A.4: Liquefaction capacity enhancement of indigenous Helium Liquefier

Helium liquefaction was achieved at Cryo-engineering and Cryo-module Development Division (CCDD) at RRCAT using a completely indigenous system for the first time in the country in August 2010. For details, please see RRCAT Newsletter, Vol. 24, Issue 1, 2011. The liquefaction capacity of the system was 6 lit/hr. Now, with continuous efforts, the liquefaction capacity of the system is enhanced to more than 35 litre/hr. In this report, those steps are described, which lead to this achievement.

This system is based on reciprocating type expansion engine and uses cross counter flow type heat exchangers. These heat exchangers are made up of coiled high finned density copper tubes in a shell. Gradually improvements were carried out to increase the liquefaction rate of this liquefier by adding liquid nitrogen pre-cooler stage and optimization of different parameters. With these changes the liquefaction rate of this liquefier touched 20 lit/hr (Fig.A.4.2). Due to limitation of present heat exchangers in handling higher gas flow and refrigeration produced by the expansion engines further enhancement in liquefaction rate was not possible.

To further enhance the liquefaction rate, new reciprocating type cryogenic expansion engines with larger refrigeration capacity were designed and fabricated. Also, state of the art brazed aluminium plate fin heat exchangers with high heat transfer rate and efficiency, coupled with low pressure drop were developed through a local vendor. In total six heat exchangers are required in a helium liquefier. First brazed aluminium plate fin heat exchanger built by the vendor for temperature range 300 to 80 K was integrated with the newly built reciprocating type expansion engines. Our current system uses brazed aluminium plate fin heat exchanger up to 80 K whereas below 80K finned tube in shell type heat exchangers from earlier system were integrated after suitably matching their thermal characteristics. One new compressor in parallel with the older compressor was integrated with the system to meet the required flow rate. With these modifications the liquefier was operated, its first cooldown performance is shown in Fig.A.4.1. Liquefier cooldown along with 250 litre main Dewar, both at room temperature, was started as shown by point (1). Cold box reached liquefaction temperature along with main Dewar as shown by point (2). Liquid started collecting in the Dewar, point (3). After about five hours of stable operation Dewar became full and liquid started flowing back through the return line. This brought down the J-T inlet temperature to 4.5 K, as shown by point (4). Helium plant was shut down at point (5). This system demonstrated a liquefaction capacity of more than 35 litre/hr. During subsequent trial runs the liquefier was integrated with 1,000 litre helium Dewar, Fig.A.4.3.

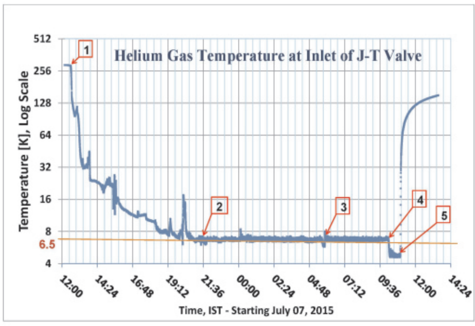

Fig. A.4.1: Graph showing helium gas temperature history at the inlet of J-T valve.

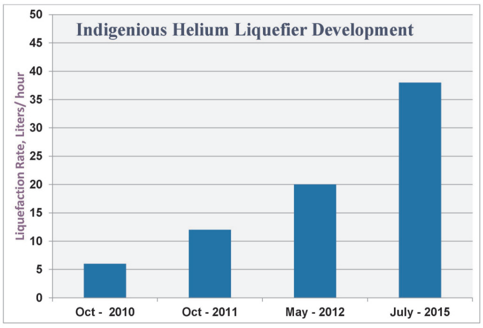

Fig. A.4.2: Liquefaction rate enhancement of indigenous helium liquefier

For prolonged operation of this system with impure helium gas, an integral helium purifier design is in its advanced stage.

High efficiency brazed aluminium plate fin heat exchanger manufactured in India were first time successfully deployed in a helium liquefaction system. Six numbers of high efficiency brazed aluminium plate fin heat exchangers are being made to reach a liquefaction rate of 50 litre/ hr in the indigenous helium liquefier.

Fig. A.4.3: Photograph showing indigenous helium liquefier liquefying helium in a 1,000 litre Dewar

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