# Outboard Marine Engine Development Technology

# Content

# ❑Outboard Engine Product Development

## Structural design

### ➢ Conceptual design

-Full-engine frame construction

-System concept definition and key parameter specification

-3D model design

### ➢ Topological design

-CAE analysis

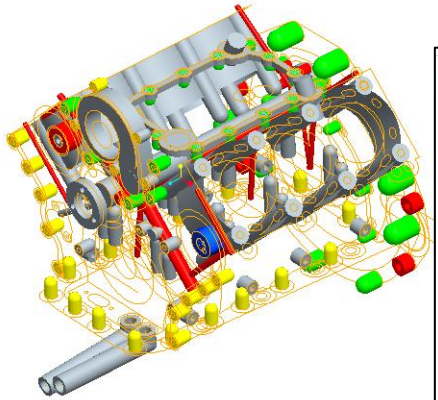
-3D design optimization

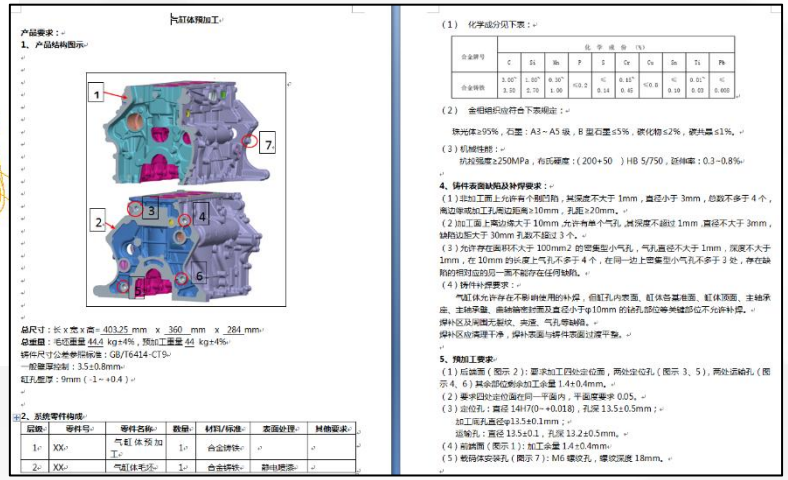
### ➢ Detailed design

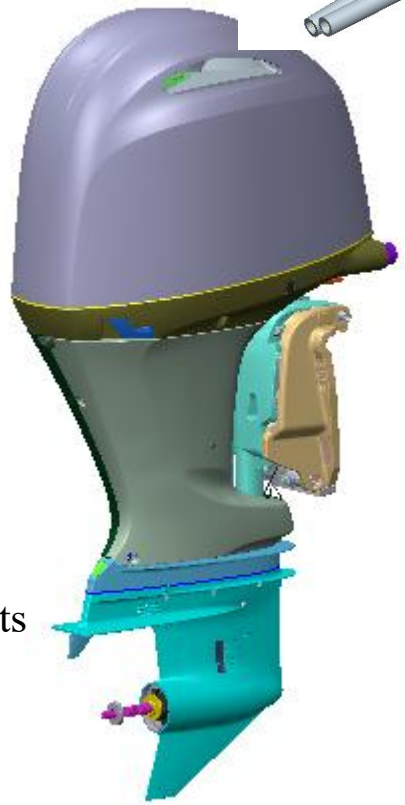
-2D drawing design

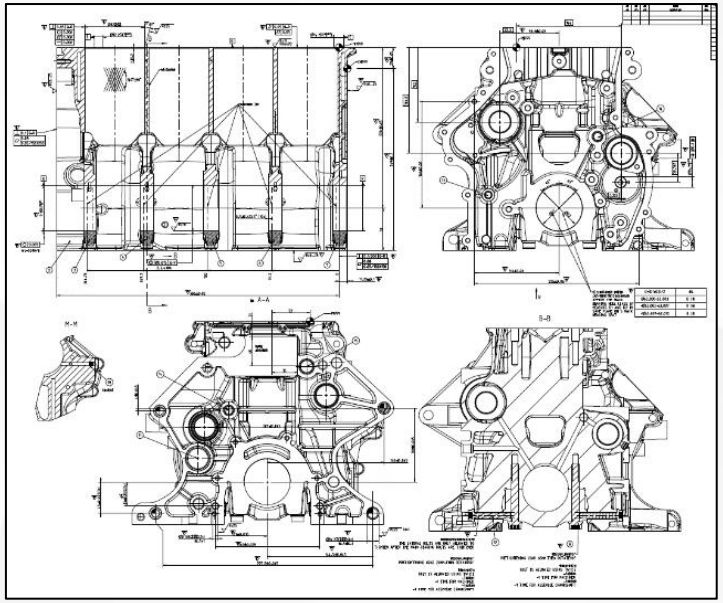
-Preparation of design report and technical documents

-Dimension chain and overall layout check









# ❑CAE technical competence

1. 1D thermodynamic simulation analysis
2. Simulation analysis of distribution mechanism
3. Crankshaft strength and modal simulation analysis
4. Connecting rod fatigue strength analysis
5. Analysis of cylinder head bolt strength and locking safety
6. Analysis of connecting rod bolt strength and safety rate of connecting rod cover separation
7. Analysis of strength and locking safety of main bearing bolts
8. Main shaft bearing surface pressure and performance calculation
9. Camshaft bearing surface pressure and performance analysis
10. Spring strength calculation of valve
11. Oil and gas separation analysis and calculation
12. Analysis and calculation of cylinder deformation
13. In-cylinder combustion CFD analysis
14. Strength simulation of cylinder body and cylinder head assembly
15. Calculation and analysis of 1D lubrication system
16. CFD calculation and analysis of water jacket
17. CFD analysis of intake duct
18. CFD analysis of exhaust duct
19. CFD calculation and analysis of intake manifold
20. Intake manifold strength analysis
21. Modal analysis of the engine
22. Analysis of stiffness and vibration of suspended soft pads
23. Gear strength analysis
24. Drive shaft strength analysis
25. CFD analysis of water intake cooling system of underwater system
26. CFD analysis of exhaust and drainage of underwater system
27. Overall strength analysis of underwater devices
28. Thermal management analysis inside the cabin cover
29. Modal analysis of cylinder head cover

# ❑CAE technical competence

## Waterway CFD calculations

### ➢ Input conditions

-3D data of cylinder body, cylinder head and cylinder head water hole, etc

-Flow calculation results of 1D cooling system

-Cooling system schematic

### ➢ Content analysis

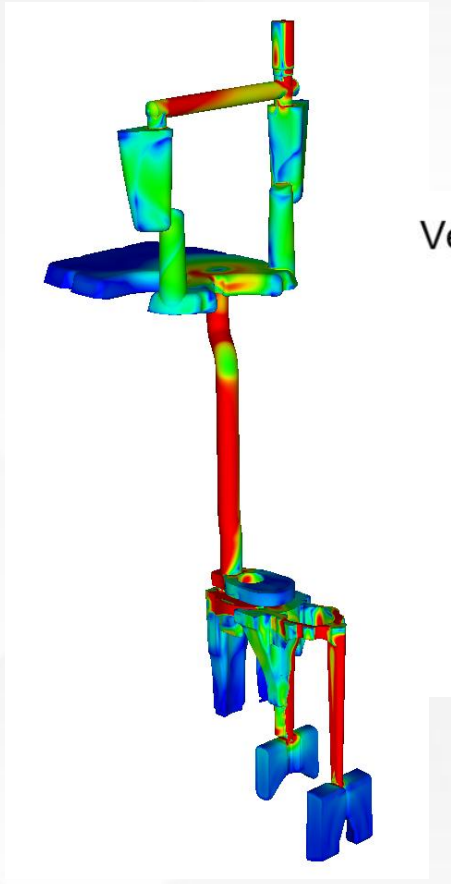
-Water jacket pressure loss evaluation

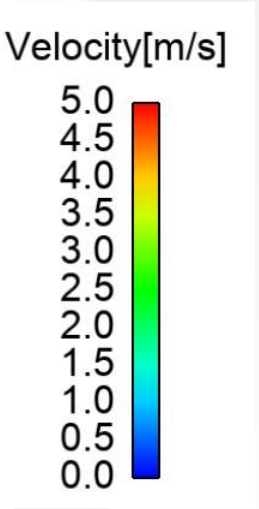
-Evaluation of water jacket flow rate and flow uniformity

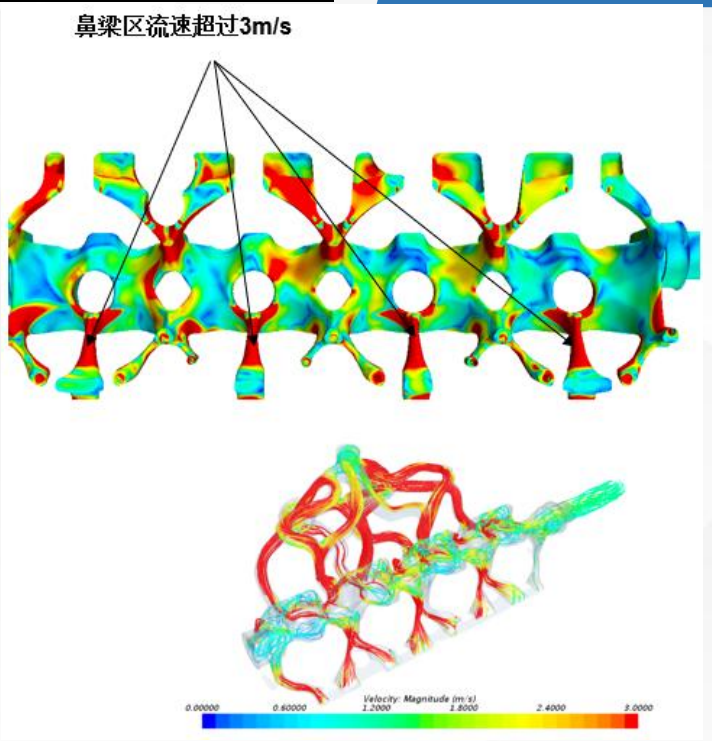
-Evaluation of convective heat transfer coefficient

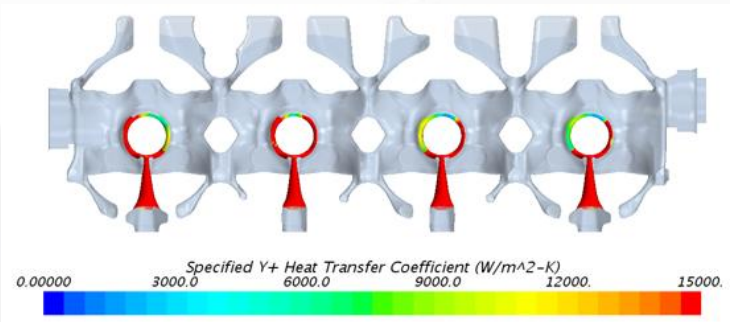
### ➢ Deliverable

-Analysis model and calculation report





# ❑CAE technical competence

## Fatigue strength calculation of transmission system (driveshaft, spline, bearing and gear)

### ➢ Input conditions

-Use the working condition load spectrum

-3D model and parameters of spline, bearing, gear and housing

### ➢ Content analysis

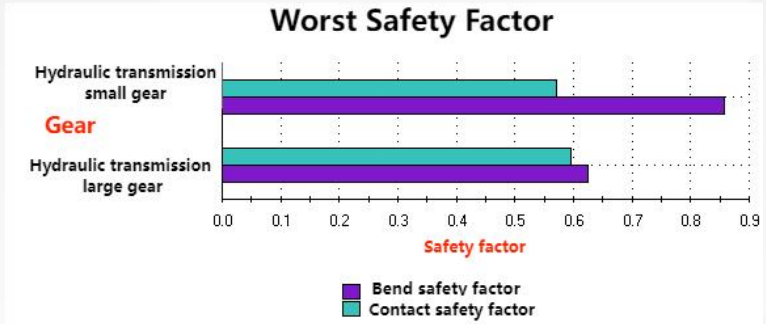
-Transmission shaft strength, fatigue safety factor

-Bearing life calculation

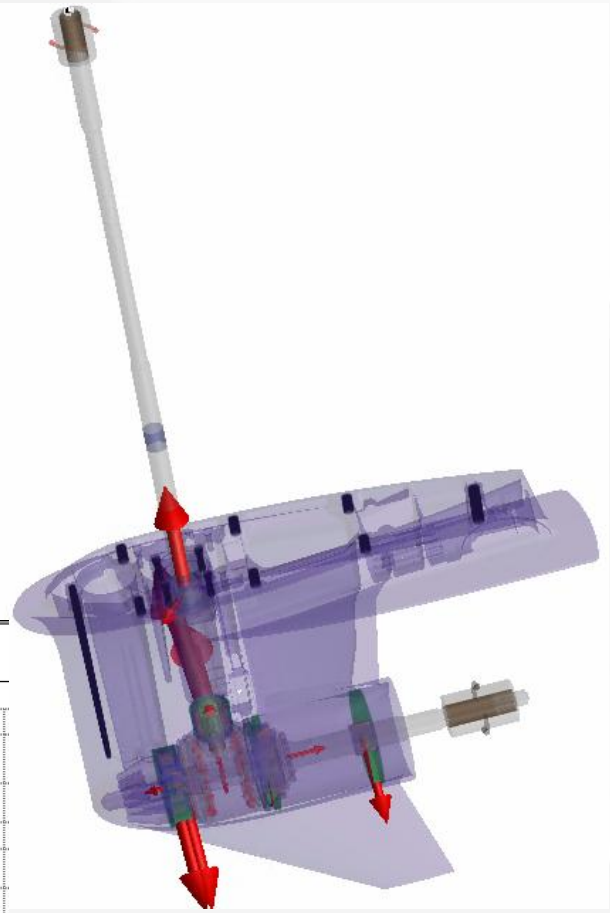
-Gear contact stress, bending stress, safety factor

### ➢ Deliverable

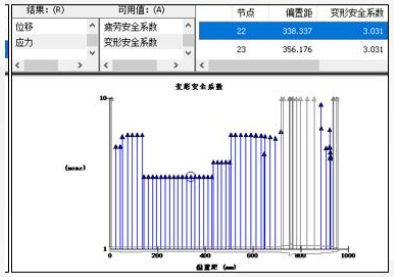
-Analysis model and report




| Gear | Contact stress (MPa) | | Bend stress (MPa) | | Safety factor | |
|---|---|---|---|---|---|---|
| | Left | Right | Left | Right | Contact | Bend |
| Hydraulic transmission large gear | 3005.397937 | 0 | 792.910518 | 0 | 0.5958 | 0.6251 |
| small gear | 3005.397937 | 0 | 550.611915 | 0 | 0.5714 | 0.8574 |



最小静强度安全系数3.0



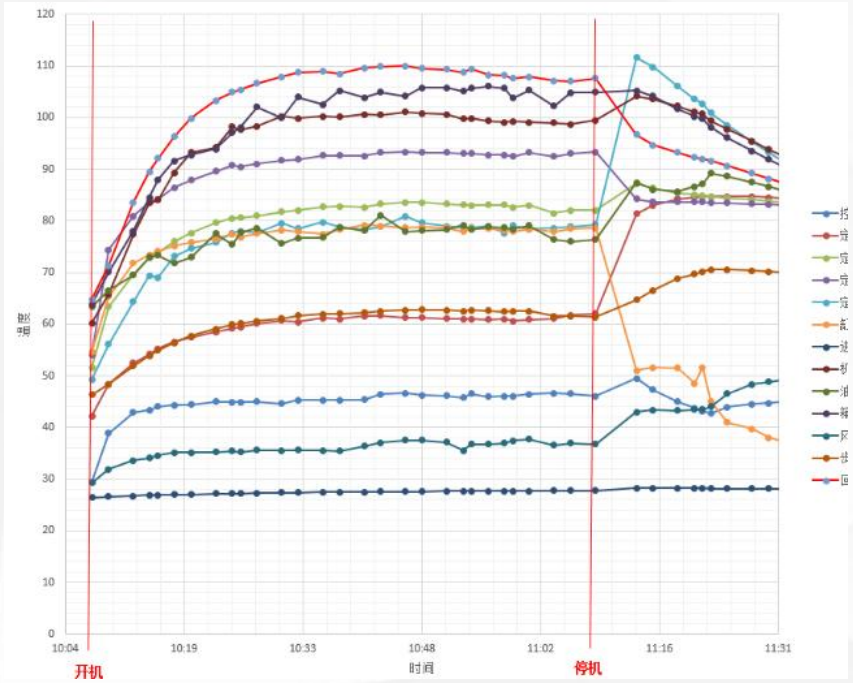
齿轮箱箱体

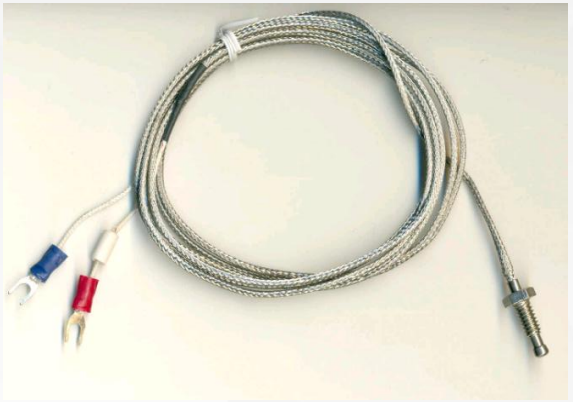
| 连接 | 功率 (kW) | 扭矩 (Nm) | 力 (N) | | | 力矩 (Nm) | |
|---|---|---|---|---|---|---|---|
| | | | X | Y | Z | X | Y |
| 倒档圆柱滚子轴承 | 0 | 25.588541 | 0 | 6303.6 | 5097.0 | 0 | -20.585113 |
| 刚性连接 1 | 0 | 5.422672 | 40.4 | 2812.3 | 2673.2 | -4.6566e-10 | 8.776028 |
| 间隙轴承 5 | 0 | 21.257443 | 0 | 1255.0 | 807.7 | 0 | -3.340179 |
| 间隙轴承 8 | 0 | 0 | 5.0483e-11 | 0 | 0 | 0 | 0 |
| 驱动轴滚针轴承 | 0 | 0 | 352.8 | -11466.0 | 0 | 102.088788 | 11.590366 |
| 驱动轴推力轴承 | 0 | 0 | 0 | 0 | -8434.2 | 153.316596 | -4.738158 |
| 轴承座内滚针轴承 | 0 | 0 | -1042.1 | 1577.1 | 0 | 8.986635 | 5.692358 |

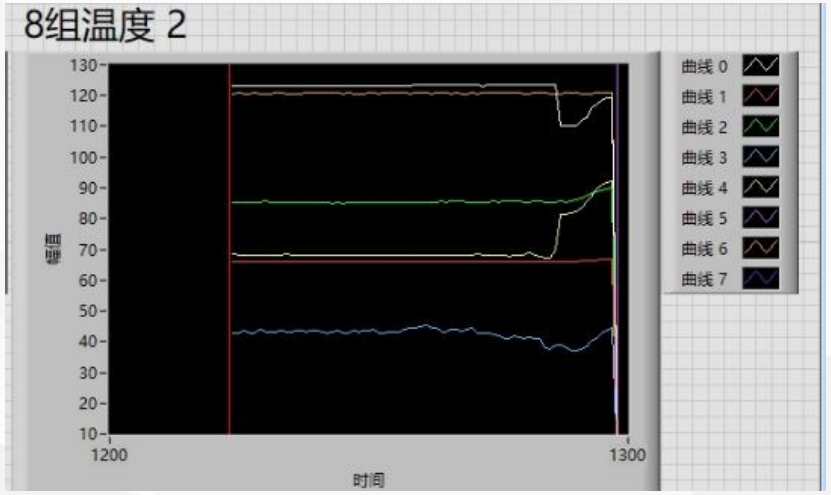
# ❑Test and validation

## Temperature field test

- Temperature at each point of steady state under different loads
- Temperature change curve of fuel, oil, air and water at each point






# ❑Test and validation

## Vibration NVH test

Cylinder body 3 cylinder intake side

Upper front suspension

Fuel pump measurement point

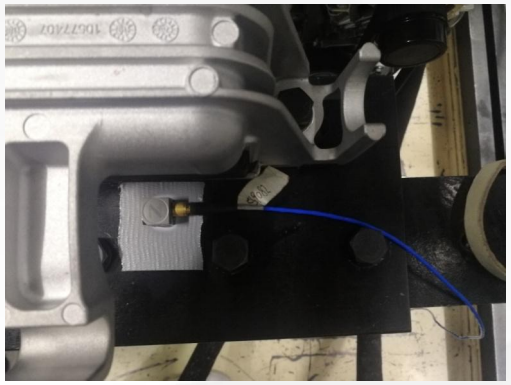
X: crankshaft direction

Y: direction of intake and exhaust

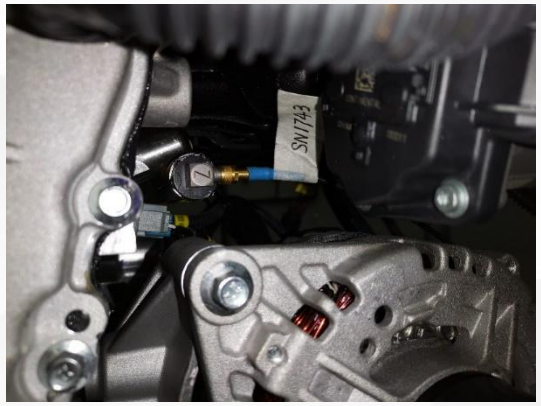
Z: vertical direction

Vibration measurement points include

- Engine block
- Upper/lower suspension mounts
- Key component attachments
- Hull vibration comfort analysis.



Lower front suspension



High pressure common rail measurement point

# ❑Cooperation cases

**Project name: Horizontal-Shaft Outboard Engine Development**

◆OEM:

◆Cooperation period: 2022~

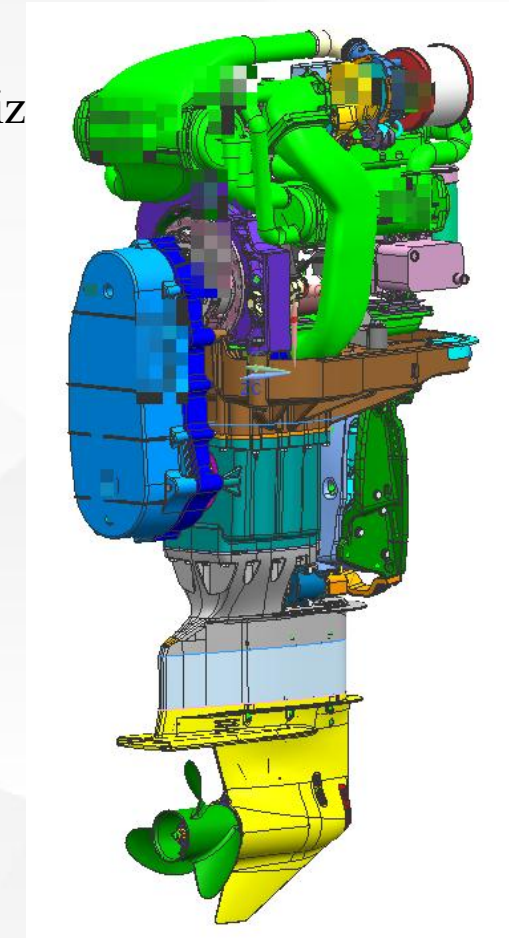
◆Main technical features: 300 horsepower horiz shaft outboard engine development

◆Our work: 3D and 2D design of the whole machine, CAE simulation analyse

◆Current status:

1) Design finalized.

2) Prototype testing underway.



| Number | Item | Content |
|---|---|---|
| 1 | Engine power (kW) | 220.6(300HP) @3600-4000rpm |
| 2 | Maximum speed (rpm) | 4000 |
| 3 | Belt Transmission ratio | 4/3 |
| 4 | Above-water ratio | 13/26 |
| 5 | Underwater gear ratio | 26/13 |
| 6 | Overall gear ratio | 4/3 |
| 7 | Propeller speed (rpm) | 3000 |
| 8 | Weight kg | 450 |

# ❑Cooperation cases

**Project name: 25-30 HP outboard engine development**

◆OEM:

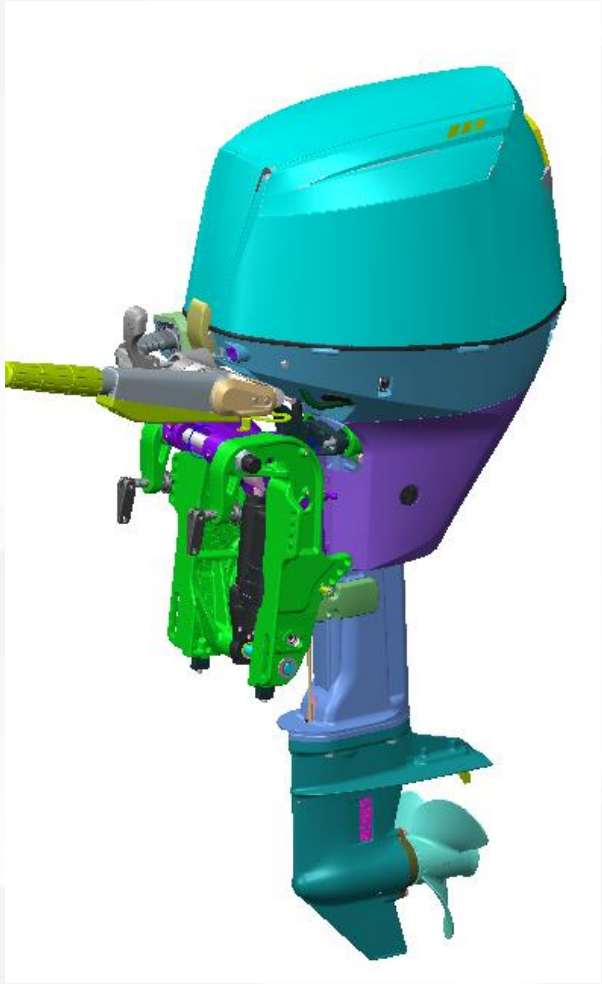
◆Cooperation period: 2024~

◆Our work: 3D and 2D design of the whole machine, CAE simulation analysis

◆Current status:

1) Completed design and development;

2) Prototype trial production



| Number | Item | Content |
|---|---|---|
| 1 | Engine power | 30HP @5800-6200rpm |
| 2 | Maximum engine speed (rpm) | 6000 |
| 3 | Gear ratio | 2.17： 1 |
| 4 | Type | In-line 4 cylinder, four stroke, 8 valves, self suction, electric injection |
| 5 | Fuel | gasoline |
| 6 | Bore × Stroke | 61×57 |
| 7 | Compressionratio | 10.2： 1 |
| 8 | Weight kg | 60-72 |

# ❑Cooperation cases

**Project name: 90-130 HP Outboard engine development**

◆OEM:

◆Cooperation period: 2022~

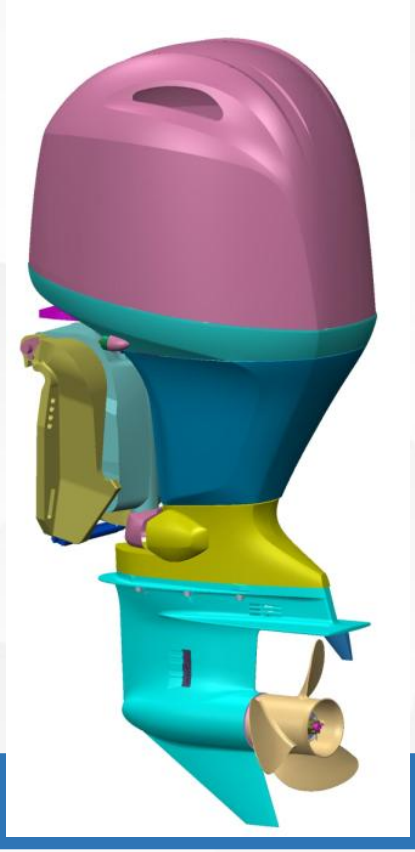
◆Main technical features: 130 horsepower outboard engine development

◆Our work: 3D and 2D design of the whole machine, simulation analyse

◆Current status:

1) Completed design and development;

2) Performance standards.



| Number | Item | Content |
|---|---|---|
| 1 | Engine power (kW) | 95.6(130HP) @5300-6300rpm |
| 2 | Maximum engine speed (rpm) | 6000 |
| 3 | Gear ratio | 2.15： 1 |
| 4 | Type | In-line 4 cylinder, four stroke, 16 valves, self suction, electric injection |
| 5 | Fuel | gasoline |
| 6 | Bore×Stroke | 81×88.9 |
| 7 | Compression ratio | 10.2： 1 |
| 8 | Weight kg | 178 |

# ❑Cooperation cases

**Project name: 150-200 horsepower outboard engine development**

◆OEM:

◆Cooperation period: 2023~

◆Main technical features: 200 horsepower outboard engine development

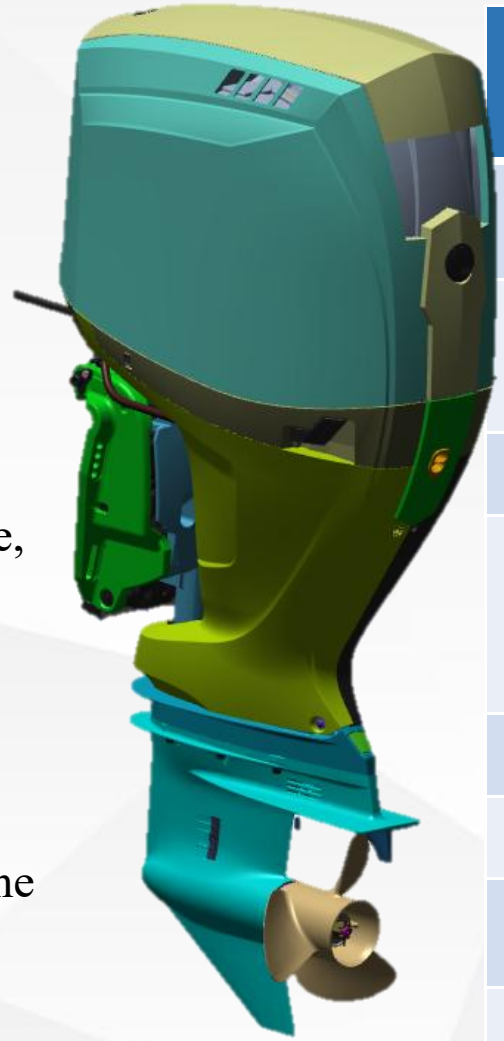
◆Our work: 3D and 2D design of the whole machine, CAE simulation analyse

◆Current status:

1) Completed design and development;

2) Calibration is completed and performance meets the standard;

3) In the durability test.



| Number | Item | Content |
|---|---|---|
| 1 | Engine power (kW) | 147(200HP) @5600-6000rpm |
| 2 | Maximum engine speed (rpm) | 6000 |
| 3 | Gear ratio | 1.86： 1 |
| 4 | Type | In-line 4 cylinder, four stroke, 16 valves, self suction, electric injection |
| 5 | Fuel | gasoline |
| 6 | Bore × stroke | 96×96.2 |
| 7 | Compression ratio | 10.3： 1 |
| 8 | Weight kg | 220 |

# THANKS !

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