

INDUSTRIAL PIPE TRACE HEATING

Pipeline Heating Solution

Wrap-around CNT film heating with segmented master-slave control for long-distance pipelines.

- Full-surface wrap replaces uneven line-type heating
- Laminates to existing pipe insulation — no new materials required
- Segmented control with precise fault location and over-temperature protection

FlexTherm · Shanghai Burning New Material Co., Ltd.

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01 CORE MATERIAL

Carbon Nanotube Heating Film

CNT heating film is a self-assembled network structure formed from freely arranged carbon nanotube arrays. It combines excellent mechanical, electrical and thermal performance with high chemical stability, and is one of the most promising energy-saving heating materials available for industrial adoption today.

99.5%

Electro-thermal conversion

Electrical energy converted into usable heat

1.35 g/cm³

Ultra-low film density

Average film thickness of only 5 μm

3500 W/m·K

Thermal conductivity

Very low heat capacity: instant on, instant off

0.89

Normal total emissivity

Strong far-infrared radiation characteristics

60%+

Thermal radiation ratio

Higher usable heat output per watt

±1 °C

Temperature accuracy

NTC sensing plus proprietary control algorithm

Surface heating, not line heating

Conventional resistance wire heats along a line, producing hot spots and cold gaps. CNT film heats across its entire surface, so heat distribution is even, controllable and repeatable across large or irregular areas.

02 SYSTEM ARCHITECTURE

CNT Flexible Thermal Management System

Encapsulation fabric > CNT heating film > FPC circuit > NTC sensor > Encapsulation fabric

Ultra-thin and fully flexible The extremely high aspect ratio of carbon nanotubes forms a self-assembling film network. It can be bent, folded and crumpled freely, solving the poor flexibility and poor surface contact of conventional heating pads.	Fast, even heating Surface temperature rises to the set point within seconds. The film emits far-infrared radiation in the 6–14 μm band, which penetrates directly into the target medium rather than only warming its surface.
Safe by design Powered from 3.7 V / 5 V / 7.4 V / 12 V / 24 V low-voltage inputs, far below the 36 V human safety limit. Multi-layer protection covers over-current, short circuit and open circuit.	Intelligent temperature control In-house hardware and control-algorithm development enables multi-level precision control, with heating profiles tuned to each customer's temperature and timing requirements.
Machine washable The film's resistance to repeated folding supports 40 standard wash cycles. FlexTherm heating assemblies carry a high waterproof rating and retain full performance after washing.	Instant heat-up, precise holding Sheet resistance is very low and extremely uniform, so heat-up is immediate at minimal power draw. Patch NTC sensors bonded to the film deliver ± 1 $^{\circ}\text{C}$ control accuracy.

Verified heat-up curve

With the highest level set to 53 $^{\circ}\text{C}$, surface temperature exceeds 55 $^{\circ}\text{C}$ within one minute, then enters holding mode and stabilises at approximately 53 $^{\circ}\text{C}$. The difference between the two measurement points stays within 1 $^{\circ}\text{C}$.

03 ADVANTAGES

Why a CNT Heating System for Pipelines

Pipe trace heating has traditionally relied on high-temperature resistance alloy wire. CNT surface heating replaces line heating with full-coverage film heating, and adds intelligent segment control.

- No thermal inertia — the system starts and stops quickly, which makes true intelligent control practical.
- Simple device structure with a small footprint; installation and maintenance are straightforward.
- No environmental pollution, high safety level and no harm to personnel.
- Radiating element and control method can be selected to match each material and process requirement.
- Far-infrared characteristics penetrate into the medium, exciting molecular resonance and raising heating efficiency and quality.
- Long service life and flexible assembly — easily wraps pipes of any orientation or profile.
- Low energy consumption, environmentally sound and safe; produces no harmful gases and no electromagnetic radiation.
- High electro-thermal conversion converts electrical energy into heat rapidly for fast start-up.

04 COMPARISON

Limitations of Conventional Pipe Heating

Issue	Impact of high-temperature resistance alloy wire
Service life	Becomes brittle after long-term use and cool-down cycles, and is prone to fracture.
Magnetism	The wire is magnetic, which can affect field-sensitive equipment or materials.
Oxidation	An oxide layer forms on the surface and flakes off, degrading heat output and conductivity.
Efficiency	Low efficiency and high energy waste — unfavourable for energy saving and emissions.
Control	System control and accurate temperature regulation are difficult to achieve.

Long-distance pipeline heating: three building blocks

1.1 Composite with insulation CNT heating material is laminated to the inner face of standard pipe insulation. No new material has to be developed or substituted, which saves both development and installation cost.	2.1 Wrap-around film layout The flexible film wraps the pipe as a continuous sheet, solving the uneven heat transfer of line-type heating elements. Very low, highly uniform sheet resistance gives instant heat-up at minimal power.
3.1 Segmented independent control The pipe run is divided into segments, each with its own heating slave module reporting to a master controller — improving inspection, maintenance and quality control.	Control benefit Segmenting the run makes temperature stability easier to measure and control, and allows any fault to be detected and located precisely and immediately.

05 CONTROL SYSTEM

Master-Slave Heating Control

Heating units 1...n operate as slave modules under a single master temperature control system. Segments can be installed or removed individually, which simplifies later inspection and maintenance.

Master control element	Function
Master MCU	Coordinates all heating segments and executes the control algorithm.
Fault indicator lamp	Fault alarm — identifies which heater segment has failed.
Heating indicator	Shows which segment is currently heating.
Over-temperature breaker	Physical switch inside the heater; opens on over-temperature and recloses once temperature is stable.
Heating output control	Drives the heater output for each segment.
Temperature signal detection	Continuously measures each heater's temperature and feeds it back for precision control.

Why segmentation matters

A master-slave architecture turns a continuous pipe run into individually diagnosable sections. Faults are located precisely rather than by trial and error, and a single failed segment never takes the whole heating line out of service.

NEXT STEP

Build It With FlexTherm

FlexTherm develops and manufactures carbon nanotube flexible heating systems for brands, OEM and ODM programmes worldwide. Every solution in this document can be tailored to your geometry, voltage, temperature profile, control logic and certification requirements.

Custom development Heating film layout, flexible electrodes, NTC control board and firmware developed to your specification.	Compliance support RoHS, CE and electrical safety documentation prepared for your target market.
Sampling & scale-up Prototype samples first, then validated tooling and mass production.	Talk to us Shanghai Burning New Material Co., Ltd. — FlexTherm carbon nanotube heating systems.