I'm not robot

reCAPTCHA

Continue

Compressor calculation example

For stage 1 of the ideal gas compressor, the ientropic compression is as follows: Pis = 2.31*(k/(k-1))*(Tdis-Tsuct)/M*Qm Equation 1: a simplified formula for calculating compression compression power is said to be eentropical when it is carried out by an ideal compressor, without friction, without internal leakage and at the same time perfectly isolated. To account for non-idealine calculation will have to be adjusted by efficiency coefficient (η), dependent on the technology used and which should be the exact manufacturer. Q. Pis=Power (kW) Zucchini=Temperature compressor insinceration (K) Tdischarge=Temperature output compressor (K) M=Molar gas weight (g/mole) Qm=Compressor test (t/h) k=Gas isentropical coefficient One will note that the key unknown in the equation above is the discharge temperature. The Tdischarge discharge temperature can be determined by abacus or calculation, for isentropical compression, please look at this page. 1.2 Total formula with gas compression coefficient The following formula can be used for high compression coefficient and high temperature ratios that prevent the eddying that the gas is ideal, and its compression coefficient ~ 1: Pis = (k* Z * R*T1)/(k-1)*[(P2/P1)(k-1)/k-1]*Equation Qm 2: the general formula for calculating [Perry's] compression power: Pis= Power (kW) Z = gas compression coefficient (can be determined in the Amagat scheme by means of calculation of low pressure and lower gas temperature) P1 = Pressure input compressor (kPa) P2 = Pressure output compressor (kPa) Qm=Compressor edging (kg/s) k=Gas yeentropical coefficient Calculated power should also be corrected by the efficiency factor provided by the manufacturer of the examined compressor. For air k=1.4 Mutual compressor high compressor high compression speed η=0.75 Mutual compressor low compression speed η=0.75 Rotary compressors η=0.7 Centrifugal compressors: η is calculated from the polytropical efficiency provided by the manufacturer. Then the chart is used to calculate the polytropical coefficient of gas, then the discharge temperature is calculated, and then the actual power required thanks to the formula 1 above. For information about industrial compressors and discussions with experts, the reader can contact the following company (no connection with MyEngineeringTools.com) : www.continental-industrie.com 3. An example of calculating compression power Compressor should deliver 2000 Nm3/h air at 6 bar g, from the air at atmospheric pressure and 20°C. The efficiency of the compressor is known and is 0.72. Step 1: Calculate the mass flow rate The compressor should deliver 2000 Nm3/h air. Normal conditions here are defined as 101325 Pa and 0°c [1], with the ideality of gas pressure basically checked, thus specific gravity PM/RT/1000 = 1.294 kg/m3. This gives a massive consumption of 2000 * 1.294 = 2587 kg / h. the discharge temperature for isentropical compression can be calculated with: In this case, Tdischarge = (20+273.15)*((101325+6*100000)/1013 25)^((1.4-1)/1.4) = 509.5 K Giving 509.5 - 273.15 = 509.5 STEP 3: Calculate Power requirements Use the formula above: Pis = 2.31 * 1.4 / (1.4-1)*(236.236.2 4-20) / 29 * 2587 / 1000 = 156 kW KROK 4: calculate the actual power requirement The efficiency of the compressor should be taken into account and equal to 0.72, which gives the required power 156/0,72 = 216,8 kW. Note: for a centrifugal compressor, the same calculation is made above, but the isentropical coefficient is replaced by a polytropical coefficient, which can be found on the charts knowing that the gas coefficient and polytropic coefficient of the compressor, as it is given by the manufacturer Channel [1] [Perry] Textbook chemical engineer Perry, Section 10 Transportation and storage of liquids, page 10-45, McGraw-Hill, 2008 With more than two hundred years of existence mutual (piston) compressors are widely used only for a hundred years. The application can be both household-oriented, for example, pneumatic tools supplied by compressed air and professional, such as industrial machines supplied with compressed gas, and the release of heavy refrigeration units. Data sheets can help you pre-select a compressor unit that is designed for practical use. Data sheets play a key role in the design and calculation of a proper compressor unit, tools, pneumatic equipment and associated power. Compressors are commonly used in the industry to transmit various carriers and, in fact, mechanical devices to compress the working environment in gas form. There are a variety of compressors, so proper selection and calculation of compressors is necessary to best meet the industry requirements of application. Typically, compression of the working environment is processed in the compressor either using rotating blades or in cylinders through pistons. Compressors with rotating blades are used for flows with large volumetric standards and low discharge pressure, while piston compressors are designed for high pressure. There are many operating conditions to consider, including current standards and practices. Thus, choosing a compressor is an important process with many aspects to consider. To select the appropriate compressor, you will need to distinguish between the actual purpose, as well as the design values such as pressure, temperature, flow rate and compressor type. Gas data, required flow rate, suction pressure and temperature and discharge pressure are key values for choosing a compressor. The selection of compressors relies on the general principles of thermodynamics applied to the theory of gas compression, comparison of several types calculation and theory of choice and calculation of compressor compressor visualize the theory of calculation. Selection of compressor units. Types of compressor blocks The main steps for choosing a compressor unit. The term compressor means that the unit to be used to increase the pressure of the compressed environment reduces a certain amount of environment passing through the compressor. The level of input and exit pressure can range from a deep vacuum to excessive pressure depending on operational needs. This is one of the conditions to match the type and configuration of the compressor. Compressors are divided, usually in two large subgroups: dynamic and positive displacement. Different types of compressors can be selected for one particular application to best adequately fit the structural features. Working environment properties. The compression compressor of gas can compress different gases. The properties of the gas thermodynamic or compressed gas mixture should be furnished with the supplier for proper adjustment of the compressor unit. To calculate the compressor unit requires the full content, the general name and chemical formula of the gas. The sheets of compressor aggregates data clearly indicate gas testing data with each component name, molecular weight, boiling point, etc. This data is very important for identifying the correct compressor values. The correlation between total gas values (pressure, temperature and volume) is called the gas equation. The simplest gas equation is the perfect gas equation. P · V = R · T de: P - pressure, V - molecular weight, R - gas constant, T - temperature. This equation applies only to gas whose temperature is above critical temperature and pressure is way below critical pressure. Air must comply with this law in atmospheric conditions. Real gas differs from the ideal gas factor called compression (Z). The term compression is used in thermodynamics to explain the deviations of thermodynamic properties of real gases from the properties of ideal gases. P · V = Z · R · The value of T I is a functional connection between the gas content, its pressure and temperature. Compression coefficient of compression process (R) is the ratio of pressure when discharged to suction pressure: R = Pd / Ps (where Pd and Ps are absolute). The single stage compressor has only one R. Two-speed compressors are 3 R. R = total compression ratio R1 = compression ratio of the first stage R2 = compression coefficient of the second stage. R = Pd/Ps R1 = Pi/P R2 = Pd/Pi Ps – Pd suction pressure – pi discharge pressure – pressure between stages When compressing air in the compressor unit, the molecular weight becomes lower, resulting in less spacing between molecules. As the number of gas molecules increases in fixed volume, its weight and fixed volume density also increase. Rising density leads to increased pressure. A vertical line from point 1 to point 2 indicates the process of isentropic compression that requires compression compression P1 to P2 in the figure below. The actual compression process stems from point 1 up and to the right that entropy rises to end up at point 2 on the isobar for P2. Compressor operations are focused on gas pressure and temperature, which will be increased, and the heat will be removed from the compressor. In most cases, it is necessary to increase the pressure of gas with the lowest power values. If the compression process is adiabatical, heat is not transmitted between the compressor and the environment to cause less work during isentropical compression. This does not involve losses in the compressor, which is really unattainable; however, it can be used for an indicative compression performance index. The index of the effectiveness of isentropical compression is identified as operational compression during an isentropical process separated by actual operations used to compress gas. Compression efficiency index is often indicated as an index of the effectiveness of isentropy. However, you can make a compressor with more than 100% isentropical performance indicators. Operations in reversible and isothermal processes are less than in the isentropical process. The temperature of gas in the reversible isothermal process is supported by reversible heat transfer during compression at suction temperature. This process will have no losses. However, the power consumed is almost always greater than the entropical capacity; Thus, the compressor classification uses an index of ientropical efficiency. Two types of compressors - displacement and dynamics - are currently present differ in the principles of medium compression. Displacement compressors compress gas to apprehend significant amounts of gas in a closed environment, followed by a decrease in volumes. Compression begins when a certain amount of gas enters the process chamber of the unit, followed by a decrease in the internal volume of the technology chamber. The dynamic type of compressor is used to compress gas using mechanical blades or a working wheel to transmit gas speed and pressure. A larger diameter of the impeller, greater molecular weight of gas or higher rotations will produce more pressure. Typically, offset compressors are selected for less gas and higher pressure values. Dynamic compressors are selected for more gas and lower pressure values. The main steps for choosing a compressor to turn on 1. Calculate compression coefficient. 2. Choose whether you need a compressor of one stage or more stages. 3. Calculation of discharge temperature. 4. Identify the necessary volumes. 5. Identify the necessary operating volumes. 6. Select a compressor model. 7. Determine the minimum torque of the selected compressor. 8. Select the actual rotation point. 9. Calculate the actual amount of operational work. 10. Calculate the required container. 11. Select the appropriate configuration. 12. Select the correct compressor. Compressor letter data The most important data of compressor equipment sheets are emphasized below: Socket pressure in ATMs and bars. Most majority household compressors produce from 6 to 8 bars of pressure; industrial compression units can produce 25 pressure bars. Pressure means that any given compressor model can produce pressure internally and discharge air mass into sealed cavities. The pressure index is calculated by class and compression unit power. The use of extra-high pressure compressors for household needs is not required. A small block with working pressure of up to 10 bars will s sufficient. Large industrial facilities cannot always operate at such values; in this case, more powerful compression machines or aggregates should be used. The compressor's operating pressure is average between maximum production pressure to stop the discharge process and minimal pressure in the system to run the compressor. Typically, the pressure deferential is 2 lanes between stopping and running the compressor. Given this index, all compressors are divided into compression machines of low, medium and high pressure. Not all compressors have sufficient ability to compress air in the production of high pressure; in fact, only heavyweight piston units can reach 30 ATM pressure index. Screw-type compressor versions may not work at such high rates; Input/exit pressure. The smallest supply flow of gas should be indicated in the data sheet of compressor units. This is necessary to ensure the capacity of the compressor. Pressure can be absolute or excess. A relative note must be made in a data sheet, as well as units of the specified pressure. Entry temperature. Volume speed, pressure requirements and the required power can affect the input temperature. Thus, the maximum entry temperature is also specified. Discharge temperature. The discharge temperature (Td) depends on the input temperature, compression index, heat indicator and gas compression. This temperature is important for the mechanical design of the compressor, selection of compression stage, cooler calculations and pipelines. Suction capacity or discharge of air (the amount of induced or forced air at the output). Regularly, the first value is stated by manufacturers of compressor equipment in technical passports, as the running compressor loses capacity during discharge due to air loss and suction power is always slightly higher. Compressor capacity is the volume of compressed air flow at a certain point in time and is expressed in m3/hour or l/min. Different types of compressors vary in capacity to specify a specific application of compressor equipment. The amount of air consumed at a certain point in time before compression is also considered a unit capacity. Otherwise, this option is called airflow speed. The reality is that there is a difference between the two parameters. So, you can rely on the output capacity. When choosing the appropriate compressor, about 30% of the oversized container is taken into account; Power measured in kW. The engine can be turbines or electric. Engine power is one of the main parameters for providing a compressor for air discharge control. The higher the power, the more electricity is consumed. Failure to comply with the correct power can lead to energy consumption without effect. As a rule, heavyweight engines are installed in high-motor units requiring this particular drive; Compressor weight and overall dimensions. These values can range from typical small unit sizes easy to transport and run in the garage to super-heavy to require more space to install. Large rooms do not pay serious attention to weight and dimensions, as the equipment is fixed and installed in a separate motor room. The size and weight of the compression unit always refer to its capabilities. Alternatively, the household compressor is quite compact, so most dimensions belong to receivers with a volume of 50, 100, 200 liters or more. If desired, compressors with rotating blades can be used for constant discharge of air without the need for receivers. Of course, without installed receivers, the weight and size of the compressors are much smaller make the device easily over-seated; The air receiver is also an important option for enabling downage. Air receivers are tanks designed to collect compressed air. The volume of the receiver allows you to continuously operate in the pneumatic line. It serves for energy saving. Another advantage is that the compressor unit can discharge the air with the specified pressure parameters. The serviced of the transferred gas. The composition of aggressive gas must be determined according to all operating conditions. This is important because of the cracks coming from corrosion under pressure in highly durable material. Liquid in the gas flow. Liquids in gas should be avoided. Otherwise, this may cause the compressor to malfunction. The separator is installed for the dehydrative working environment; electric tracing and insulation of the port entrance is carried out when the external temperature is below the point of gas dew or the components of hydrocarbons are heavier than ethane compressed. In some industries, such as the food sector, pollutants are not allowed into compressed air. At the same time, when choosing a compression unit, the power parameters should be less preferential than the design features. Sheets of compressors must meet the requirements of purity of compressed air with compression of blocks, which will be processed without lubricant oils applied to the work surface. Design features of compressor equipment Structural features of the compressor are as follows: Drive type. 4D or electric car; Air compression stage numbers. This option is justified and important for choosing piston compressors to phase out gas compression in multiple cylinders; Cooling system (oil, air and water). Mobility. Compressors to be fixed special foundation or trailer for ease of transportation; Position the part item. All components of the compressor unit can be a frame or receiver receiver Installation of the receiver: vertical or horizontal. It should also be noted the supply of power supply, due to the lack of power supply points with 380 V in some tires. In some cases, even a power supply of 220 V can be unstable. The selection of the compressor is closely related to the preliminary calculation of the above technical data. Before calculating the compressor parts, certain thin details will be highlighted. The air mass carried by the compressor is constant depending on the specifics of the compressor design. However, common practice is to identify capabilities with voluminous rather than massive values. This often leads to a failure in calculations and as a result of errors in the production of calculation. This is due to air compression, like all gases. As a result, the same air mass fills different volumes to depend on pressure and temperature values. The exact relationship between these values can be explained by complex force dependence or polytrophic equation. The compressor unit fills the receiver to increase pressure and lose volume displacement. Thus, the volumetric feeding of the compressor is variable. What value should I specify in compressor block data sheets? In accordance with industry standards and codes, the capacity of the compressor is calculated with the volume of air at the output after recalculation of physical conditions during suction. Usually physical air conditioning with a compressor violet is typical for regular operations: temperature 20 °C, pressure - 1 bar. According to industry standards and deviation codes, the actual values of the compressor unit ±5% are allowed from those specified in technical passports. Also, the value of compressed air consumers must be recalculated to meet the characteristics of the compressor unit. For example, the nominal flow is 100 l/min, thus, the pneumatic tool consumes air volume per minute, which will be 100 liters under normal conditions. Foreign manufacturers are not familiar with Russian industrial standards and codes, thus, their power calculations vary depending on calculation errors. Data from technical passports of their compressor units are based on theoretical power (suction power). The theoretical power of the compressor is determined by geometric measurement of air in the working area during one suction period. Then, this volume is multiplied by the number of periods (cycles) per unit of time. This theoretical power is higher than the actual capacity of the compressor unit. Theoretical and actual capacity difference is compensated by the power factor (Cf), which depends on the suction conditions and the specifics of the compressor unit design (valve loss: suction and discharge, volume quantity not completely displaced) to ensure a reduction in volumetric efficiency (piston compressor). The power factor of industrial design compressors is from 0.6 to 0.8. The difference in theoretical and calculations of compressors when entering and exiting may significant value. When specifying in the data sheet the theoretical capacity of the compressor unit is recalculated capacity at the output, thus, to reduce the value by 30-40%. Design compressor Compressor data sheet should all means indicate the maximum permissible working pressure. According to the maximum permissible temperature values, this data should be used by manufacturers to design the body and the main parts of the compressor to withstand the maximum permissible operating pressure and temperature. For centrifugal and mutual compressors, the maximum permissible working pressure is calculated with the addition of maximum input pressure to the maximum pressure of the dediferencial, which should take place in the compressor under a more complex set of conditions. For piston cylinders and compressors with rotating blades, the body should be above the nominal discharge pressure by 10% or 25 psi depending on what value is higher. The maximum permissible temperature should be the maximum discharge temperature for centrifugal and reciprocal compressors during operations involving some deviation values. The maximum permissible temperature for piston compressor cylinders and rotating compressor housing should be above the nominal discharge temperature. Pipeline flanges and face value Of Scraped dimensions, the nominal value of the flange and type should be clearly specified in the data sheets for all compressor universities and roses. Shaft seals and piston rod should also be clearly specified in data sheets. Oil and lubricant lubrication system The main function of the system is the uninterrupted supply of clean and cooling lubricant to bearings and seals, gears and compressor actuators. Due to its importance, the calculation of these systems should be clearly specified in the data sheets. Gas materials during compression can help in the selection of compressor materials; in particular, this applies to contact items. For example, during compression of H_2S, highly durable materials may crack sulfide. Materials suitable for operations are considered thermal, and the yield point is below 90,000 psi. Compression stages Compression coefficient (R) is the ratio of discharge pressure (P2) to suction pressure (P1) in compressor, P2/P1. If compression to higher pressure is required, the compressor calculation involves several stages of compression; in some cases, coolers are required to relieve heat between compression stages. Additional compression stages are required, for example: To reduce the temperature at the end of each stage of compression, intermediate cooling is applied to the permissible level to ensure proper compressor operations. To reduce the temperature during the entry compression phase to reset the flow needed to achieve the set compression factor. To ensure differential pressure of different types of compressors, limitation of axial loads in centrifugal compressors, limitation of rod load in piston compressors, axial axial in compressors with rotating blades. Reduce the power consumption of compressor drive due to temporary operation of coolers between stages and maintaining safe temperature restrictions. Choosing a monoverse or multi-sector compressor The choice of the correct number of compression stages is largely based on the compression ratio. Discharge temperature and operating mode are also considered when detecting the proper number of compression stages. Comparison of single-unit and two-sector compressor installed for the same application (same capacity, gas and pressure): As with many engineering solutions, it is necessary to find an appropriate compromise between the initial cost and operational / operating costs. 1. First, all consumers of air Q, l/min should be calculated. The air consumed by all consumers is summed up. This is done based on the technical characteristics of the passport to get a ratio of Q (l/min) as the volume of air that will consume pneumatics. This ratio is close to the maximum setting if a large number of consumers are involved. It can be reduced by the load factor, since not all consumers participate simultaneously in operations. The goal is to introduce a fix to reduce to be at the discretion of the compressor unit owner to provide enough air volume in the air. 2. The next parameter for calculation is compressor capacity A (l/min). Many miscalculations are the erroneous identification of option A and understanding the capacity of the compressor. All manufacturers of compressors indicate maximum air consumption in technical passports or catalogs. This option cannot be applied as an output compressor capacity because this option does not include compressor performance and design specifics. In this regard, the calculation of the compressor capacity should be as follows: $A = Q \cdot (\beta/\eta)$, where Q is the total volume of air that will be consumed by all consumers of the pneumatic system measured in l/min; β – the coefficient to rely on the structural specificity of the compressor unit by the manufacturer; η – index of compressor unit performance. β and η (for reference) for compressor operations within working pressure from 6 to 8 bars are listed below. 3. The last but not the last value for choosing a compressor is the volume of the receiver V (l). Manufacturers recommend the following range A when selecting the volume of the receiver: $V = (1/2 \div 1/8)\cdot$ Choosing a proper receiver and surround value provide pressure and alignment compensation to cause the pneumatic system to be more flexible to the load bearing. 4. When choosing pressure for the compressor, the rule to follow is that the pressure produced by the compressor should be higher than the pressure that will be exploited by compressed air consumers. Any compressor pumps the air to the maximum working pressure of Rmax., and then Subsequently, the compressor starts when the pressure drops to Rmin. The difference between the maximum and minimum compressor pressure is 2 2 5. To further select the compressor, it is important to decide on the current application: to decide how and what is the purpose of using the compressor. It is important to determine the period of time for continuous operations, maximum compressed air volume, operating pressure and other technical parameters as described above. Compressor type: This is the primary parameter for the above characteristics on which you want to depend. In order for the total required power to be calculated, we can conclude that if you need a spray compressor or any other pneumatic tool with small working pressure values, the best option would be a piston compressor. When it comes to high power and multiple air consumers, you should contemplate rotary or scroll compressor units. It should also be noted the length to which the carrier will be supplied, that is, compressed air. 6. The characteristics of the compressor, especially, power values affect the altitude above sea level, ambient temperature and atmospheric pressure. The higher the height, the lower the temperature and pressure of the environment. This should be noted when operating an air compressor under such conditions, as these conditions affect the value of the compressor capacity and nominal consumption of compressed air. Thus, if the compressor is operated at high altitudes, the original characteristics will differ from those specified in the technical passport in a certain way. In fact, the air is discharged to a height, which will lead to a deterioration of cooling of the electric motor of the air compressor and its heat-affected parts. The engine will operate at nominal characteristics at a maximum altitude above sea level of 1000 m and a maximum temperature of 40°C (see table below to specify the values of different engines under certain altitude and temperature settings). Some types of compressors are equipped with electric engines with typical power losses at high altitude. A smaller container should be supplied to the compressor shaft respectively. Algorithm of choosing an air compressor based on the values of capacity and pressure. Scheme of choosing a compressor The correct type of compressor can be selected based on the general source data, following the diagram below. The following compressor characteristics are based on the type of compressor: When choosing an air compressor, you need to be precisely accurate; otherwise, a time saved during previous calculations may cause precalculation errors, and subsequently, the selection of an incorrect compressor type fails to complete the task. An example of choosing a reciprocating compressor piston compressor is a positive offset compressor. When choosing a compressor, the main parameters such as discharge pressure, suction temperature, operation mode and gas composition and the required capacity should be determined first. The choice should also focus on the relative humidity of the performance, cost index and Compressors can have a similar piston function when used for various uses. For example, long-stroke compressors tend to be slower than short stroke compressors in functioning. In general, short stroke compressors are light weight and have less permissible load values. The compressor speed and stroke length depend on the required power. Lightweight, high-speed short stroke compressors require less power when applied. At the same time, long-term, low-speed compressors require more power when applied. Super-heavier inflators connect directly to the gear drive if possible. Consequently, the speed parameters of the drive equipment can also affect the choice of compressor. Next, you must select the number of stages. Permissible discharge temperature, piston compression ratio and performance index are key factors to note. If the approximate discharge temperature is too high, using one stage, more stage will be expected. The temperature of isentropical discharges may be preselected; but if a certain number of stages leads to a dead end, the discharge temperature should be more accurately calculated. A similar compression ratio is expected to be used for all stages when roughly calculated. Practically, it is always recommended to choose a higher compression ratio for low pressure stages to reduce more critical stages of high pressure. For operations, you should use all programs where operations require multiple stages of interculters. In this scenario, increasing the number of stages will increase the compressor block performance index. Through interculers, the compression process is considered close to isothermal compression, which will result in less power. If the working environment condenses in the interculer, the liquid should be separated from the gas, while the compressed gas mass before discharge decreases, resulting in less energy consumption. However, adding stages increases the number of valves, intermediate pipelines and coolers. When using several stages, loss of pressure in valves and pipelines would reduce the advantages of intercullers and efficiency. The cost of the compressor increases with an increased number of steps due to the need for coolers, valves, pipelines and additional cylinders. Cylinders should be selected for each stage when choosing the number of steps. To choose the right opening of the cylinder, you need to know the entry conditions, capacity, speed and stroke length. It is necessary to correctly select the nominal pressure values for the cylinder for safe operations, take into account the load, loss and power. It is also necessary to take into account the power of the imbalance, which comes from the compressor to the frame, potential vibrations, which will damage the shaft and drive gears, as well as the noise level; optimize the compressor position, performance index and cost. Optimized. Optimized.