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REFRIGERATING MACHINES PRODUCING
REFRIGERATION AND HEAT FOR MICROBIOLOGY
INDUSTRY PROCESSES

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RESUME: A la production d'un composé proteique et vitaminé (CPV) des paraffines, le processus s'opere avec un fort dégagement de chaleur de potentiel bas au niveau à une température 20°...30°C et en même temps avec une forte consommation de chaleur à une température 65°...85°C. Telles conditions sont les plus favorables pour l'utilisation de la pompe à chaleur (PC) particulièrement si on tient compte de leur fonctionnement de l'année entière aux charges constantes.
La PC permet de stabiliser la température de la biomasse à la fermentation au niveau optimal, ce qui augmente la puissance annuelle de l'installation technologique de 12...15% et diminue la consommation de vapeur d'eau pour le chauffage des lignes technologiques et l'évaporation.
Dans le rapport on examine les charges thermiques pour obtenir d'une unite de production et les parametres de la PC pour les entreprises fonctionnées et à construire. On indique que l'évaporation directe et la condensation du réfrigérant aux appareils technologiques donnent la possibilite au coefficient de performance constant d'augmenter la température de la source de chauffage de 70° à 90°C et par cela même de tripler l'utilisation de la chaleur produisant par la PC.
Dans le rapport on décrit la construction de la PC et on donne une argumentation au choix du butane en tant qu'un refrigérant. On tire une conclusion du rationnel de l'application de la PC aux autres installations de l'idustrie microbiologique.

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Large amounts of heat are usually released during the production of a protein-vitamin concentrate(PVC) from paraffins in the fermenters.Heat is removed by the circulating water supply system of a facility.However, when the water temperature in this system is raised in summer the temperature conditions are disturbed causing the bacteria activity decrease,and hence the fermenters capacity is lowered to 40% of the rated capacity,and due to this the annual output of product is reduced by 12-15%.

These losses could be avoided by thermal stabilizati n of the biomass accumulation process due to applying refrigeration in summer.But this approach is not profitable in terms of economy since it involves the increase in energy consumption and additional capital investments the efficiency of which is reduced with seasonal utilization during 3000...4000 hours per year.

The use of heat pumps with simultaneous utilization of generated heat and cold has been considered expedient after having studied the heat balances of facilities for producing the PVC and temperature levels of production lines.The heat pumps being applied at operating facilities with installed production equipment as well as at the facilities being constructed where equipment has been designed for operation with heat pumps they have revealed economy and energy efficiency.

What heat loads and temperature levels are there at the facilities producing the PVC?

8 kJ of heat is released per 1 kg of yeast of dry product in the fermenter during fermentation.Bacteria are the most active at the biomass optimum temperature of 32°C in the fermenter.The deviation from this temperature reduces greatly the fermenter capacity.Therefore as stated above thermal stabilization of its process is the main task for maintaining the plant maximum capacity.

At the same time to produce 1 kg of yeast it is necessary to supply 4,0 kJ of heat for heating the water used for washing the equipment and flushing the yeast suspension as well as for heating and evaporating the suspension. Besides, heat is necessary for hot water supply and heating the facility premises. The water at the temperature of 50-70°C is necessary for these purposes. Development of special equipment with direct-evaporation refrigerant heat exchangers and refrigerant condensation in process apparatuses and the raising of the temperature of heat source (of condensation) to 85-90°C permit to increase the application of heat generated by the heat pump to 10-12 kJ per 1kg of yeast involving giving up the use of heating steam for suspension evaporation produced by a boiler plant or heating and power plant.

Thus the aim was to develop a heat pump which being introduced into processes plants would produce maximum economy benefit. Besides it is necessary to allow for the increase in capital costs due to its installation as well as maintenance costs. It was necessary to select capacity of a unit equipment, flow diagram, temperature levels, type of refrigerant and type of the drive taking into account the specific conditions of a heat pump operated for producing the PVC.

Having considered all these problems the heat pumps have been developed manifesting the following characteristics.

	For operating facilities	For facilities being constructed
Refrigerant	N-butane	
Refrigerating capacity, MW	16,0	20,0
Refrigerant evaporating temperature, °C	15	27
Heating capacity, MW	20,0	25,0
Refrigerant condensing temperature, °C	75	85
Shaft power, MW	5,40	6,05
Water temperature:		
-at the evaporator inlet, °C	25	-
-at the evaporator outlet, °C	20	-
-at the subcooler inlet, °C	28	28
-at the subcooler outlet, °C	38	70
-at the condenser outlet, °C	70	-

As the table shows N-butane is used as refrigerant in the heat pump.Some reasons account for such a choice:

1.The PVC production is based on the products of petroleum chemical plants including butane.Its cost is ten times lower than that of conventional freons applied in heat pumps,besides there are actually no transportation costs associated with charging and recharging the refrigerating system.

2.There shall be no vacuum in any point of the system under any working conditions of the heat pump and the pressure shall not exceed 1,25 MPa.It is particularly important in case of a branched system when refrigerant heat exchangers are integrated in process apparatuses with their strength affecting greatly the performance of the process plant.

Refrigerating capacity of a single unit has been selected such that there is a unit per a fermenter assembly with annual output of 8000-9000 t of dry product.

Accordingly heating capacity of a heat pump has been selected.The simplest cycle of a heat pump plant has been selected with a refrigerant single throttling and condensate subcooling by the water.Such a cycle has proved to be the most economical due to the considerable refrigerant subcooling downstream of the condenser by the water intended for hot water supply in the new plants and by the water recirculated to a process cycle after biological cleaning,the temperature of those not exceeding 28°C.

The process requirements call for special temperature levels which have been selected bearing in mind that coefficient of performance of a heat pump shall not be less than 3,6-4,0 to provide for maximum benefit.

The adopted temperatures meet those requirements.

And finally let's discuss the drive.In the plants under consideration it is not possible to utilize the heat of processes for providing steam- or gas-driven compressor of a heat pump,therefore the only type of the drive to use is a synchronous motor with a step-up gear.

All these factors have influenced the heat pump design.A centrifugal two-section,two-flow compressor is applied with two compression stages in each section equipped with integral control apparatuses at the first stages inlets.Thrust bearings are applied.The closed lubricating system under refrigerant suction pressure is used.There is a face seal with a steel-graphite friction pair only at the drive end of a shaft.

Such a design of the compressor is the most advantageous as a two-flow scheme with an opposite arrangement of sections which relieves a thrust bearing from axial thrusts, and a closed lubricating system with one shaft seal provide for high reliability of a compressor, and integral inlet control apparatuses of a radial type enable lowering the capacity to 30% of the rated one with the actually constant coefficient of performance.

An apparatus assembly comprising the evaporator, condenser with a float level control and subcooler is delivered with a unit for the operating facilities.

To improve heat transfer the refrigerant system of a heat exchange tube is finned.

The heat pump is operated automatically. It is remotely controlled.

The automation system is based on a microprocessor controller.

CONCLUSIONS

The microbiology industry shows large consumption of heat used for process flows, evaporation and etc., and at the same time during the biomass accumulation the large amount of heat is released which is to be removed. The combination of these two processes is the most beneficial condition for the application of heat pumps with simultaneous utilization of heat and cold.

At present we develop a heat pump for a lysine plant.