IP Pipeline Technology

New Pipeline In-line Inspection Technology Based on Self-propelled

Agenda

- PART 1. About Our Company
- PART 2. New Pipeline Challenge
- PART 3. Robot Structure
- PART 4. Performance Verification
- PART 5. Summary

PART

1

About IP Pipeline Technology

About IP Pipeline Technology

Company Introduction

IP Pipeline Technology is a reliable company of pipeline inspection and data analysis with rich experience. Based on Shenyang university of technology Professor YANG's team.

Since its R&D in 1995, IP has provided the internationally leading technology to pipeline owners and operators. Its world-class inspection team provides the entire inspection service spectrum for onshore and offshore pipelines worldwide.

Efficient & Flexible are IP's key benchmarks. Focus on timely communication with customers and efficient response. Based on strong R&D strength and industry experience, providing flexible customized technical solutions to customers.

About IP Pipeline Technology

Team Development History

Initial Phase:

Initiated the research of in-line inspection tool in 1995.

Maturity Phase:

1. Products reached international standard in 2007.
2. Offshore pipeline tools were successfully developed in 2009.

1995

2000-2004

2005-2009

2010-2021

R&D Achievement Phase:

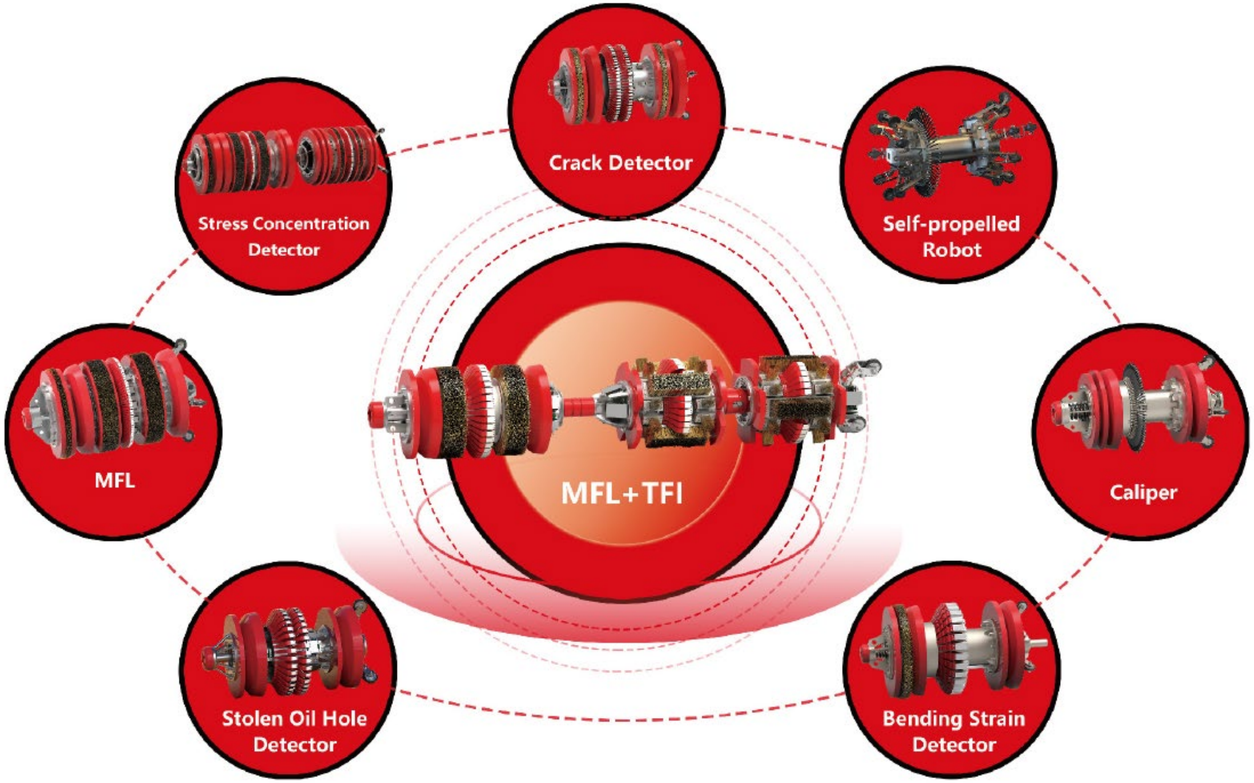
1. The first MFL tool was successfully developed.
2. The Chinese Prime Minister Wen Jiabao presented the Science and Technology Progress Award at Beijing Great Hall of the People in 2004.

Customer Approbation Phase:

1. In 2011, won the first prize of Technology Progress Award from CNPC and Sinopec.
2. Provided the internationally leading technology to pipeline owners and operators worldwide.

About IP Pipeline Technology

Product Range

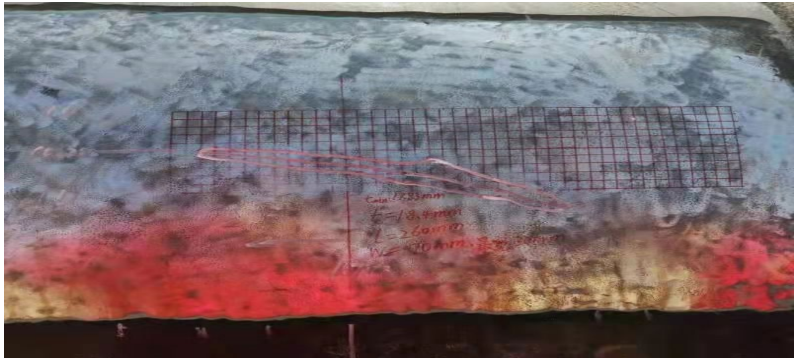


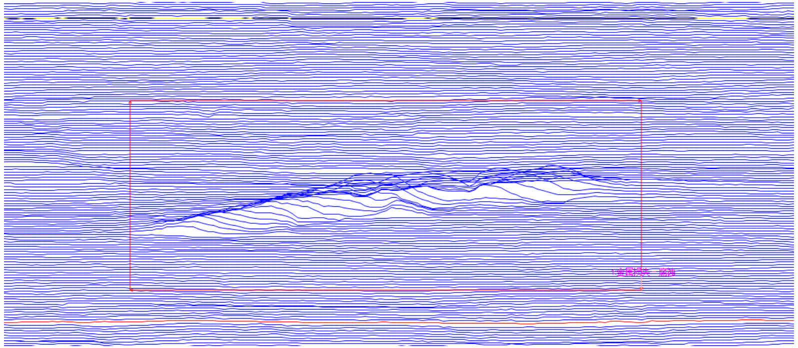
About IP Pipeline Technology

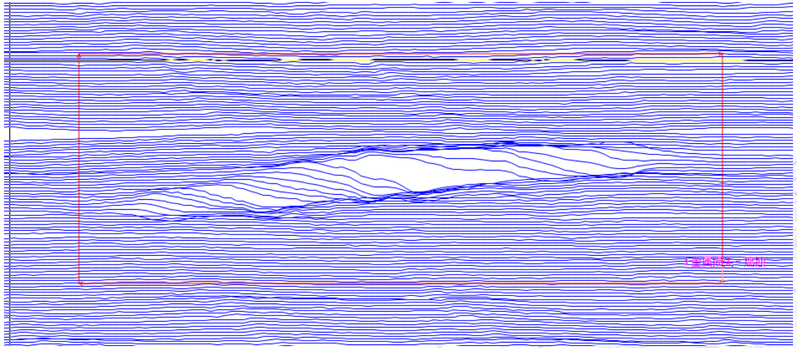
MFL+TFI

- Flexible customization
- High-definition
- Mass data storage
- Speed control system
- Soft steel brush

About IP Pipeline Technology





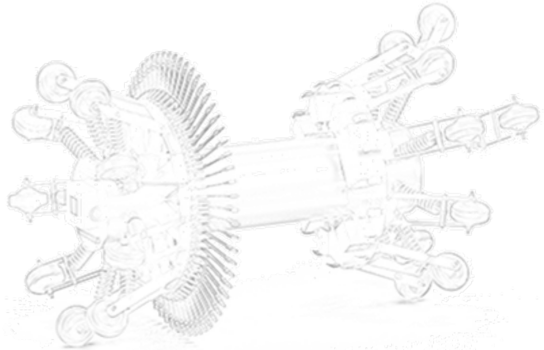


2019-6-17, Huoerguosi – Jinghe pipeline, 48inch. Excavation verification of oblique metal loss.

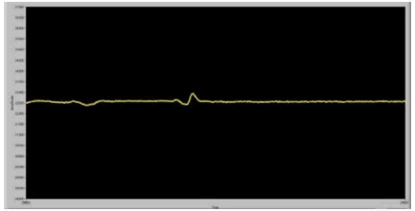
About IP Pipeline Technology

Crack Detector

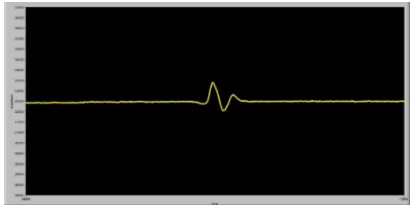
- All-round crack detection
- Detection ability of cracks on the weld
- Flexible customization
- Complementary to MFL



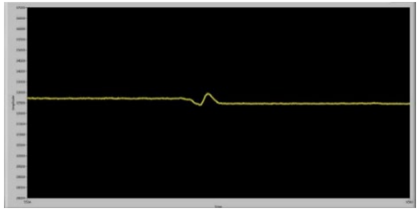
About IP Pipeline Technology



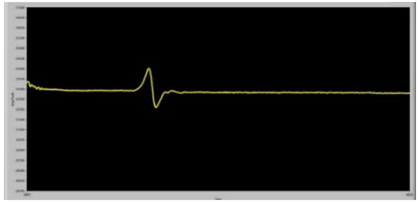
Crack buried at 9mm



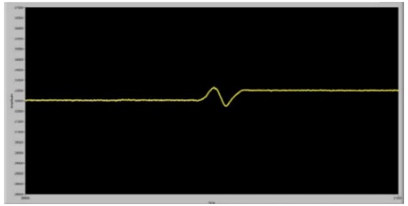
Crack buried at 6mm



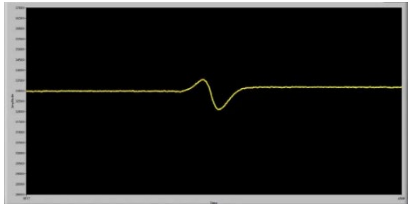
Crack buried at 8mm



Crack buried at 5mm



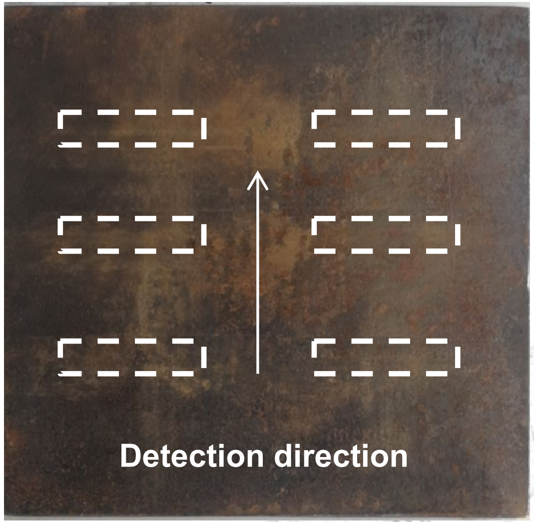
Crack buried at 7mm



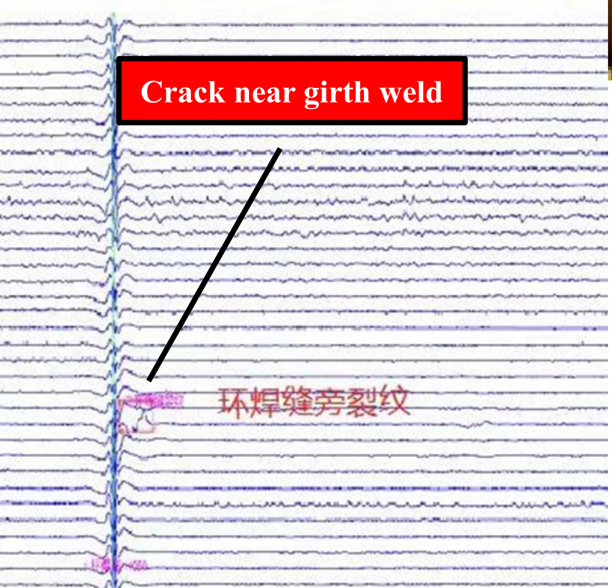
Crack buried at 4mm

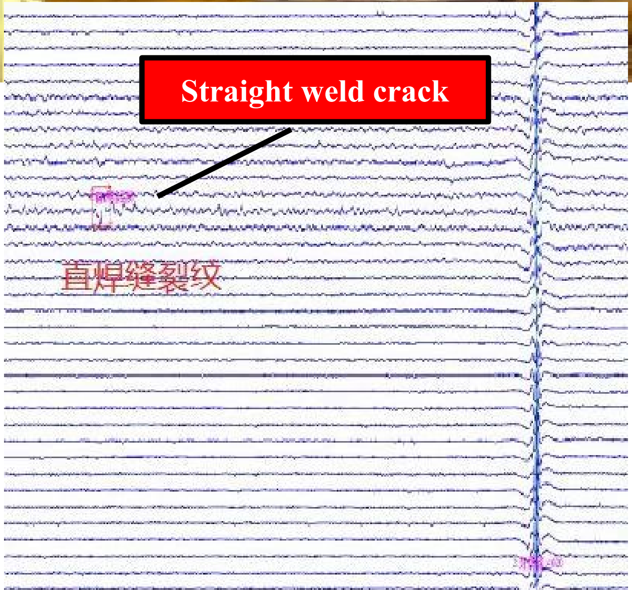
Thickness：10mm；
Crack depth:1-6mm、width:1.2mm、length:40mm

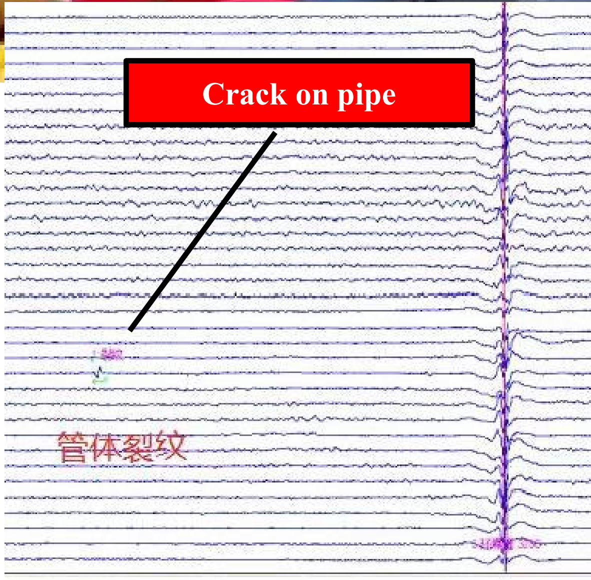
https://ppsa-online.com/Newsletters/?ppsa-2021-jun.pdf#page=8




Client: Pipe China- Western Pipeline
Pipeline name: Kewu refined oil line
Pipe length: 298km
Diameter: Φ457 mm
Wall thickness: 7.1mm


Crack near girth weld
环焊缝旁裂纹

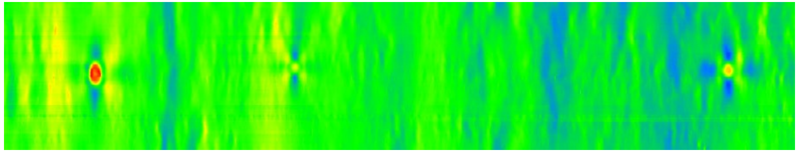

Straight weld crack
直焊缝裂纹


Crack on pipe
管体裂纹

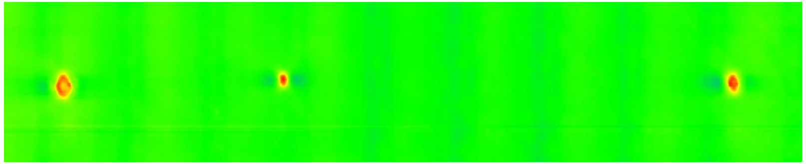
About IP Pipeline Technology

Stress Concentration Detector

The pipeline stress concentration inspection technology utilizes the different recognition rates of the stress magnetic signal under different excitation intensities to achieve stress detection. Not only can it be carried out simultaneously with the MFL, but also is not affected by the MFL. It is a new and efficient stress concentration detection method.

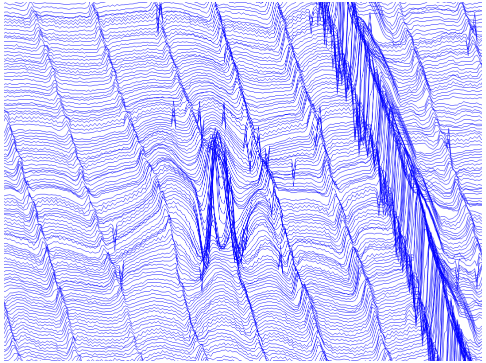


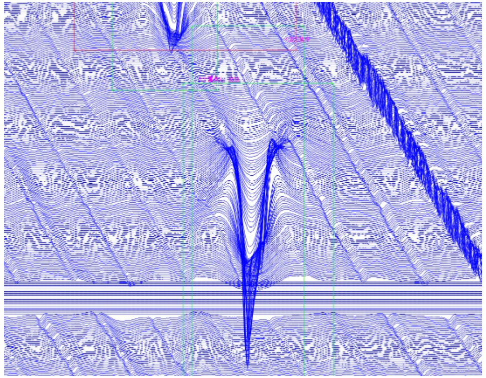
Strong magnetic



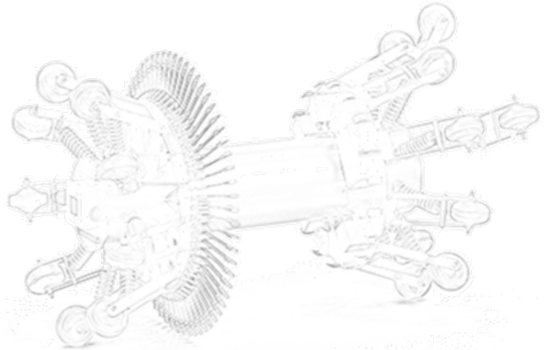
Weak magnetic

About IP Pipeline Technology





Client: CNPC
Pipeline name: West second line
Pipe length: 120km
Diameter: 48inch
Wall thickness: 18.5mm



PART

2

New Pipeline Challenge

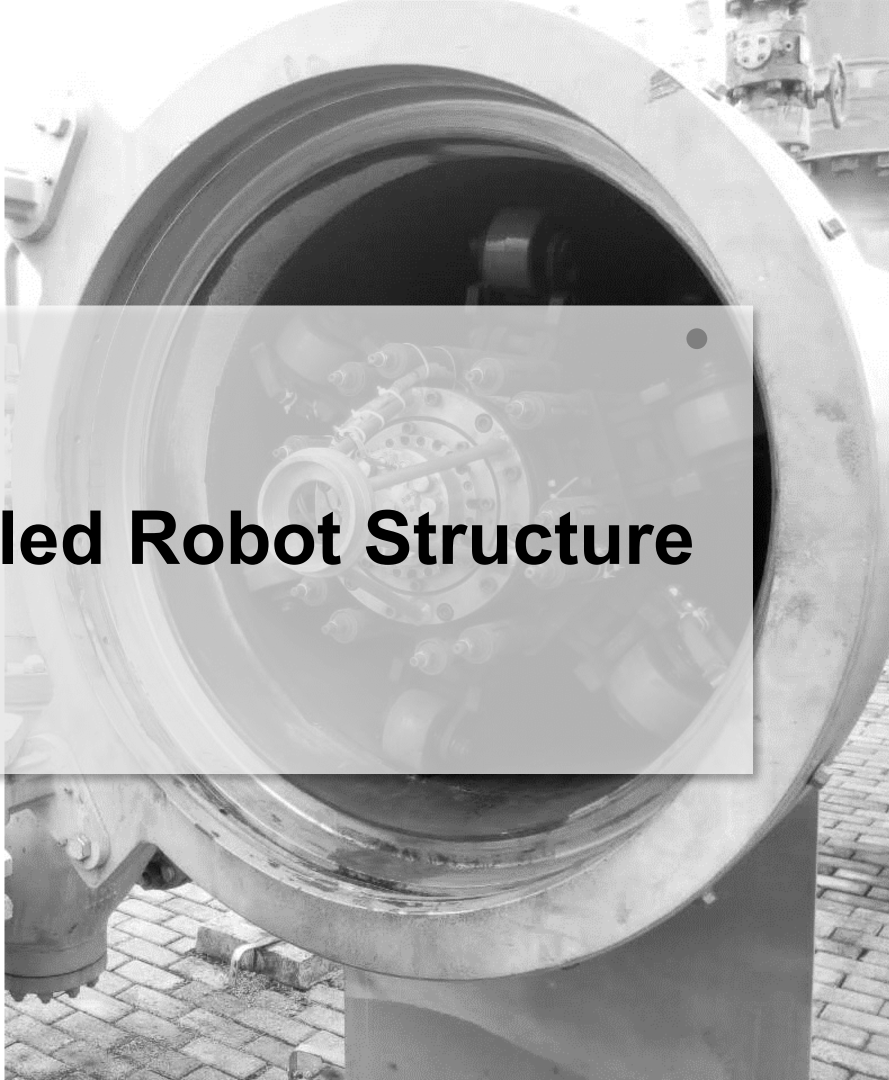
New Pipeline Challenge

- Excessive cost
- Unsafe conditions
- Unstable operation

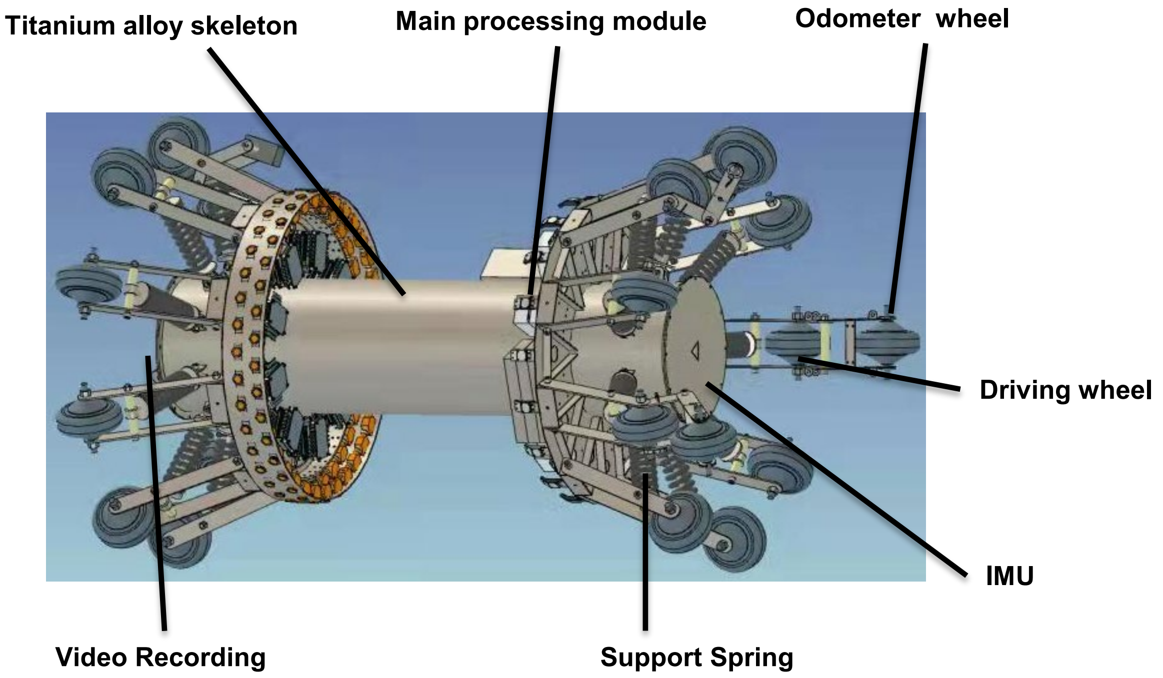
PART

3

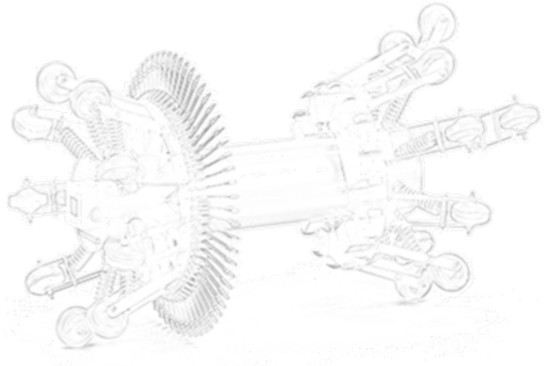
Self-propelled Robot Structure



Mechanical Structure



The self-propelled robot adopts a six-wheel and six-motor parallel drive mode, with a compact structure and large driving power to ensure its smooth operation in the pipeline.



Travel Control System

The motor control system detects the posture angle of the robot through the IMU sensor and adjusts its operation mode according to the real-time posture to ensure its smooth operation.

Posture matrix:

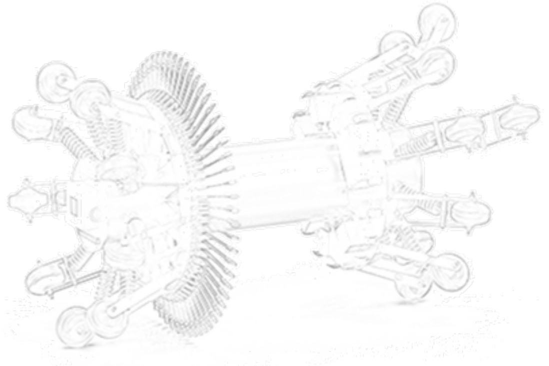
$$C_b^n = \begin{bmatrix} T_{11} & T_{12} & T_{13} \\ T_{21} & T_{22} & T_{23} \\ T_{31} & T_{32} & T_{33} \end{bmatrix} = (C_n^b)^{-1} = (C_n^b)^T = T$$

The posture angles are calculated as follows：

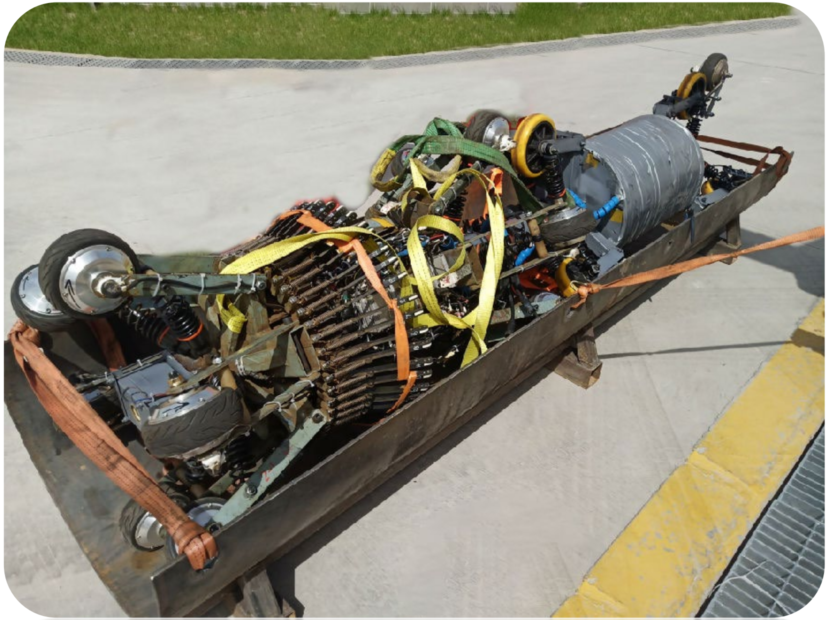
$$\theta = \sin^{-1}(T_{32})$$

$$\gamma = \mathrm{tg}^{-1}(-\frac{T_{31}}{T_{33}})$$

$$\psi = \mathrm{tg}^{-1}(-\frac{T_{12}}{T_{22}})$$



Travel Control System



After the robot enters the motion state, the projection of the relative acceleration vector of the navigation coordinate system relative to the earth coordinate system on the navigation coordinate system is:

$$\vec{a}_{en}^{\,n} = \vec{a}_{ib}^{\,n} - (2\vec{\omega}_{ie}^{\,n} + \vec{\omega}_{en}^{\,n}) \times \vec{V}_{en}^{\,n} + \vec{g}^{\,n}$$

Based on the robot's posture and acceleration information, the power control method is reasonably distributed to ensure smooth operation, and the climbing and braking functions are activated on the uphill and downhill pipelines.

PART

4

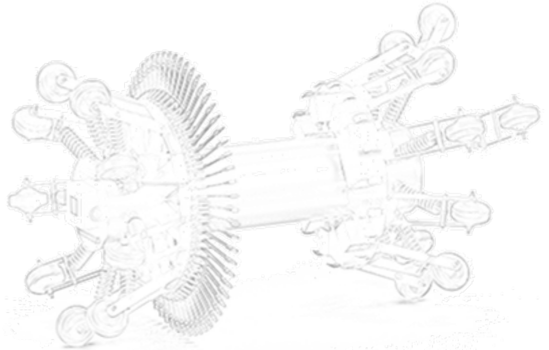
Performance Verification

Performance Verification

Passing Ability Test

The total length of the loop pipeline used in the experiment is 66 meters, including four 3.5D bends.
To verify the robot's passing ability and continuous operation ability.

Result:
The average speed of the robot is 1m/s and the mileage is 36 km.

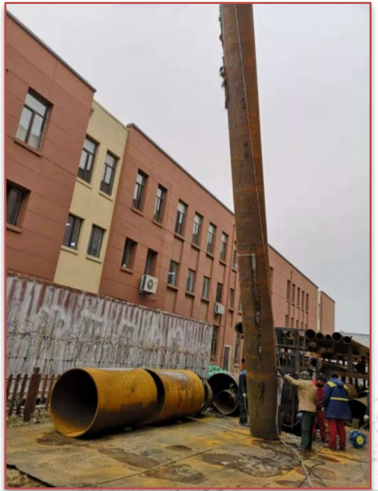


Performance Verification

Climbing test

30°

45°



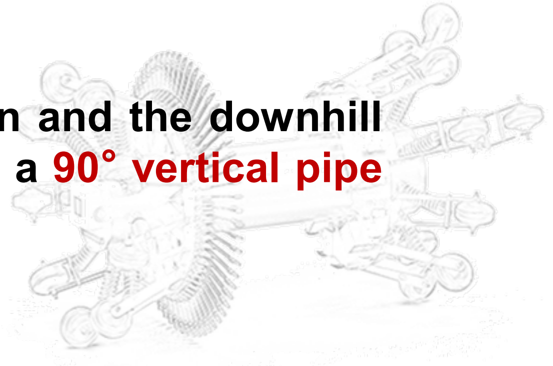
90°

Performance Verification

Climbing test

Slope （°）	Drive current （A）	Brake current （A）	Uphill speed （m/s）	Downhill speed （m/s）
10	14	4.5	1.6	0.2
20	16.5	7.6	1.6	0.25
30	27	12	1.6	0.4
45	36	15	1.6	0.45

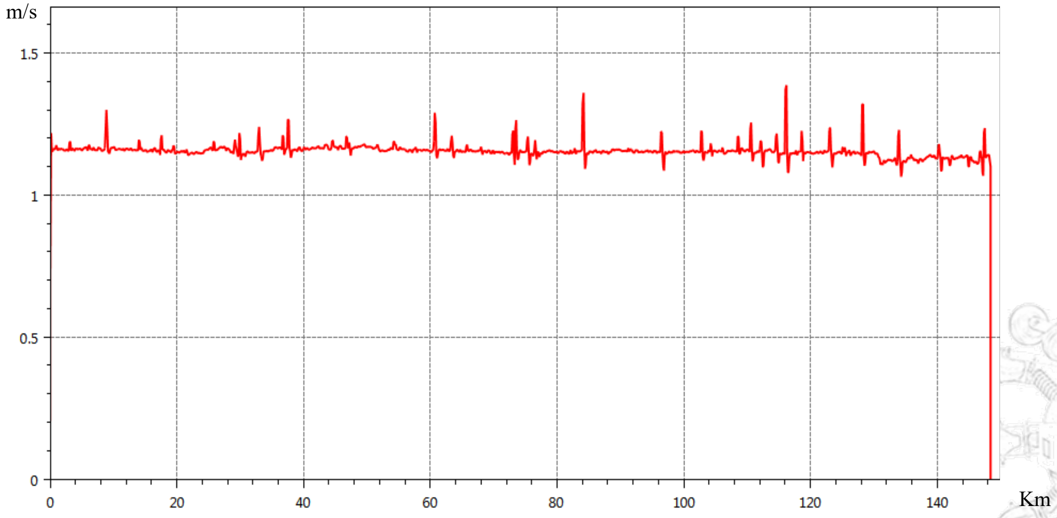
Result：
Robot can stabilize the speed in both the uphill pipe section and the downhill pipe section to ensure stable operation, what is more, it has a 90° vertical pipe section climbing ability.

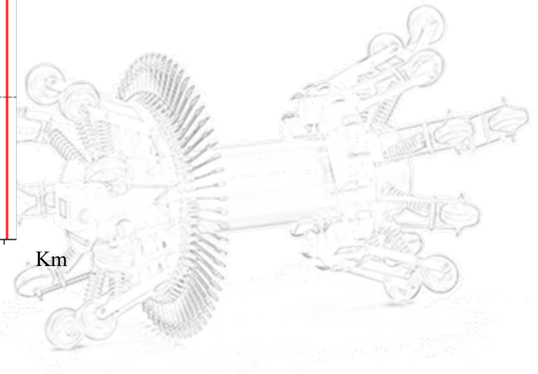


Performance Verification

Case Study

30inch self-propelled pipeline detector carries caliper sensor, video recording system, lighting system, and IMU. The speed of the detector is stable at 1.5m/s and the mileage is 151km.

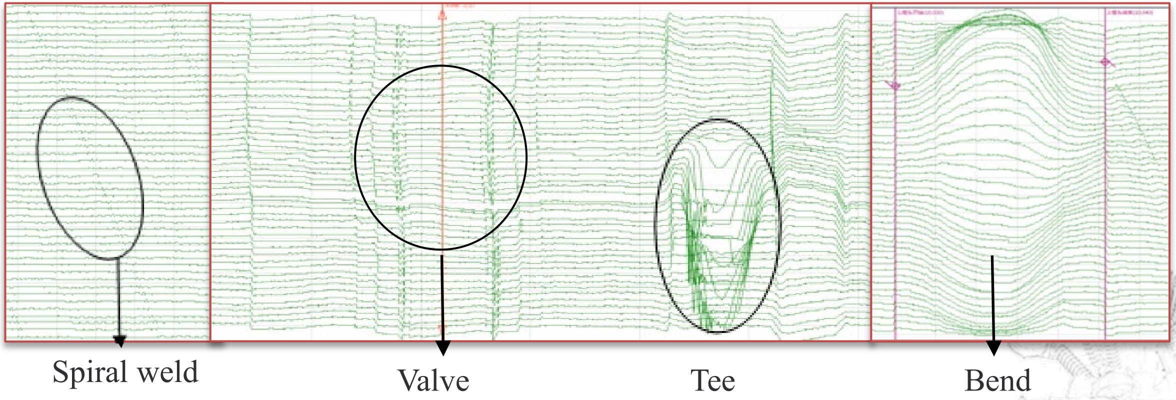




Performance Verification

Case Study

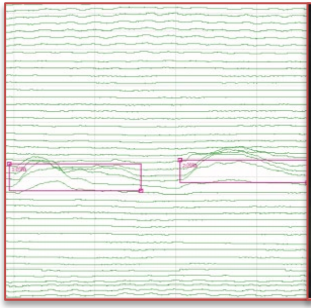
The geometric deformation detection probe carried by the self-propelled detector can identify the pipe features such as pipe spiral welds, valves, tees and so on.



Performance Verification

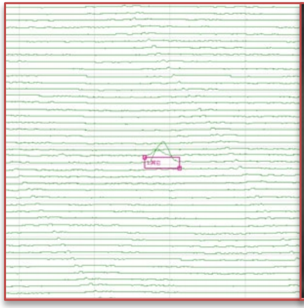
Case Study

The detector carries a video recording system to record the situation in the pipeline. The dent signal may be caused by deformation or a foreign body. By comparing the detection signal with the video information, the dent signal caused by a foreign body in the pipeline can be distinguished.

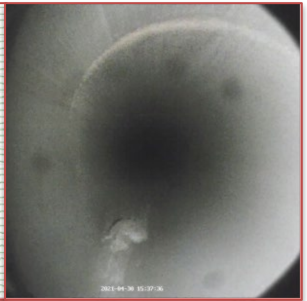


Foreign body signal1

Water



Foreign body signal2

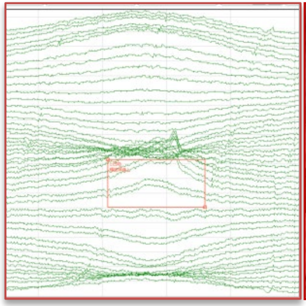


Cement block

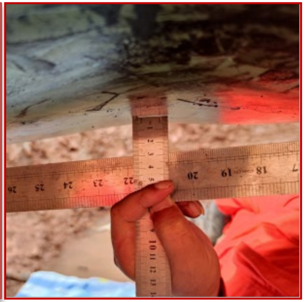
Performance Verification

Case Study

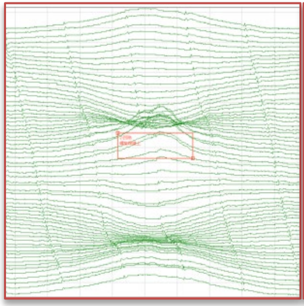
Excavation verification shows that the detector can effectively inspect the 151km new pipeline with a stable speed and high accuracy. The two dents are located at the mileage of 136184.2m and 58877.4m respectively. The actual depth of dent1 is 27mm, the detection result is 26mm, and the accuracy is 96%. The actual depth of dent2 is 25mm, the detection result is 24mm, and the accuracy is 96%.



Dent1



Verification 1



Dent 2

Verification 2

PART

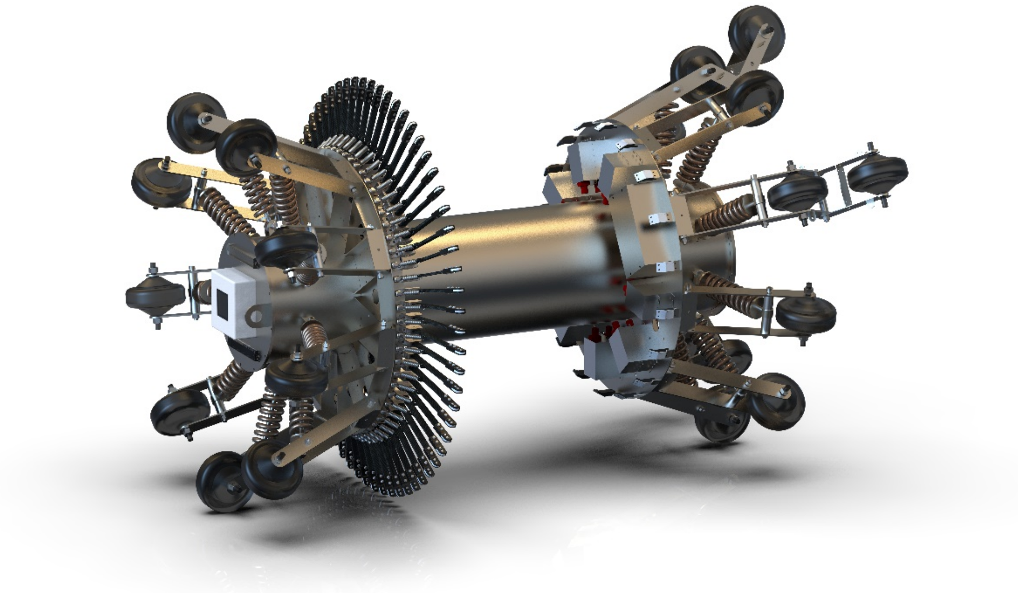
5

Summary

Summary

The self-propelled robot can record its posture information, control the power system to deal with uphill and downhill, ensure stable running speed, and have the ability of 90° climbing and downhill.

It can realize geometric deformation detection and mapping before commissioning. In addition, the robot can also be equipped with stress detection probes, crack detection probes, etc., to achieve a comprehensive inspection of new pipelines.



Thank you

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