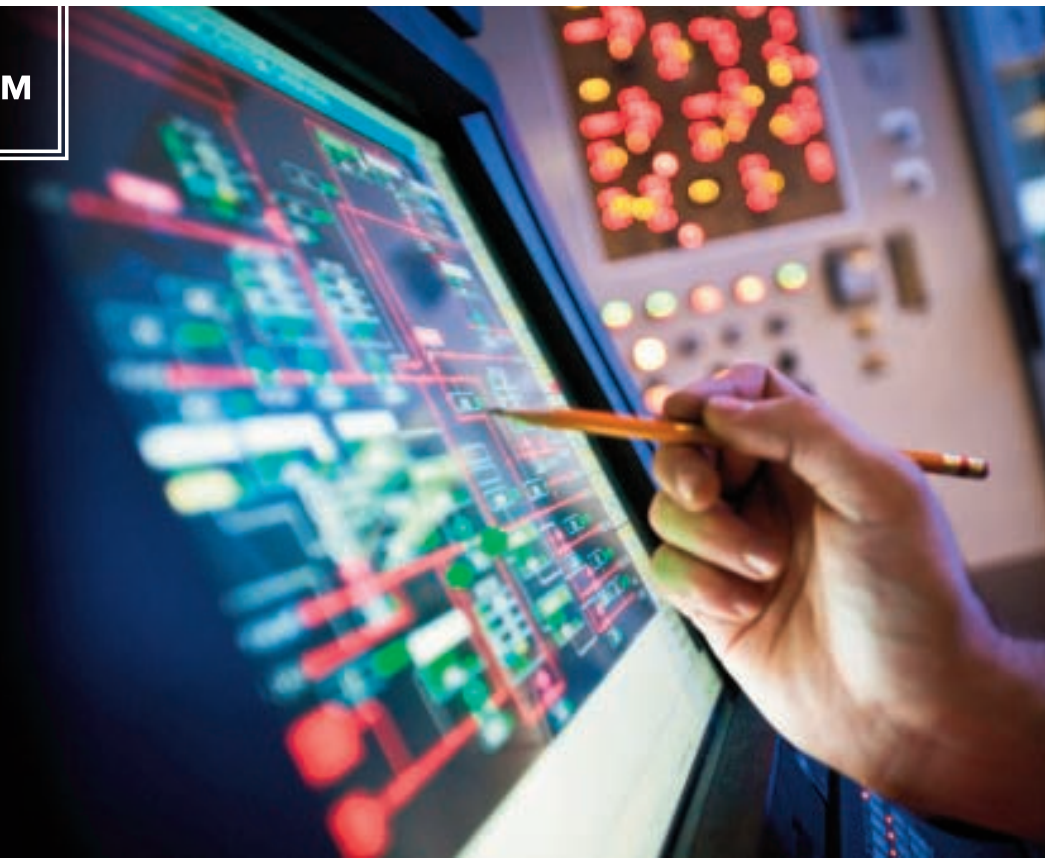
MANCHESTER 1824

The University of Manchester
Intellectual Property **UMIP®**

CryoMan-SMR™

Natural gas liquefaction **redefined**



A revolution in gas liquefaction technology

Executive Summary

CryoMan-SMR™ allows increased and highly flexible LNG production through a combination of reduced energy consumption, low equipment count and simple engineering coupled with vastly improved applications of salient parameters and operating conditions for more efficient natural gas processing.

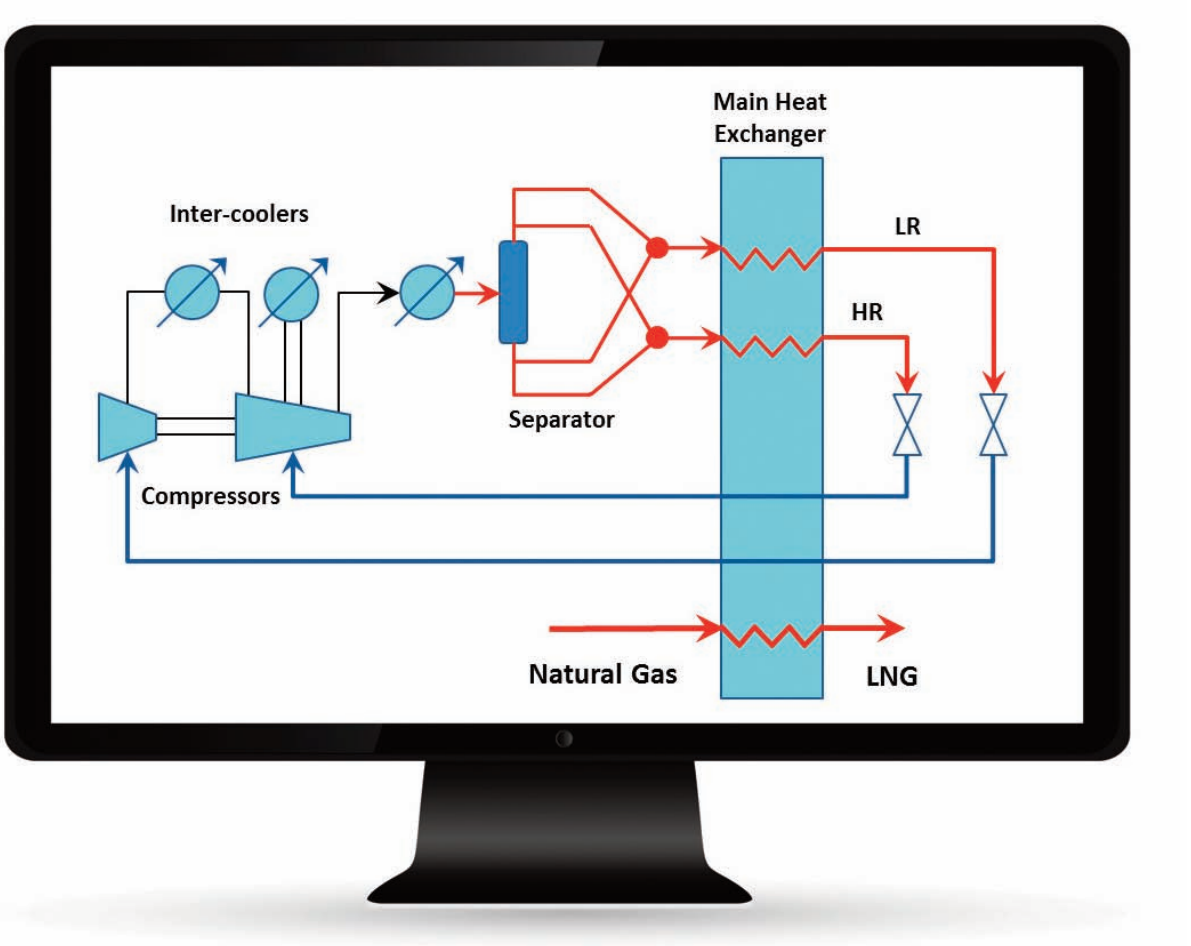
The economic benefits from energy savings are utilised to increase the LNG production. For example, in a 1.0 mtpa plant, with an annual operating cost of $67 million, an increase in LNG output of 9% is expected to yield about $105 million in additional net revenue p.a.

Introduction

CryoMan-SMR™ is a new process technology for natural gas liquefaction that provides a step change in plant flexibility and overall efficiency. The plant can easily be adapted to a wide range of gas compositions while having unrivalled power consumption. It uses design technology from the licensor, The University of Manchester, and is being commercialised through the CryoMan-SMR™ consortium consisting of UMIP, The University of Manchester's agent for Intellectual Property (IP) commercialisation and Process Integration Limited (PIL), experts in cryogenic process enhancement.

The consortium is offering evaluation and development licences under the University's IP in this field. This will be complemented by the additional support provided by PIL through access to proprietary algorithms and cryogenic expertise.

CroMan-SMR™ process flow



Process Description

Using CryoMan-SMR™, natural gas is cooled and liquefied to produce LNG in the main cryogenic heat exchanger using split refrigerant loops of mixed compositions.

The mixed-component refrigerant leaves a multi-stage compressor and is partially condensed by air or cooling water. The first feature of the process is that the mixed refrigerant composition is carefully selected, using proprietary calculation methods. A separator splits vapour from liquid. The low power requirement of CryoMan-SMR™ is achieved by setting the ratios of gas-to-liquid mixing of the product streams leaving the separator. A calculation method has been developed which can set these variables for any LNG composition, temperature and pressure.

By mixing fractions of vapour and liquid products, light refrigerant (LR) and heavy refrigerant (HR) streams are produced. Both LR and HR streams are then cooled in the Main Heat Exchanger prior to pressure let-down, which is usually achieved by throttle valve, or by using expanders. After expansion, the pressure of HR is kept greater than that of LR. Subsequently, the cold HR and LR streams enter the Main Heat Exchanger to provide cooling for the natural gas and for both refrigerant streams prior to pressure let-down. Having provided the process cooling requirements, these HR and LR streams leave the Main Heat Exchanger and are recycled back to the compressors. LR feeds the lowest compression suction stage whereas HR feeds an intermediate compression stage.

The CryoMan-SMR™ Advantages

- 6% - 8% increased production over other small-scale LNG designs
- Enhanced energy efficiency due to better alignment between the hot and cold composite curves
- Simple design with low power consumption
- Large train performance capability delivered through simple modules
- A single mixed refrigerant cycle

Technical Features of CryoMan-SMR™

- Two mixed refrigerant streams with different compositions are created internally by flash separation, stream splitting and mixing
- These refrigerant streams evaporate over different temperature ranges, resulting in closer alignment between the hot and cold composite curves
- Introduction of an intermediate pressure level helps to reduce the compressor shaft power consumption, as less refrigerant is sent to the lowest pressure level
- More operating variables are introduced for more flexible operation
- Relatively simple configuration compared to other complex cascade LNG processes

Energy efficiency comparison

The following comparison tables were constructed using data from an optimisation exercise carried out using the University of Manchester's proprietary algorithms.

Feed Pressure (Bar)	Shaft Power (kW)		The CryoMan-SMR™ Advantage
	Typical SMR process	CryoMan-SMR™	
40	2818	2599	7.8%
65	2390	2259	5.5%
100	2084	1924	7.7%

For 1.0 mtpa LNG production:

Feed Pressure (Bar)	Shaft Power (MW)		Shaft Power (MW)	
	SMR process	CryoMan-SMR™	Shaft Power (MW)	Operating Cost (MM$/yr)
40	37.8	34.9	2.9	1.75
65	32.1	30.3	1.8	1.05
100	28.0	25.8	2.1	1.28

Annual operating hours: 8520 Power cost: 0.07 $/kWh

For further details please contact us