

Pump Circulation Systems or Gravity Flooded Systems?

By **Ramesh Paranjpey**

Technical Advisor & Consultant, Pune

I started my refrigeration system design career in 1967 and designed more than 500 industrial plants as well as cold storages till 1992 using mostly ammonia as refrigerant. All these systems used gravity flooded ammonia systems.

In the 1990's, use of pump circulation systems made inroads in Indian market and today it has become a standard practice to use ammonia pump circulation systems almost in all plants. Many customers, not aware of the pros and cons install them on the basis of consultant's recommendations though they may not be cost effective designs and technically sound solutions.

The latest publication by National Horticultural Board for Cold Storages No.NHB-CS-Type 01-2010, also suggests on page 57, that cooling coil surface area may be 5-10% lower if a pump circulation force feed system is used. However, most of the manufacturers of coolers indicate that there is no separate selection for pump circulation coolers and the cooler selection remains same in either case.

There are various views expressed by many in this field and I am making an attempt to highlight advantages and disadvantages of both systems so that users and practitioners can make a right decision as to which system is better suited for their application.

The *Industrial Refrigeration Handbook* by W. F. Stoecker page 184 states:

"Properly designed flooded evaporators and evaporators operating with liquid recirculation operate with equal effectiveness." What then is the basis for choosing between flooded coils and a liquid recirculation system serving multiple coils?

The book on *Design Essentials for Refrigerated Storage Facilities* page 120 sums it up nicely in few words:

"The dominant refrigeration system for intermediate to large storage facilities is the liquid overfeed ammonia refrigeration system. This system is suitable for low and medium temperature cold storage."

The important words to be noted are – "medium and low temperature" as also "intermediate to large cold storages". This means where lengthy refrigerant distribution pipe work and/or specialized process evaporators are required.

So the decision making is very simple. We need to look at our requirements and decide whether it fits into one of the above

norms. If not, installing a pump circulation system may not bring necessary benefits and on the other hand would increase the first cost which is difficult to recover in low priced consumables like potatoes, vegetables or other similar commodities.

One would also readily agree that cold room storage temperature of these commodities do not fit into the bracket of medium or low temperature and the choice therefore is then narrowed to decide whether it is a medium or large capacity cold storage.

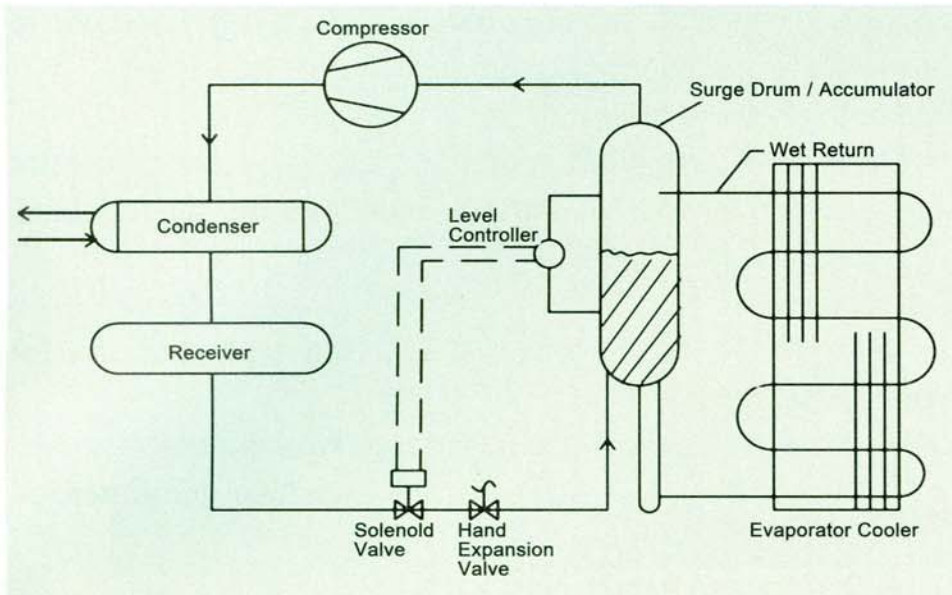
Having arrived at the proper decision based on the above, we shall now look at both advantages and disadvantages of pump circulation systems.

The Advantages of Liquid Overfeed or Pump Circulation Systems are:

1. The evaporator surface is used efficiently because of good refrigerant distribution and complete wetting of the internal tube surfaces.
2. At low temperatures, achieving good heat transfer in the evaporator is crucial, since the plant operates with high compression ratios, where quantities of flash gas are appreciable, affecting proper wetting of the surface. The fundamental liquid pump circulation or overfeeding causes more wetting of tubes associated with high velocity of refrigerant that results in higher heat transfer rate.
3. There is uniform liquid distribution in all coolers and all perform equally. In normal systems, if the number of coolers is more, the evaporator closest to the compressor receives more liquid, whereas the evaporator far away may starve. Also, the pressures/temperatures are not equal in all evaporators.
4. Refrigerant feed is unaffected by fluctuating ambient conditions and condensing temperatures. The flow controls

About the Author

Ramesh Paranjpey is a mechanical engineer with an M.Tech in refrigeration from IIT Bombay with over 35 years experience. He has worked in very senior positions starting with Kirloskar Pneumatic in Pune, Carrier Transicold in Bangalore and Singapore as well as Voltas-Air International Pune. Presently he works for himself as a technical advisor & consultant. He is an ASHRAE Fellow, past president ASHRAE W.I. chapter and past president ISHRAE Pune chapter. He can be contacted at pramesh@vsnl.com



Gravity Flooded system

need not be adjusted after initial setting, since overfeed rates are not very critical. The suggested flow rates indicated in various publications vary widely.

5. Since all the major equipment containing refrigerant is housed in a plant room, the distance between compressors and low pressure ammonia storage vessel is short, thus reducing suction line pressure drops and superheat, thereby elevating compressor saturated suction temperature which can lead to power saving.
6. Overfeeding ensures that the vapours coming out of the low pressure evaporator are as close to saturated condition without any superheat, thus lowering compressor inlet gas temperature, which also means corresponding lower discharge gas temperatures, which are a critical factor for ammonia systems working at low temperature applications. Higher discharge temperatures pose many problems for compressor lubrication.
7. The compressors are protected from liquid slugs resulting from load fluctuations and due to malfunctioning of controls since suction gas first returns to the low pressure vessel and not directly into the compressor.
8. Flash gas resulting from refrigerant throttling losses is removed at the low pressure receiver before entering the compressor.

This gas is then directly drawn to the compressor and eliminated in the low side system design. It does not contribute to increased pressure drop in evaporators or wet suction return line to the low pressure receiver.

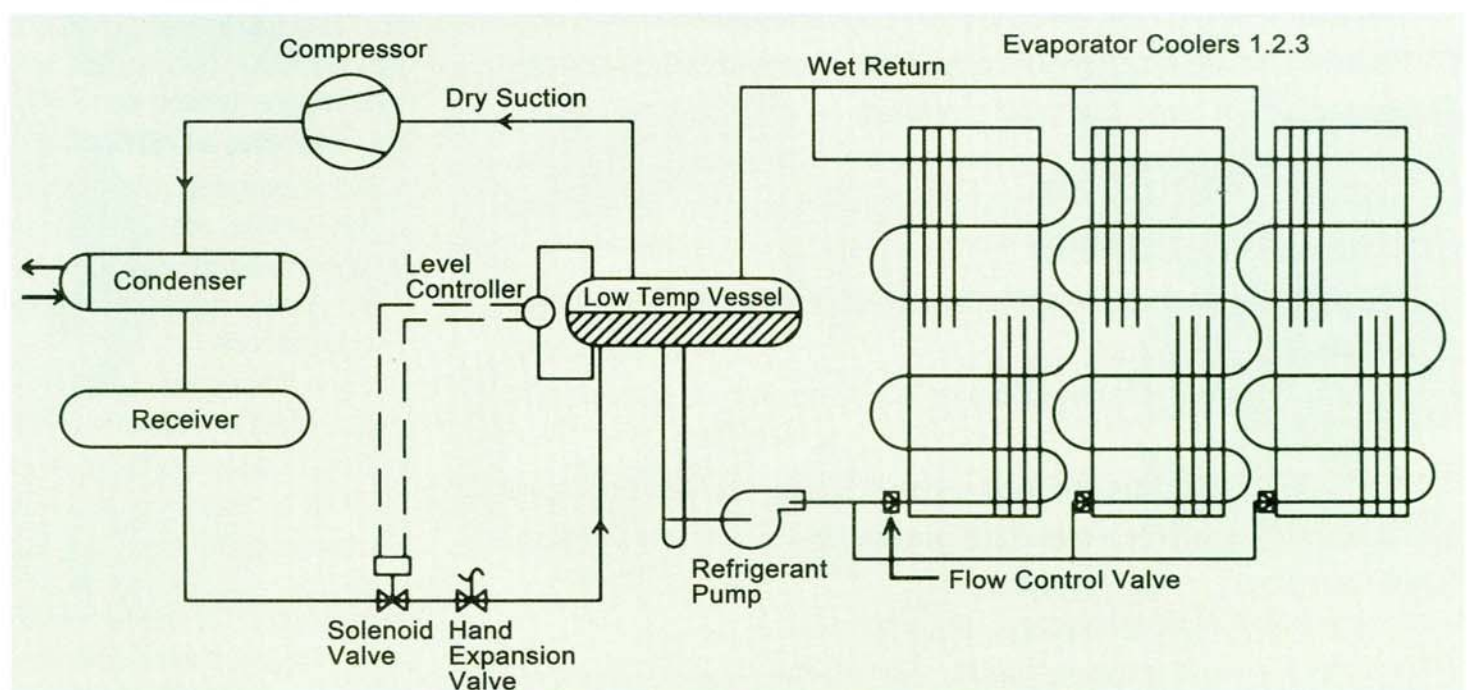
9. Because of ideal entering suction gas conditions, the compressor lasts longer, there is less wear and fewer breakdowns compared to a conventional system.
10. In pump circulation system design, the advantage is that

one effectively decouples the refrigeration system from the load, allowing more efficient operation and a lot of flexibility for design and operation.

11. The fault finding and trouble shooting is also easier as one can be sure that the refrigeration system design is OK, so long as enough liquid is available in the low pressure receiver at the required temperature to meet the demands of all the evaporators. It is then easier to concentrate on performance analysis of low/evaporator side independently in case proper results are not being achieved. This is not so easy where the system is directly responding to the load.
12. Refrigerant-containing parts like HP/LP receivers, controls, level indicators, alarms, refrigerant pumps and oil drains are located in the plant room under the supervision of an operator and not far away and therefore can be supervised effectively.
13. Automatic operation is convenient. With simple controls, evaporators can be hot gas defrosted with little disturbance to the system.
14. Oil does not accumulate in the evaporators and need not be drained from each evaporator. Oil draining is convenient as the low pressure receiver is located in the plant room.
15. In case of sudden stoppage of plant, the production does not suffer as some liquid at low temperature is available in the L.P. receiver, acting as a reservoir for some duration.
16. Cost of accumulators and level controllers for each evaporator is eliminated as these are not required for pump circulation systems

The Disadvantages Are

1. Higher initial cost due to the additional components in an overfeed system design, over and above the normal gravity flooded systems, such as low pressure receiver, circulation pumps and associated controls.
2. Refrigerant quantity in the system is more, thus the size of receiver also increases.
3. Larger diameter of liquid and wet return suction line sizes are needed due to higher circulation rate
4. Piping insulation is much more since liquid supply lines are



Pump Circulation System

also cold, needing additional insulation and suction lines are much bigger.

5. Additional power required for the refrigerant pumps, as also its associated additional maintenance since it is one more moving part.
6. In a gravity flooded system or a pump circulation system, compressor power can be saved by unloading them in response to the the load and maintaining room temperatures during holding periods, but pumps would continue to consume power since they have to work round the clock.
7. An expert designer is needed to ensure proper sizing, construction of L.P. vessel, selection of controls, pipe sizing and location and elevations of various equipments to make a package.
8. One of the major concerns in designing the system is to avoid pump cavitation problems caused by low available net positive suction pressure. Many installations are seen where the NPSH required by the pump is more than the NPSH available, leading to cavitaion.
9. Many installations are seen where incorrect refrigerant feed devices are used, like hand expansion valves that are two phase flow devices which are standard components in gravity flooded designs. Constant flow, automatic liquid flow regulator is required to be installed, so that once the flow is adjusted properly it will remain constant despite fluctuations in liquid line or evaporator pressures.
10. Requires proper adjusting of low temperature liquid flow rate and its pressure at the inlet of coolers. Many installers have experienced poor evaporator performance if these are not adjusted properly as most of the surface of the evaporator is then used to overcome sub-cooling instead of using the surface for evaporation.
11. If a hot gas defrost system is not properly engineered, with both liquid and gas being present in the suction line, hydraulic shocks are experienced in many plants using pump circulation systems.

Conclusion

The use of liquid overfeed system is advantageous:

1. When there are more than 4 to 6 evaporators of large capacity in medium or large size cold storages.
2. Plant room is located far away from the processing area where evaporators are located, involving lengthy refrigerant distribution pipe work.
3. Special evaporators like spiral freezers/IQF or plate freezers are involved.
4. The requirement is for medium or low temperature commodity storage.

If these conditions do not exist then it would be more appropriate to go in for a standard gravity flooded system design.

References

1. *ASHRAE Handbook-Refrigeration 2010*
2. *Industrial Refrigeration Handbook-W.F. Stoecker*
3. *Design Essentials for Refrigerated Storage Facilities* ❖

Planning a Modern Centre for Perishable Cargo

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perhaps, for the first time anywhere in the world for the trade to look into the operations of cargo.

Dedicated Power Station

State-of-the-art, 100% redundant electrical and generator supply system for 650KVA is installed for ensuring uninterrupted, high quality power supply.

Conclusion

In summary, the salient features of a typical centre for perishable cargo are:

- Capacity of handling requisite volume of perishable cargo.
- Double deep cold storages with individual computerized temperature control
- Designed to handle peak loads and freighter loads.
- Dedicated truck parking with reefer points.
- EDI connectivity
- On line connectivity and viewing with real time cameras
- Centralized control for security aided by digital cameras
- Computerized weighing stations
- X-ray machines suitable for Europallets.
- Moveable and fixed work stations for palletisation.
- Ball mat floor for effortless maneuvering of unit loads.
- Modern communication systems through displays, PA systems and EPABX
- Fully temperature controlled to maintain top quality of produce in its transit from receiving are to warehouse area. ❖



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ISHRAE or Indian Society of Heating, Refrigerating and Air Conditioning Engineers, consists of a group of persons interested and actively involved in the field of Air Conditioning (including Heating and Ventilating), Cooling and Freezing. Founded in 1981 with only four members, today the membership has grown close to 10,000 spread over 35 chapters & sub-chapters across India. ISHRAE is an "International Associate" of ASHRAE, American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., headquartered in Atlanta, Georgia with a membership of over 50,000, the largest such Society in the world. Numerous benefits are derived by ISHRAE on account of this association.

The objectives of ISHRAE are :

- Advancement of the science of HVAC&R or Heating, Ventilating, Air Conditioning and Refrigeration.
- Continuing education of members and other interested persons in these sciences through lectures, demonstrations and publications.
- Encouraging research and developement of software to help the HVAC&R industry.
- Encouraging students of engineering colleges to take courses in air conditioning and refrigeration and to join this industry.

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