Journal of Zhejiang University-SCIENCE A

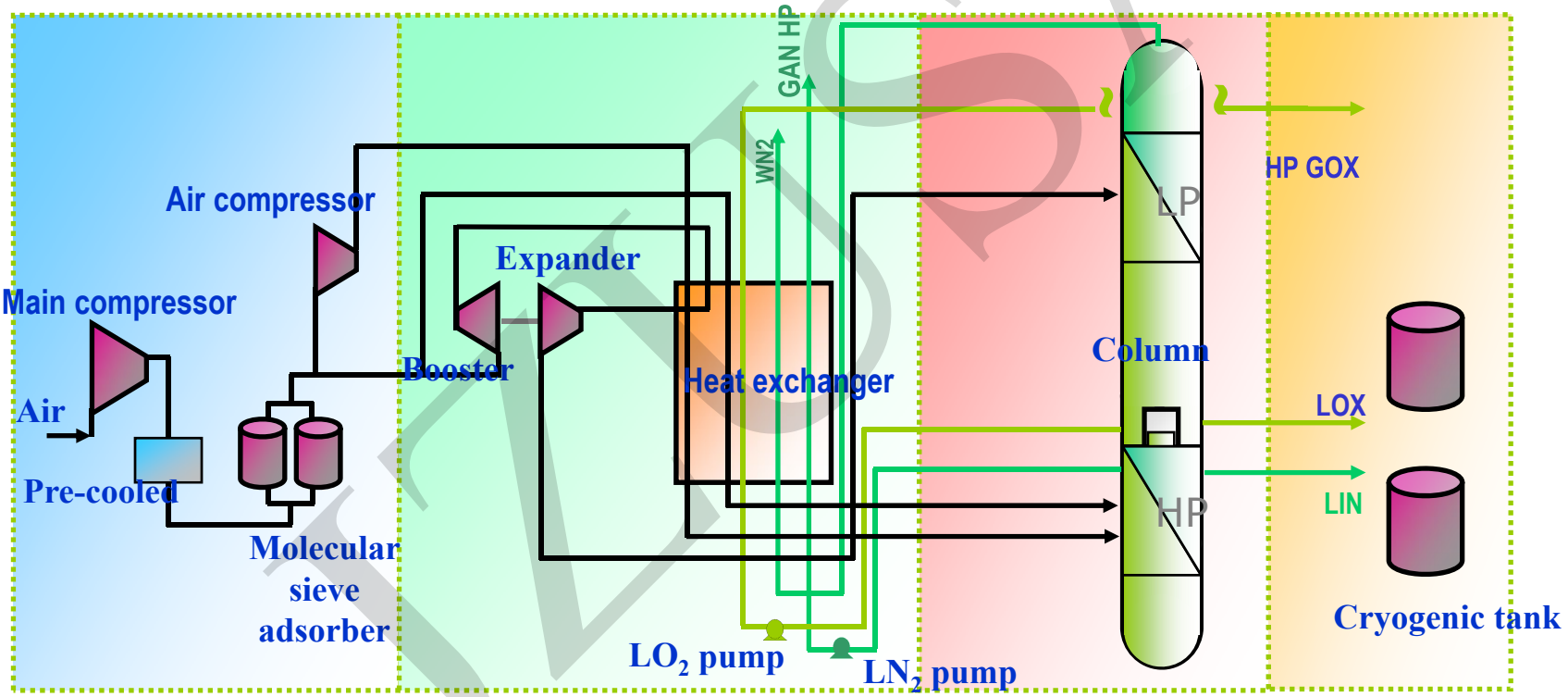
Research and development of large-scale cryogenic air separation in China

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Typical flow in air separation

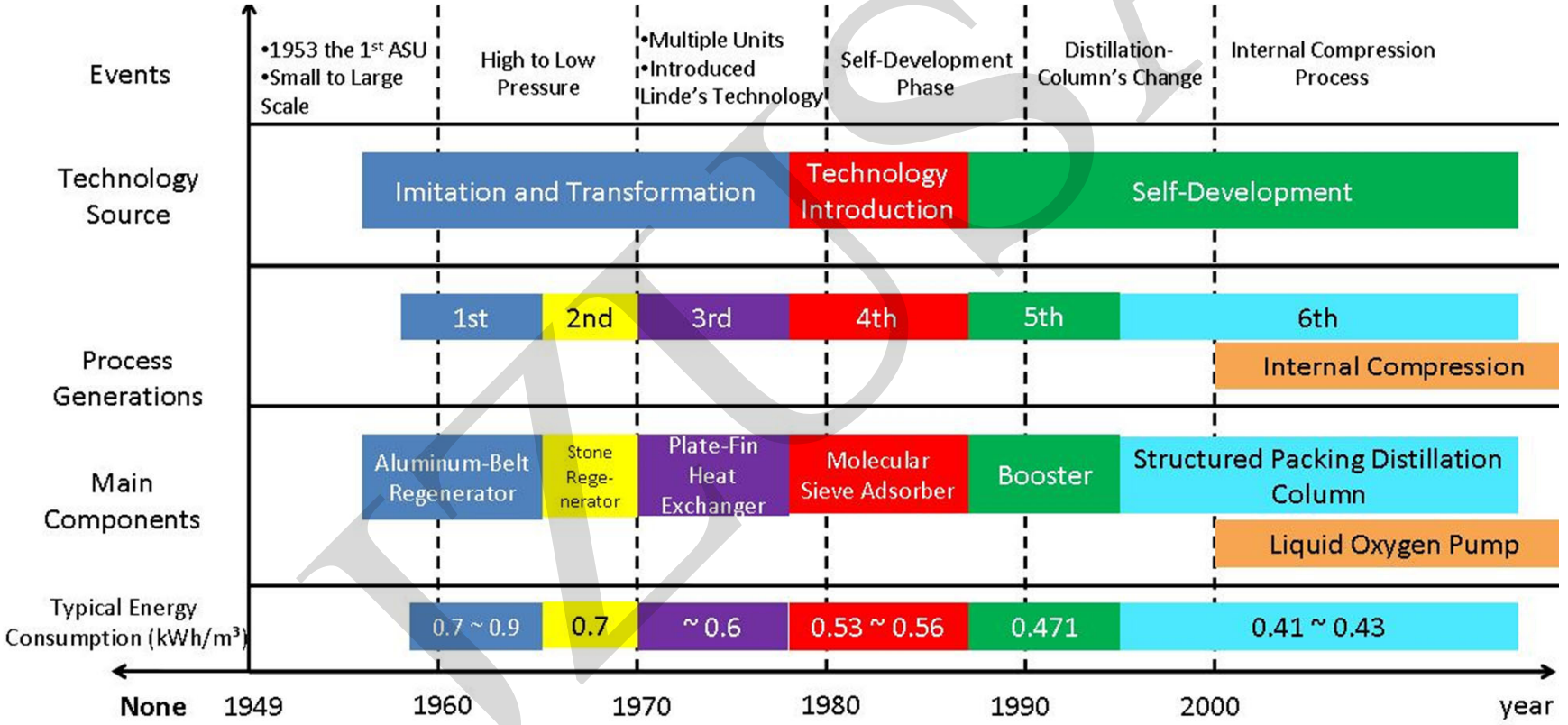
Industrial gases such as oxygen (O_2), nitrogen (N_2), and argon (Ar) are regarded as the "blood" of modern industries such as in steelmaking and chemical product industries. Large-scale air separation (ASU) typically comprises main compressor, molecular sieve adsorber, expander, heat exchanger, column, *et al*.



Typical internal compression process and key equipment in air separation industry

Technology evolution of ASU in China

At the beginning of 1953, the production capacity of an ASU was only 20 Nm^3/h O_2 in China. After 60 years of development, China now has the ability to produce a series of commercial ASU products with a capacity ranging from 20 000 to 100 000 Nm^3/h.

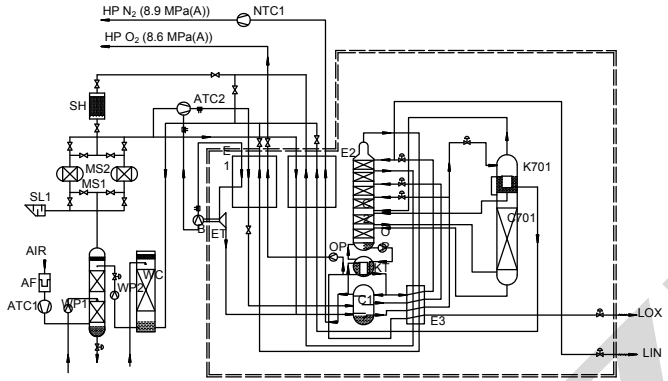


Technology evolution of cryogenic air separation industry in China

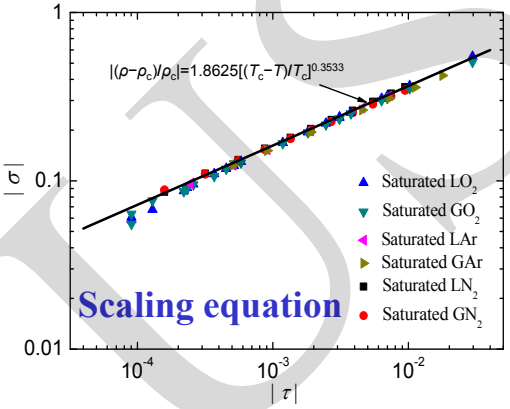
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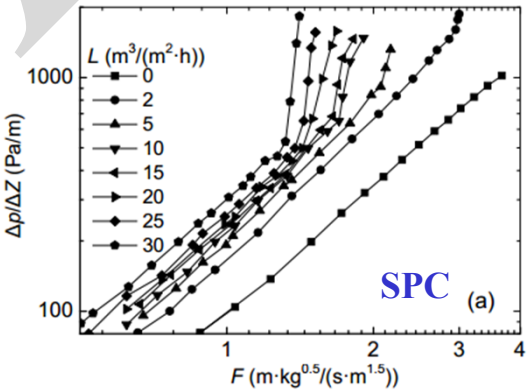
State-of-the-art of an ASU in China

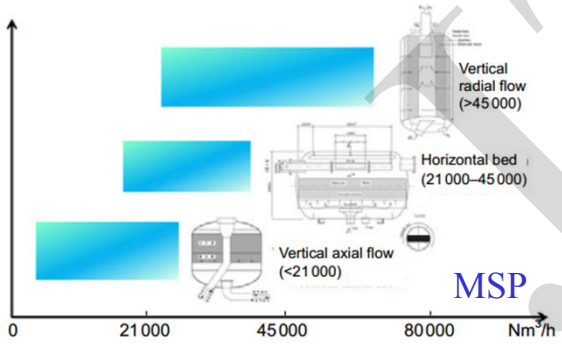
China has certainly caught up with the international development pace by independent innovation of ASUs beginning around 1986. Air booster and high pressure gas expansion processes with molecular sieve purification (MSP), structured packing column (SPC) and distributed control system were applied, the extraction ratios are > 99% and >82% for O_2 and Ar, respectively. The specific power consumption is 0.38 kWh/m^3, a slightly higher than those of international level of 0.28-0.3 kWh/m^3.

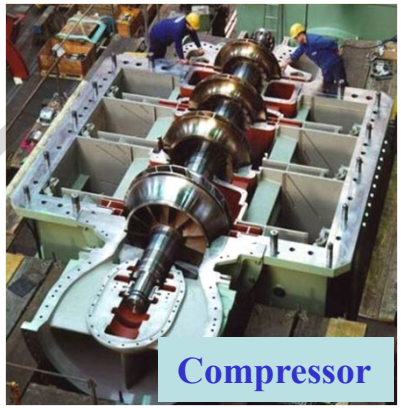


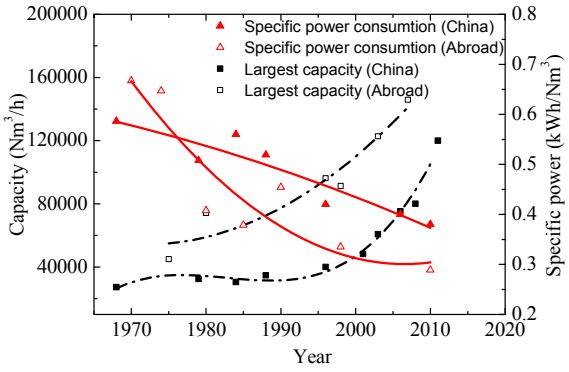
Process flow diagram of ASU designed by Hangyang for 60 000 Nm^3/h of O_2





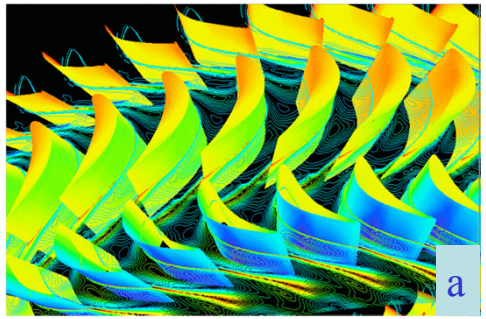


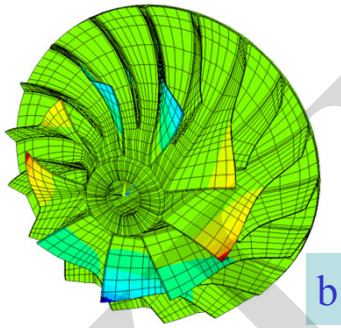


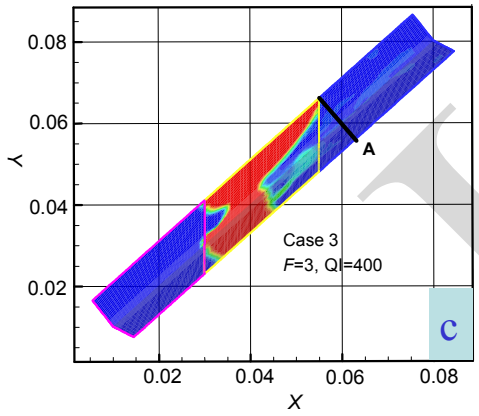


Research and development capabilities

With the rapid development of air separation technology, air separation enterprises and related research institutions have undertaken fundamental research in order to greatly advance this technology in China. CFD techniques have been widely used in the performance analyses and optimizations of almost all of the equipment of ASUs. Experimental testing are also greatly strengthened in the ASU enterprises.





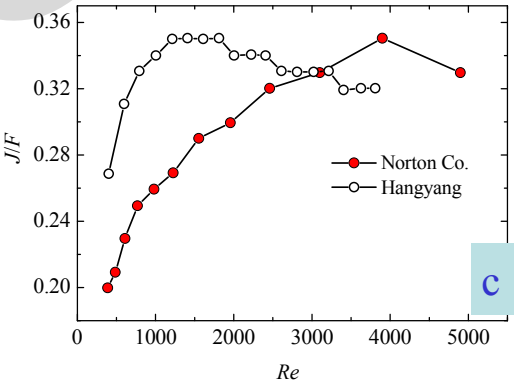


Application of CFD and other technology

a: CFD simulations of unsteady flow of compressor; b: Ansys simulation of impeller strength; c: CFD two-phase simulations of SPC







Advanced experimental technology

a: Wind tunnel testing platform for heat exchanger; b: Test platform for SPC; c: Performance comparison of heat exchanger

Conclusions

- Chinese ASU enterprises have successfully resolved a large number of key technical issues of equipment design and manufacturing, which include: process design according to the needs, equipment design with specified performance and so on; China is now able to independently manufacture 60 000 Nm^3/h ASUs, and has the capabilities for designing and manufacturing larger ASU systems, up to 120 000 Nm^3/h.
- Most of the static equipment can be designed and made in China, while some special devices, such as large-flow expanders, high-pressure cryogenic liquid pumps, and cryogenic valves, generally have to be imported.
- In general, the power consumption approaches 0.38 kW/m^3 O_2 with the domestic large-scale 60 000 Nm^3/h ASUs which are characterized by long-term safety, reliable operation, easy operation and beautiful appearance.

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