TONEXUS

CCUS Technology and Product Application Manual

2025

01 Corporate Introduction

Tonexus listed on the Shenzhen Stock. Exchange Main Board (003027), upholds the corporate philosophy of “Co-Creating a Net-Zero Industrial Future”. The company is committed to becoming a globally recognized strategic partner in pollution, carbon reduction and industrial net-zero, contributing Tonexus’s expertise to the world’s green transition.

Core Business Areas

Flue Gas Treatment (EPC & Catalysts), CCUS,R&D and Production of New Energy Materials and Equipment, etc.

Key Service Sectors

Steel, Power Generation, Coking, Construction Materials, Chemical Industry,Non-Ferrous Metals, Waste Incineration, Pulp & Paper, Renewable Energy, etc.

2006
Founded

2020
Listed

25 million
Corporate Assets

300,000+ m²
Corporate Land

100,000+ m²
Building Area

800+
Employees

02 Tonexus TX-1 absorption solvents advantages and applications

2.1 The pain points of carbon capture

Easily degradable

For coal-fired flue gas/lime kiln gas and other gas sources with complex conditions and high oxygen content, conventional absorption solvents are prone to degradation and failure, resulting in a large amount of one-time waste liquid.

High cost

The traditional process has insufficient heat utilization and is used in combination with traditional absorption solvents, resulting in high steam energy consumption (3.5 - 4.0 GJ/tCO_2; cost proportion > 70%).

High losses

High amine escape and conventional absorption solvent operating losses in regeneration, significantly increasing absorption solvent costs.

2.2 TX-1 Core Performance: Redefining the Economics of Carbon Capture

Parameter Content	MEA Absorption Solvent	Tonexus TX-1 Absorption Solvent	Customer Value
Regeneration Energy Consumption	3.9-4.1 GJ/t CO_2	**2.1–2.5 GJ/t CO_2**	Over 35% direct reduction in steam costs
Life span	3-10 months	**12-30 months**	absorption solvent service life is extended by 2-3 times, and the cost is reduced by more than 30%.
Net Acid Gas Loading	18-20 L/L	**30-36 L/L**	20% reduction in the size of some pipes, equipment, etc.
Oxygen Tolerance	Poor, need to repeatedly start the amine liquid purification and recovery device	**Excellent for long term stable operation**	Suitable for cement kilns/steel mills with high oxygen exhaust gas

2.3 TX-1 Laboratory Data Interpretation

Serial Number	Absorption Solvent Type	Initial Degradation Time (min)	Note
1	4M MEA	11	1. Using MEA as the reference object, the better stability is found in PZ and DGA, 3x and 2x respectively. 2. Polyamine AEEA has relatively poorer resistance to degradation.
2	4M DEA	10	
3	4M DGA	23	
4	4M MDEA	18	
5	4M PZ	36	
6	4M AEEA	8	
7	4M AEEA	160	AEEA stability increased 20 times with stabilization technology
8	2M AEEA+2MPZ	16	
9	4M TX-1a	373	33 times better than MEA
10	4M TX-1b	597	54 times better than MEA
11	4M TX-1c	1200	109 times better than MEA
12	4M TX-1c (+100 mg/LFe3+、100 mg/L Cl^-)	1140	103 times better than MEA

1. Test Condition:

- 1.0Mpa O_2
- 120°C
- 600rad
- 22-25L/LCO_2

2. Concept Note:

Initial degradation time of an absorption-enhanced oxidation process is usually characterized by the first "resistance" and then accelerated, the resistance time is the initial degradation time.Here, a 10% drop in pressure is taken as the end point of the reaction.

2.4 Material Breakthrough: TX-1 Absorption Solvents – High Performance with Full Customization

- **Needs Identification – Develop absorption solvents with distinct characteristics tailored to different steam prices (RMB 30–250/ton).**
- **Customized Products – Product development has expanded from "point-based" to "line-based" (covering three major categories of absorbents). Furthermore, based on variations in equipment design and user requirements, the TX-1 series is further customized to create the TX-2 series.**

2.5 TX-1 Proprietary Energy Saving Process: Extreme Energy Savings Potential + Reduced Waste Liquid Emissions

Application Scenario	Technology Adaptation Program	Cost Reduction
High CO_2 low partial pressure gas source (CO_2 > 12%)	Interstage cooling + Classic process	5-10% reduction in regenerative steam consumption
High water vapor content low partial pressure gas source (H_2O>13%) + high impurity content	Pretreatment tower sub-functional design + Water balance dual control design + Classic process	Reduction of wastewater discharge by 30-90%; Use of desulfurization agent by 20-50%
Ultra-low CO_2 content gas source	Absorption solvent enhanced mass transfer design + Classic process	/
Low Steam Consumption Requirements	Classic process + Two-stage heat transfer design for regeneration tower + Non-system heat source medium subjected to MVR treatment.	Regeneration energy consumption as low as 2.0 GJ/t CO_2

2.6 Modeling Customer Benefits: Economic Leapfrogging with Policy Dividends

A cement plant with an annual production capacity of 300,000 tons of CO_2 capture as a simulation (the specific benefits need to be accurately calculated according to the actual program and local policies, welcome to contact for a free program and accurate analysis)

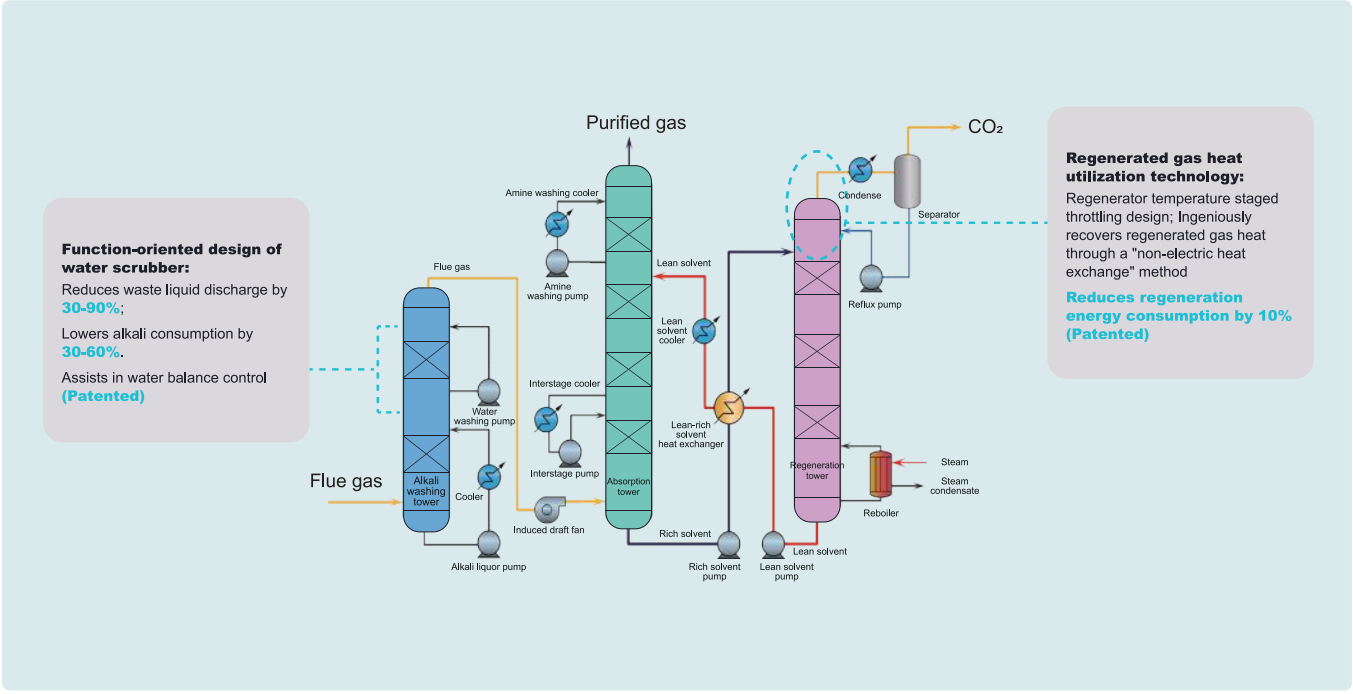
Cost Item	Traditional Solution	Tonexus TX-1 Solution	Annual Savings
Absorption solvent use and waste liquid disposal costs	$5.3/tonne ($CO_2$)Total $1.59 million	**$4.2/tonne ($CO_2$)Total $1.26 million**	$330,000
Steam energy consumption	About 2 tons of steam are needed for each ton of CO_2 processed, which costs a total of 300,000 tons of CO_2 at a cost of $21 for 1 ton of steam: 1.2*21*300000=$12.6 million	**About 1.2 tons of steam is needed for each ton of CO_2 processed, which costs a total of 300,000 tons of CO_2 at a cost of $21 for 1 ton of steam:** **1.2*21*300000=$7,560,000**	$5.04 million
Carbon tax expenditure	$1.845 million ($6.15/ton) 0 (full capture exempt from carbon tax)		$1.845 million

Annual Net Revenue = (Absorption solvent $0.33M + Steam $5.04M + Carbon Tax $1.845M) = **$7.215M**

03 Tonexus TX^{io} Wet Capture Process Technology Advantages

3.1 Introduction to Tonexus TX^{io} Wet Capture Process

Figure 1 Process Flow Diagram



CO_2 capture wet process: Capture + Regeneration

Our carbon capture technology responds to the needs of owners to capture and recover CO_2 from flue gases.The absorption solvent (the core of the wet capture technology) used has a fast absorption rate, high net CO_2 capture load, and the lowest regeneration energy value in China (the lowest regeneration energy value can be less than 2.0t steam/tCO_2).

In terms of heat utilization within the carbon capture device, the proprietary heat exchanger equipment is designed with a perturbed structure to achieve a very low temperature difference (5~7 k) at the hot end of the heat exchanger, realizing highly efficient heat recovery and utilization.At the same time, the latent heat of regenerated gas is skillfully applied to solve the problem of unutilized latent heat of regenerated gas in the traditional process.

Aiming at the organic amine absorption solvent due to its inherent saturation vapor pressure, aerosol and other issues, resulting in the purified gas out of the tower process will escape loss, this technology takes this into full account, using the optimization of the absorption solvent composition, strengthen the means of gas-liquid separation, and strict control of the process conditions, to greatly reduce the part of the fugitive loss.In addition, the alkali washing tower adopts the design of temperature reduction and impurity removal function, which can greatly reduce the generation of waste liquid after alkali washing and lower the treatment cost.

The carbon capture technology solution adopted by our company fully exploits the absorption solvent system, high-efficiency equipment, extreme energy-saving process, etc., to ensure that it is technically the leading level in China.

Utilization of CO_2 after capture

- **Energy sector:** Design of CO_2 mineralization for oil repulsion, fracturing, etc.
- **Chemical synthesis:** Methanol/Acetic acid/Olefins/Methane/Carbonate
- **Industrial applications:** Saline wastewater treatment (containing Na, Cl^-, NO_3^-), food-grade CO_2 (mature technology), utilization of inert protective gas (stirring bottom blowing, welding), etc.

3.2 Core technology breakthrough: capture and regeneration

It is well known that the CO_2 recovery solution for CO_2 sources with low partial pressure (low concentration) of flue gas usually adopts the chemical absorption method, and the core of the chemical absorption capture technology lies in the absorption solvent,The core evaluation criteria for the application of absorption solvent in such units are usually regeneration energy consumption, degradation resistance, and operational losses.When the unit is characterized by low CO_2 content and high O_2 content, it has the following highlights after design:

① The requirement of the Absorption Solvent's anti-degradation ability should be the primary consideration, especially when the gas source recovered by the device contains a certain amount of O_2, the anti-degradation ability of the Absorption Solvent should be strictly required (primarily oxidative degradation).Tonexus Technology TX-1 absorption solvent can be customized to solve the problem of oxidative degradation of absorption solvent according to different needs of devices and products.

② Comprehensively evaluates the price of steam in the public works, and considers whether to adopt the energy-saving process of "Interstage Cooling","MVR"; at the same time, it is recommended to adopt the patented technology of Tonexus Technology's process, which can make the best use of the internal energy of the system to reduce the overall energy consumption of regeneration without any significant increase in the input.

3.2.1 System Optimization Breakthrough

Absorption Solvent type		Regeneration temperature (°C)	Net capture capacity L/L	Regeneration energy consumption (GJ/t)	Operating losses (kg/t-CO_2)	Anti-descent capacity/min
MEA		112~118	18~24	3.9~4.2	1.5~2.9	13 min
Domestic first-class absorption solvent		106~111	24~28	~2.8 (~2.4)	~1.0	/
Tonexus TX-1 Series	A	104~108	30~36	~2.5 (<2.1)	0.4~0.8	**4.5 h**
	B	104~108	24~30	~2.7 (2.4)	0.3~0.7	**7.6 h**
	C	107~112	20~25	~3.4	0.8~1.3	**20.4 h**

—— Comparison of performance between TX-1 and other absorption solvent

Figure 2 Comparison of TX-1a before and after operation

The use of TX-1 series absorption solvents features extremely strong anti-oxidative degradation capability, which is an exclusive technology in the industry. In long-term continuous operation of engineering installations, the color of the absorption solvent remains almost unchanged, with stable capture performance and stable CO_2 output, it can be recirculated.

3.2.2 Process Highlights

- Pretreatment tower sub-functional design, can significantly reduce 30%~90% waste liquid discharge and desulfurization liquid consumption, and assist the water balance control.
- Absorption tower purge gas is subjected to an enhanced gas- liquid separation section to minimize the loss of absorption solvent amine escape.
- Regeneration tower top regeneration latent heat utilization process, enhance the system water balance control ability and heat recovery, optimize the regeneration tower temperature distribution.
- Non-system heat source medium subjected to MVR design.

3.3 Tonexus CCUS Production and Service Capability

3.3.1 Equipment supply

- Non-standard absorption towers, storage tanks, separators and other atmospheric pressure vessels
- Non-standard desorption columns, drying beds, distillation columns, heat exchangers and other low and medium pressure vessels

Figure 3 Workshop overhead traveling crane

Figure 4 Laser cutting machine

Figure 5 NDT Booth

Figure 6 Atmospheric/Pressure vessel equipment

3.3.2 Absorption Solvent Supply

- TX-1a Low-energy-consumption absorption solvent;
- TX-1b Balanced absorption solvent;
- TX-1c Economy absorption solvent.

- TX-2 absorption solvent is customized and designed according to customer needs.

3.3.3 Total Solutions

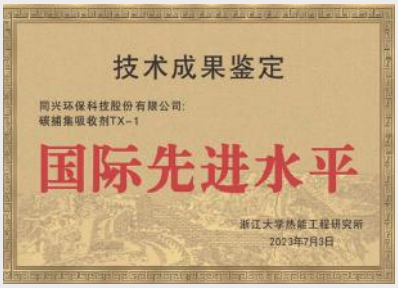
One-stop delivery:

- Feasibility study
- Process design
- Equipment supply
- Construction and installation
- Commissioning and performance guarantee

Industry Cases: Implemented 10,000-ton demonstration projects in coal-fired power plants, cement plants, etc., with experience in treating complex working conditions (e.g., high sulfur, high humidity flue gas).

04 Service Items

4.1 Core Technology



Tonexus Technology leads the consortium, partnering with Zhejiang University and the Chinese Research Academy of Environmental Sciences to undertake the National Key R&D Program (China-South Korean intergovernmental cooperation) (2023–2026).

In July 2023, Tonexus Technology's TX-1 carbon capture absorption solvents passed the technical achievement appraisal at Zhejiang University.

Technical metrics: Under conventional process ***(without energy-saving technology)***, the TX-1 absorption solvents demonstrates ***21*** times higher oxygen resistance compared to MEA, with a regeneration energy consumption of ***2.56 GJ/t CO_2***. It has reached internationally leading standards.

4.2 Projects

Supplied CO_2 absorption solvents for three shipments of two 10,000-ton-scale marine carbon capture units.

Carbon capture from cement kilns and purification to **food-grade CO_2.**

100,000-ton/year **CCUS with coupled carbon and nitrogen production.**

TX-1 absorption solvents demonstrated an **average CO2 capture rate of >98%** in a lime kiln gas application.

05 Tonexus CCUS Cooperation and Business Model

5.1 EPC(EP,BOT) turnkey services

- **Service process:** Covering design-build-commissioning, including pre-assessment and feasibility study, process design and optimization, equipment supply and construction commissioning.
- **Standard controls:** Meet the requirements of design, equipment manufacturing, construction safety, and performance indicators.
- **Policy dividend application service:** Filtering the optimal policy combination according to the project scale and technology route for declaration.

5.2 Agent Cooperation

Tonexus provides technical solutions and core equipment, and the agent is responsible for local relations and construction coordination.

06 Appendice

6.1 Qualifications

Environmental Engineering Air Pollution Prevention and Control Engineering Class A Qualification

Environmental Protection Engineering Specialized Contracting Grade 1 Qualification

Chemical Engineering Grade B Qualification for Chemical Petrochemical and Pharmaceutical Industries

Pressure Piping Design Qualification

Pressure Vessel Manufacturing Design Qualification

Special Equipment Production License Qualification

6.2 Patents

Serial number	Name	Type
1	A low partial pressure and low energy consumption flue gas CO_2 capture method	Patents for inventions
2	A low partial pressure low energy consumption flue gas CO_2 capture system	Utility model
3	A decarburising absorption solvent	Patents for inventions
4	Composite carbon dioxide absorption solvent based on organic amine and its preparation method	Patents for inventions
5	A water-based two-phase decarburizing absorption solvent	Patents for inventions
6	Modular carbon dioxide absorption tanks	Utility model
7	System for integrated utilization of blast furnace gas and its method of use	Patents for inventions
8	Carbon dioxide capture devices	Patents for inventions
9	A kind of coke oven gas rich oxygen combustion carbon enrichment process system	Patents for inventions
10	Wet Carbon Capture Process Coupled with Collective Water Balance Control and In-System Heat Utilization	Patents for inventions
11	Wet carbon capture process coupling water balance control with utilization of internal heat of system	Patents in the U.S., EPO and South Africa
12	A wet decarburization technology regeneration heat recovery process system	Patents for inventions

Authorized 2 patent for invention and 2 utility models

Abbreviations

Serial number	Abbreviations	Chinese name	English name
1	CCUS	碳捕集、利用与封存	Carbon Capture, Utilizationand Storage
2	MVR	蒸汽机械再压缩	Mechanical Vapor Recompression
3	EPC	工程总承包	Engineering 、Procurement 、Construction
4	EP	设计、采购	Engineering 、Procurement
5	BOT	建设-经营-转让	Build-Operate-Transfer
6			
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