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Energy saving opportunities in air drying process in high-pressure compressors

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Abstract

Moisture carried over from the compressed air generation facility can cause damage to sensitive end users that require high quality air so compressed air must be kept moisture-free. Accordingly, humid air taken in the compressor must be dried appropriately to prevent precipitation. In this study, the technology which is used to dry compressor inlet air is solid desiccant wheel. Desiccant material impregnated into the desiccant wheel requires heat to be regenerated so this technology will be cost-effective when waste heat comes into play. In addition, Compressors have a distinct advantage when it comes to reducing energy consumption and costs, because the savings are already there for the taking. Compression heat can be an economic heat source to reactivate the desiccant materials to remove moisture from inlet air. In this paper, a solid desiccant wheel is coupled with an air compressor to dry inlet air. This innovative system uses compression heat from the compressor first stage to reactivate desiccant wheel. As well, energy analysis is done to demonstrate how much energy can be saved if a solid desiccant wheel is coupled with an air compressor.

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Keywords: Desiccant wheel; air compressor; waste heat; heat recovery; compression heat.

1. Introduction

Atmospheric air contains moisture and this moisture is concentrated as the air is compressed. To avoid technical problems because of water precipitation in piping and air-compressing systems, compressed air must be dried. Vapor removal process costs money so it is important to use energy-efficient way to dry air. Nowadays, technologies applied

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to remove moisture from compressed air consist of after-coolers, refrigerant dryers, over-compression systems, and absorption and adsorption dryers. However all them are energy-consuming, in recent years adsorption dryers have been improved to use waste heat to remove compressed air moisture in order to decrease energy costs. But in this study, instead of compressed air leaving first compressor stage, compressor inlet air at ambient pressure, which has high capacity to contain more moisture, is considered to be dehumidified. The technology proposed in this paper is solid desiccant wheel impregnated with desiccant materials like silica gel absorbing moisture. As shown in figure.1, this wheel is divided into two sections, process air and reactivation air sections. Moist process air flows through desiccant wheel and its moisture is picked up by desiccant material. Subsequently latent heat is released and process air temperature goes up so warm and dry air leaves desiccant wheel during sorption process. As wheel rotates between two sections continuously, moisture absorbed by desiccant material should be removed during desorption process so it needs to be regenerated by a heat source providing hot reactivation air. Then hot air goes through wheel regeneration section and the desiccant is reactivated. Desiccant dryers are capable of delivering air at consistently low dew points, typically -40°F/°C or less. This technology is an excellent choice when the compressed air will be exposed to freezing conditions.

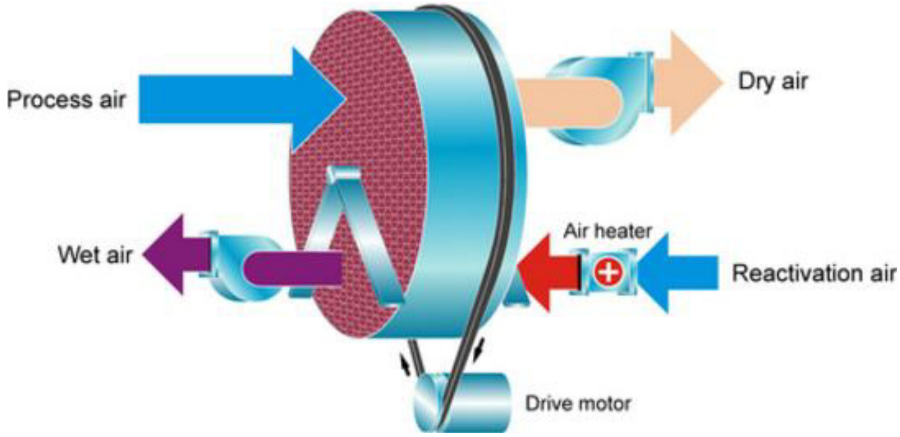

Fig. 1. Solid desiccant wheel operation [1]

On the other hand, air compressors convert a huge amount of inlet energy to heat so compressed air leaving air compressors carries heat which can be recovered to use in other applications. In this study, as shown in figure.2, a solid desiccant wheel is coupled with an air compressor and compression heat picked up between the first and second stages of the compressor is applied to regenerate desiccant wheel. In this way, the inlet air is dried by waste heat and subsequently due to heat taken from the first stage, cooling load on inter cooler installed between stages is decreased.