A Literature Review on Jet Ejector System

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Abstract---Jet ejectors are the simplest devices among all compressors and vacuum pumps. They do not contain any moving parts, lubricants or seals; therefore, they are highly reliable devices with low capital and maintenance costs and also energy saving device. Furthermore, most jet ejectors use steam or compressed air as the motive fluid, which are easily found in chemical plants. Due to their simplicity and high reliability, they are widely used in chemical industrial processes; however, jet ejectors have a low efficiency. The major consideration of this study is to optimize jet ejector efficiency at each operating condition. Consequently, the motive stream consumption and operating cost is minimized. Many factors affect jet ejector performance, including the fluid molecular weight, feed temperature, mixing tube length, nozzle position, throat dimension, motive velocity, Reynolds number, pressure ratio, and specific heat ratio. This paper reviews the various research on jet ejector with different application.

Key words: Primary nozzle, diffuser, motive fluid , nozzle design and position, C.O.P. ,secondary fluid.

I. INTRODUCTION

A jet ejector is a device in which suction, mixing and dispersion of secondary fluid is done by utilizing the kinetic energy of a motive (primary) fluid. When jet ejectors are used as a device for contacting gas–liquid, the secondary fluid may be dispersed by the shearing action of the high velocity motive fluid or the motive fluid itself.

II. WORKING PRINCIPLE OF JET EJECTOR SYSTEM

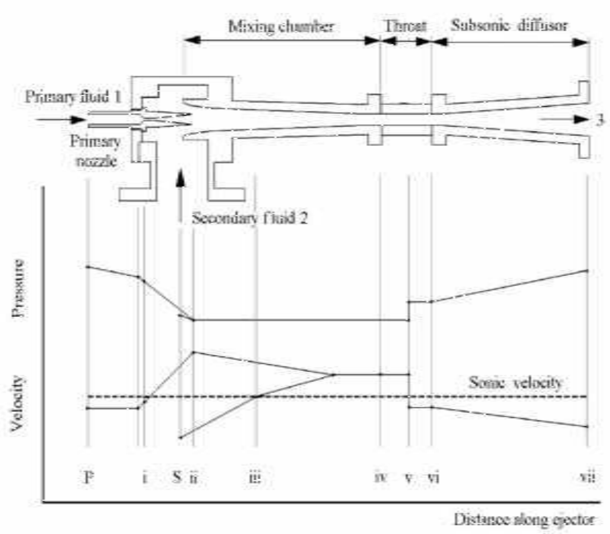

Fig. 1: Jet Ejector Working

Figure 1. shows the typical ejector system in which the jet of primary fluid issuing out of a nozzle creates a low pressure region around it. The pressure differential between the entry point of the secondary fluid and the nozzle tip provides the driving force for entrainment of the secondary fluid. Two principal flow regimes in ejectors are coaxial-flow and froth-flow. The coaxial-flow constitutes a central core of primary fluid with secondary fluid flowing in the annular region formed between the jet of primary liquid and ejector. Froth-flow regime is a co-current flow of fluids with one phase completely dispersed in the other. Witte (1969) termed the phenomenon of change from coaxial-flow to froth-flow as mixing shock. Here a part of the kinetic energy of the flow is dissipated in the shock creating the gas-liquid dispersion. The mixing shock results into generation of small bubbles and consequently creation of high interfacial area (~ 2000m2/m3). Ejectors thus, give superior gas-liquid mass transfer rates and higher rates of reaction as compared to conventional gas-liquid contacting equipment like stirred tanks, bubble columns, packed columns, etc. There could be diverse objectives for ejector design depending on application as follows:

1) To get large entrainment of the secondary fluid.
2) To produce intense mixing between the two fluids.
3) To pump fluids from a region of low pressure to a region of high pressure.

III. LITERATURE REVIEW

*A. Szabolcs Varga, Armando C. Oliveira, and Bogdan Diaconu [1]*studied Ejector efficiencies for the primary nozzle, suction, mixing and diffuser were determined for the first time, according to their definitions, using an axisymmetric CFD model. Water was considered as working fluid and the operating conditions were selected in a range that would be suitable for an air-conditioner powered by solar thermal energy. Ejector performance was estimated for different nozzle throat to constant section area ratios. The results indicated the existence of an optimal ratio, depending on operating conditions. Ejector efficiencies were calculated for different operating conditions. It was found that while nozzle efficiency can be considered as constant, the efficiencies related to the suction, mixing and diffuser sections of the ejector depend on operating conditions.

B. Natthawut Ruangtrakoon, Satha Aphornratana and Thanarath Sriveerakul [2] was done experiment experimental investigation of a steam jet refrigeration. A 1 kW cooling capacity experimental refrigerator was constructed and tested. The system was tested with various operating temperatures and various primary nozzles. The boiler saturation temperature ranked from 110 to 150°C. The evaporator temperature was fixed at 7.5 °C. Eight primary nozzles with difference geometries were used. Six nozzles have throat diameters ranked from 1.4 to 2.6 mm with exit Mach number of 4.0. Two remained nozzles have equal throat diameter of 1.4 mm but difference exit Mach number, 3.0 and 5.5. The experimental results show that the geometry of the primary nozzle has strong effects to the ejector performance and therefore the system COP.

C. Natthawut Ruangtrakoon, Tongchana Thongtip, Satha Aphornratana, and Thanarath Sriveerakul [3] validated experiment result using CFD. The effects on the primary fluid pressure, mass flow rate and Mach number were observed and analysed. The Mach number contour lines were used to explain the mixing process occurring inside the ejector. It was found that shock's position of the mixed fluid and the expansion angle of the primary fluid jet stream within the mixing chamber played a very important role in the ejector performance.

D. Kang Guanqun and Wang Qiang [4] studied to optimize geometric design for the flaps of an ejector nozzle, coupled computation investigations on flow field and solid temperature filed of the nozzle were conducted and presented in this paper. Finite volume method is employed to solve flow Navier-Stokes equations. For the calculation of convective fluxes, numerical dissipation in shear layer and total enthalpy non-conservation passing strong shock can be eliminated with the help of modified Roe scheme while the resolution of shock wave and entropy condition are satisfied. Diffusive fluxes are evaluated by central differencing scheme which can dispel possible odd-and-even decoupling modes. Time-stepping is executed using LUSGS implicit method with multigrid acceleration. Diffusive equation of solid temperature field is discretized applying central difference method of two order accuracy.

E. K. S. Agrawal [5] was done Experimental Observation for Multi- Nozzle Liquid Jet Ejector for Chlorine (Cl_2)-Aqueous Caustic Soda System(NaOH) at Laboratory Scale. The prediction of removal efficiency of gas in liquid jet ejector is an important factor as it influences the design of the mass transfer equipment. The major factors which affect the efficiency of jet ejector are flow rates like gas and liquid and the concentration of absorbing liquid and solute in the gas. Experiment was done with different set of nozzle plates. In this work, the rates of absorption of chlorine from different concentration of gas into aqueous sodium hydroxide solutions of various concentrations were measured at 30°C using a liquid jet ejector. The experimental results were analysed on the basis of the penetration theory for gas absorption. The theoretical model to calculate rate of absorption is developed. The rate of absorption predicted from developed model is compared with experimental results. They were in good agreement. In this work, an attempt also has been made to develop mathematical model to estimate enhancement factor for jet ejector applying Higbie penetration theory.

F. K. S. Agrawal [6] had made mathematical model to predict, mass transfer coefficient and interfacial area has been proposed for multi nozzle jet ejector and it is also compared with experimental data obtained. The measured values of the interfacial area in the jet ejector are about in the range of 3000 to 13000 m^2/m^3in the ejector. To predict mass transfer characteristics the value of gas side mass transfer coefficient (k_G) and interfacial area (a) are required to be predicted. Here a mathematical model is developed to predict the value of (k_G) and (a) using chlorine-aqueous sodium hydroxide solution.

G. K. S. Agrawal [7] considered The prediction of removal efficiency of gas in liquid jet ejector is an important factor as it influences the design of the mass transfer equipment. The major factors which affect the efficiency of jet ejector are flow rates like gas and liquid and the concentration of absorbing liquid and solute in the gas. This deals with statistical modelling for removal efficiency of gas in multi nozzle jet ejector for industry scale jet ejector. The developed model is based on statistical techniques to predict removal efficiency for variation in gas and liquid Concentration. The model is simulated using STATGRAPHICS PLUS 4.0 software for plotting the response surface. The same model is validated by experimental data of industry scale jet ejector.

H. Fan Shi Kong, Heuy Dong Kim, Yingzi Jin and Toshiaki Setoguchi [8] was studied about Chevron nozzle and was applied to jet ejector system to activate the shear actions between the primary and secondary streams, by means of longitudinal vortices generated from the Chevron. A CFD method has been applied to simulate the ejector-diffuser flow field. The present CFD results were validated with existing experimental data. The operation characteristics of the ejector system were compared between Chevron nozzle and conventional convergent nozzle for the primary stream. The ejector-diffuser system performance is discussed in terms of the entrainment ratio, ejector efficiency, pressure recovery as well as total pressure loss. The numerical simulation results with and without Chevron nozzle have been compared. In the numerical analysis, the Chevron nozzle influence on shock system was obviously obtained. More longitudinal vortices were generated which involved more secondary stream. As the result of the updated model, the model with 10 Chevrons nozzle shows the better results: entrainment ratio was improved 14.8% in average, and the maximum 21.8%. At the same time, pressure recovery was increased 8.5% in average.

IV. CONCLUSION

Jet ejector system has different operating characteristic with different application. Primary application is in refrigeration and air- conditioning.

Primary nozzle design, nozzle exit position , effective mixing area , back pressure on diffusor , Fluid velocity, pressure ratio and specific heat ratio are operating performance parameter.

Their use as mass transfer equipment for liquid-liquid extraction, gas absorption, gas stripping, mass transfers, slurry reaction like hydrogenation, oxidation, chlorination, fermentation, etc. has increased.

V. FUTURE SCOPE

For researchers there is wide scope for analysing and developing new model of jet ejector for mass transfer and other vacuum creation and flow-mixing application. Also more work should be done on multi- nozzle jet ejector.

REFERENCES

[1] Szabolcs Varga, Armando C. Oliveira, Bogdan Diaconu ,2008, Numerical assessment of steam ejector efficiencies using CFD , international journal of refrigeration 32 (2 0 0 9) 1203 – 1211.
[2] Natthawut Ruangtrakoon, Satha Aphornratana, Thanarath Sriveerakul , Experimental studies of a steam jet refrigeration cycle: Effect of the primary Nozzle geometries to system performance , Experimental Thermal and Fluid Science 35 (2011) 676–683
[3] Natthawut Ruangtrakoon, Tongchana Thongtip, Satha Aphornratana, Thanarath Sriveerakul, CFD simulation on the effect of primary nozzle geometries for a steam ejector in refrigeration cycle, International Journal of Thermal Sciences 63 (2013) 133e145.
[4] Kang Guanqun, Wang Qiang ,2011, Prediction study of geometric optimization for an ejector nozzle with coupled flow-heat transfer method ,International Conference on Advances in Engineering.
[5] K. S. Agrawal **,** Rate of absorption and interfacial area of chlorine into aqueous sodium hydroxide system , African Journal of Environmental Science and Technology Vol. 7(7), pp. 694-701, July 2013.
[6] K. S. Agrawal, Interfacial area and mass transfer characteristics in multi nozzle jet ejector, International Journal of Emerging Technologies in Computational and Applied Sciences (IJETCAS) ,ISSN (Online): 2279-0055 ,2013.
[7] K. S. Agrawal, Removal Efficiency in Industrial Scale Liquid Jet Ejector for Chlorine-Aqueous Caustic Soda System, International Journal of Engineering Trends and Technology (IJETT) – Volume 4 Issue 7 - July 2013,ISSN: 2231-5381.
[8] Fan Shi Kong, Heuy Dong Kima, Yingzi Jin and Toshiaki Setoguchi, Application of Chevron nozzle to a supersonic ejector–diffuser system ,5th BSME International Conference on Thermal Engineering 2014.