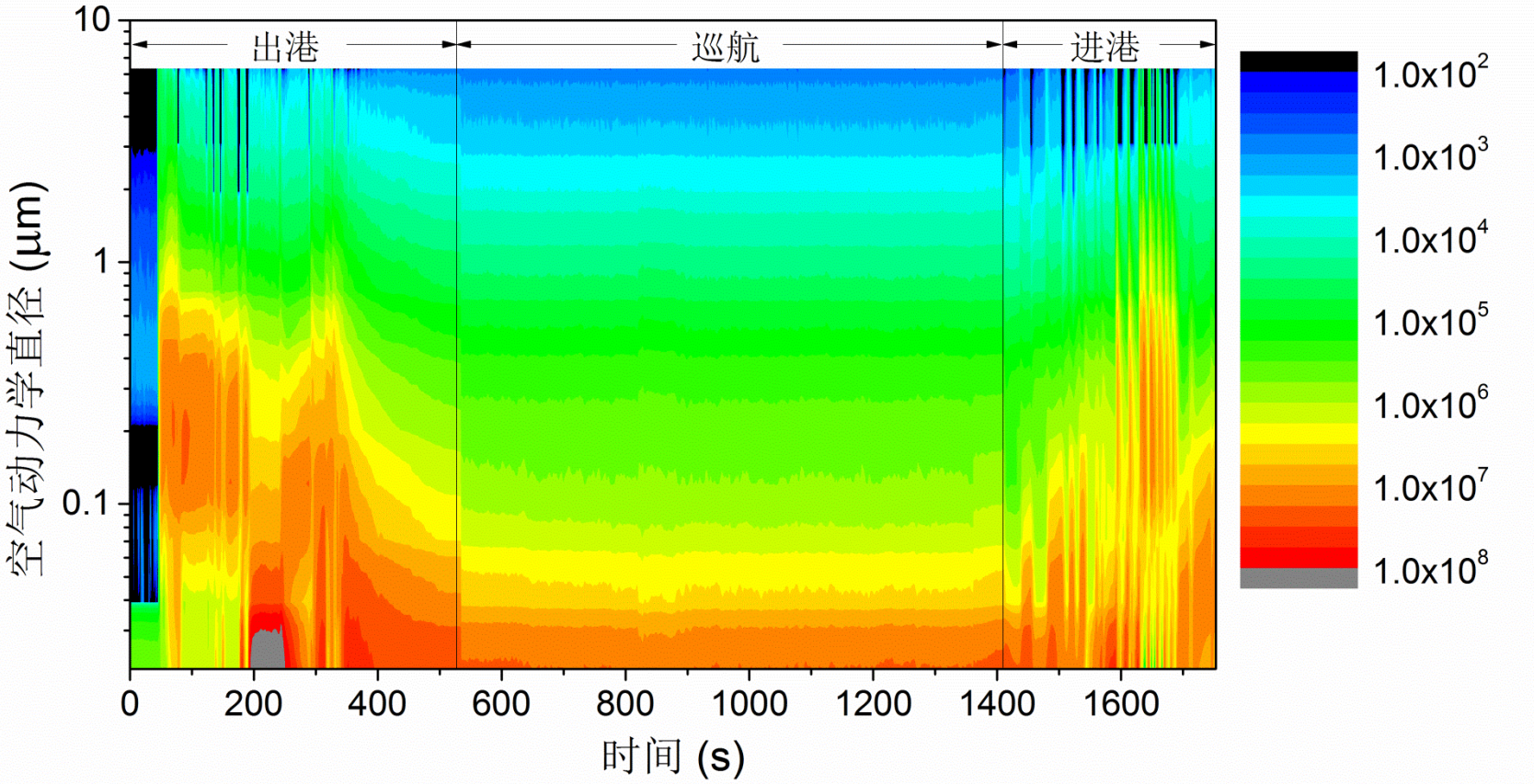
- 而在进港工况下，渔船从巡航速度开始持续减速。在整个进港工况下，发动机功率变化较为频繁，特别是突然拉大功率的时刻，发动机迅速升高到较大负荷状态，缸内燃烧条件的急剧变化使不完全燃烧的情况加剧，从而导致CO、HC和PM排放浓度发生很大的波动。

  At inbound phase, the speed of ships decelerate continuously, the engine load changes rapidly. Same as the outbound situation, rapidly change of the combustion condition result in the aggravating of incomplete combustion and the big fluctuation of CO、HC and PM emission concentration.

测试结果 Results

- 颗粒物排放粒径分布瞬态数据

Transient Data Of Particle Size Distribution



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测试结果 Results

- 进港和出港工况下有较高数量浓度的核模态颗粒物产生。

  Inbound and outbound phase generate higher number concentration of Nuclear Mode PM than cruise phase.

- 在巡航和作业阶段，颗粒物排放，无论是核模态颗粒物还是积聚模态颗粒物都较进出港阶段的浓度要小，并且粒径分布稳定，变化较小。

  The concentration of both Nuclear Mode PM and Accumulation Mode PM is less at cruise phase and working conditions, and the Particle Size Distribution is steady.

- 在离港工况下，船舶保持持续加速，不断增加的发动机负荷使得颗粒物燃烧过程中产生较多核膜态微粒。

  At outbound phase, the continuously acceleration increase the engine load ,and result in more output of Nuclear Mode PM.

测试结果 Results

- 而在进港工况下，船舶间断性的依靠螺旋桨反向旋转产生阻力使船减速。此时负荷是以间断性的增大，使得各个粒径范围的颗粒物变化剧烈。

  At inbound phase, ships decelerate by inverse rotating of the propeller discontinuously. The discontinuously increasing of engine load leads to the rapid change of PM at every particle size.

- 船舶进出港工况都是发生在码头附近，而很多码头都分布在城市区域内，有些甚至是城市中心地带。因此，船舶进出港产生的污染物，特别是细颗粒，对城市大气环境带来严重的影响。

  Most of the ports are located in the city, some of which even located in the city center. So the ship emissions of inbound and outbound phase impact city environment severely especially with the fine particles .

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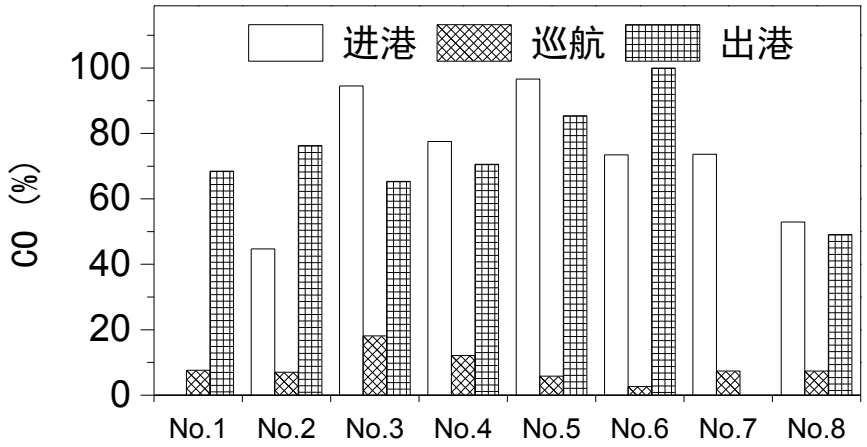
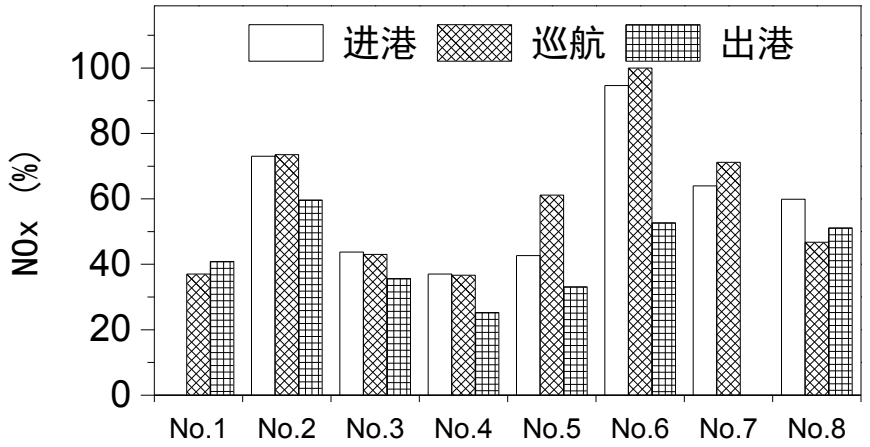
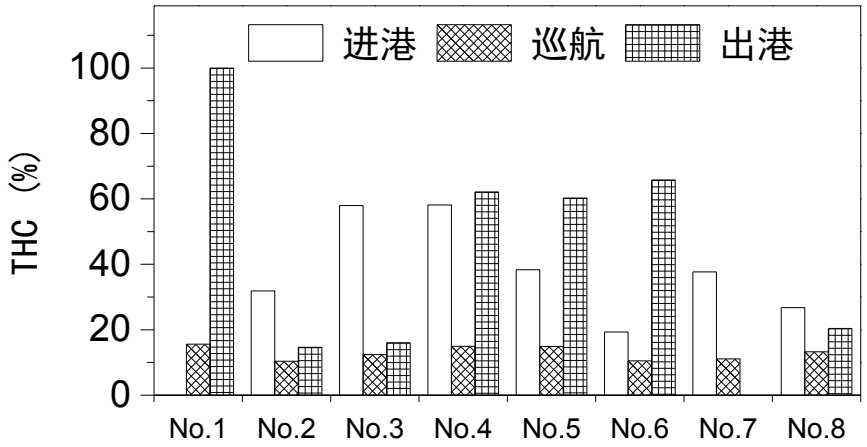
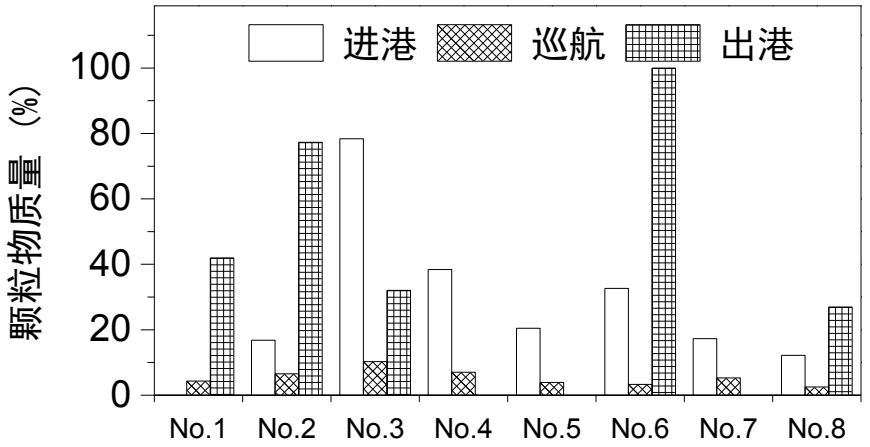
测试结果 Results

- 基于燃料消耗量的排放因子*Emission Factors Based On Fuel Consumption*









8艘测试船舶基于燃料消耗量的排放因子相对大小

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测试结果 Results

- 由于进出港工况油耗相对较小，使得CO、HC和PM基于油耗的排放因子高于巡航工况下的排放值。

  Emission Factors of CO、HC and PM based on fuel consumption are lower at inbound and outbound phase because of the lower fuel consumption.

- 对于NOx来说，虽然巡航或作业工况下的油耗较高，但单位时间较大的排放量使得NOx基于油耗的排放因子从整体上高于进、出港工况的排放值。

  As for NOx, although the fuel consumption of cruise phase and working conditions is higher than that of inbound and outbound phase, the emission Factor based on fuel consumption is still higher due to the larger emissions per unit time.

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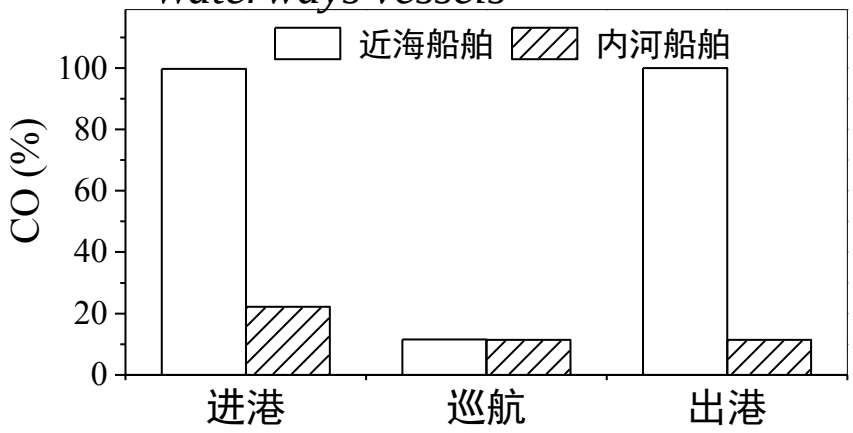
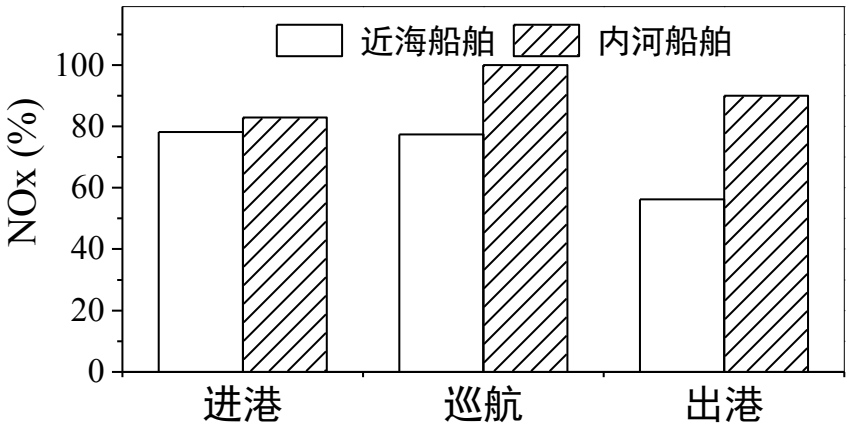
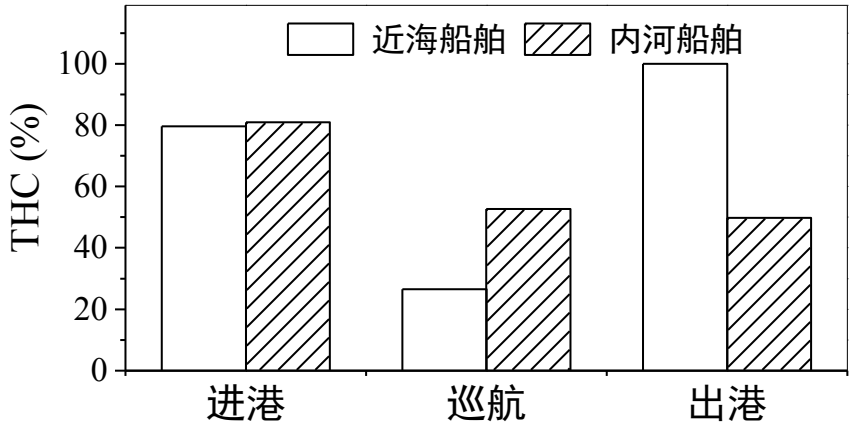
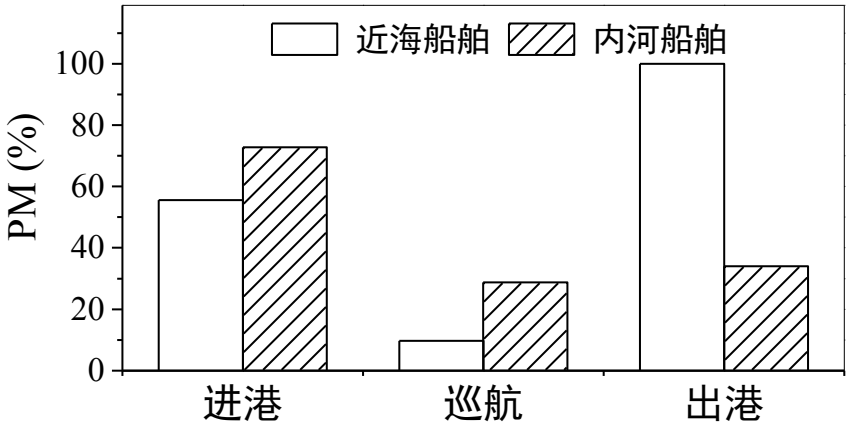
测试结果 Results

- 与内河航运船舶排放测试结果相比*Compared with the Inland-Waterways vessels*









近海船舶与内河船舶的比燃油排放因子对比

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测试结果 Results

- 对于CO，近海渔船的排放在巡航阶段与内河航运船舶基本相当，而进出港阶段则显著高于内河船舶；

  As for CO, the CO emission of the offshore fishing boats is roughly equal to that of the inland-waterway vessels at cruise phase, but it is significantly higher during inbound and outbound phase.

- 近海渔船在进港阶段和巡航阶段的HC、NOx和PM排放相对于内河船舶较小；

  The HC、NOx and PM emission of offshore fishing boats is less than that of inland-waterway vessels at inbound phase and cruise phase.

- 而对于出港阶段的排放情况，近海渔船的HC和PM相对于内河船舶显著增加，而NOx则相应减小；

  As for the emission of the outbound phase, the HC and PM emission of offshore fishing boats is significantly higher than that of inland-waterway vessels ,while the NOx emission is lower.

测试结果 Results

- 将两者的排放情况进行对比，需要考虑近海渔船和内河船舶的运行状况可能存在的差异：

  Considering the differences between the offshore fishing boats and inland-waterway vessels :

  - 虽然都采用船用柴油机作为船舶的动力来源，但是由于燃油的差异，可能导致发动机排放情况的显著差异；

    The difference of the fuel may result in a significant emission difference ,although both of them are diesel engine.

  - 近海渔船和内河船舶航线的水流状况不同；

    The water flow condition is different.

  - 对于城市环境影响更大的进出港阶段的排放，港口条件及附近水域的航行状况的影响也是另一个需要考虑的重要因素。

    Given that the emissions at inbound and outbound phase impact city environment severely , port condition and navigational status nearby become important considerations.

发动机台架实验方法研究

使用设备：发动机测功机；
油耗仪；
气体分析仪；
ELPI；

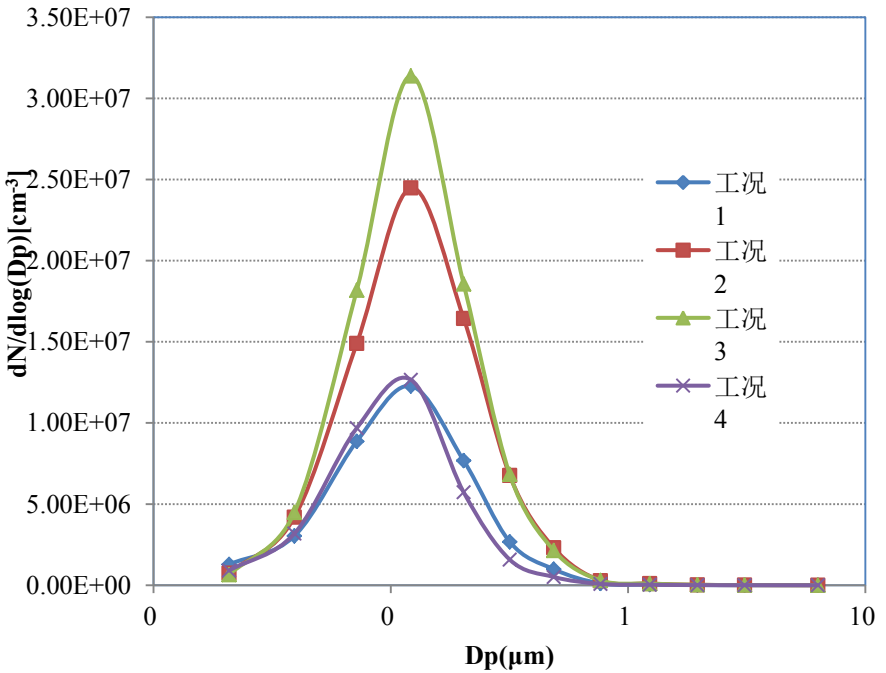
工况：
按船用柴油机5工况

典型实验结果

各工况点气体污染物测试结果

	CO浓度	THC浓度	NO_X浓度
	ppm	ppm	ppm
1	251.18	131.44	442.53
2	412.06	83.21	413.22
3	485.88	67.86	447.60
4	323.03	59.74	637.51
5	533.10	76.82	436.80
….	……..	…….	……..

PM测试结果



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结论 Conclusions

1. 从污染物瞬时排放浓度来看，测试船舶在巡航或作业阶段各种污染物排放基本保持稳定，但在进、出港阶段下出现较大的波动。这主要与各个航行阶段发动机的运行状态有很大的关系。

   The instantaneous concentration are basically stable at cruise phase or working condition, while the fluctuation is significant during inbound and outbound phase , which is related to the operating conditions of the engine.

2. 进出港工况下CO、HC和PM比燃油排放因子要高于巡航工况下的排放因子，而NOx比燃油排放因子则是在巡航工况下较大。

   Emission Factors of CO、HC and PM based on fuel consumption at inbound and outbound phase are higher than that of cruise phase. As for NOx, emission Factors Based On Fuel Consumption are higher at cruise phase.

结论 Conclusions

3. 颗粒物，进出港阶段有较高数量浓度的核模态颗粒物排放，而在巡航阶段，颗粒物排放，无论是核模态颗粒物还是积聚模态颗粒物都较进出港阶段的浓度要小，并且粒径分布稳定，变化较小。

   Inbound and outbound phase generate higher number concentration of Nuclei Mode PM than cruise phase. The concentration of both Nuclei Mode PM and Accumulation Mode PM is least at cruise phase among the three phases, and the Particle Size Distribution is steady.

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结论 Conclusions

4. 近海渔船与内河船舶的排放情况相比，渔船的CO排放在巡航阶段与内河船舶基本相当，而进出港阶段则显著高于内河船舶。近海船舶在进港阶段和巡航阶段的HC和NOx和PM排放相对于内河船舶较小，而对于出港阶段的排放情况，近海船舶的HC和PM相对于内河船舶显著增加，而NOx则相应减小。对于近海船舶和内河船舶排放特点的差异，以及排放控制策略的异同需要更加全面和深入的研究。

Compared with the Inland-Waterways vessels emission, the CO emission of the offshore fishing boats is roughly equal to that of the inland-waterway vessels at cruise phase , but it is significantly higher at inbound and outbound phase. The HC、NOX and PM emission of offshore fishing boats is less than that of inland-waterway vessels at inbound and cruise phase. As for the emission of the outbound phase, the HC and PM emission of offshore fishing boats is significantly higher than that of inland-waterway vessels ,while the NOx emission is lower. Deeply and comprehensively research is needed for the emission characteristic and emission control strategy.

致谢

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谢谢聆听
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