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In the compressor phase of complete gas 1, the isentropic compression is as follows: Pis = 2,31*(k/(k-1))*(Tdis-Tsuct)/M*Qm Equation 1: simplified compression power calculation formula Compression is said to be isentropic when carried out with an ideal compressor, without friction, without internal leakage and fully insulated. Consideration of non-ideals shall be corrected by an efficiency factor (η) depending on the technology used and which the manufacturer should match. With : Pis=Power (kW) Tsuct=Temperature inlet compressor (K) Tdischarge=Temperature outlet compressor (K) M=Molar weight gas (g/mol) Qm=Compressor transfer rate (t/h) k=Gas isentropic factor One note that in the above equation the unknown key is the discharge temperature. The Tdischarge discharge temperature can be determined by abacting or by calculation, for isentropic packaging, see this page. 1.2. General formula used for the gas compression factor The following formula may be used for high compression ratios and high temperature ratios which prevent the assumption that: that the gas is complete and has a compression factor of ~1: Pis = (k*Z*R*T1)/(k-1)*[(P2/P1)(k-1)/k-1]*Qm Equation 2: general compression power calculation formula [Perry] : Pis=Power (kW) Z = gas compression factor (can be determined in the Amagat diagram by calculating the reduced gas pressure and reduced temperature) P1 = Pressure input compressor (kPa) P2 = Depressurisation compressor (kPa) Qm=Compressor transfer rate (kg/s) k=Gas isentropic factor The calculated power shall also be corrected by the efficiency factor specified by the manufacturer of the compressor under consideration. For air k=1.4 Piston compressor high compressor speed η=0.75 Piston compressor low compressor compression speed η=0.75 Rotating compressors η=0.7 Centrifugal compressors : η calculated from the polytropic efficiency specified by the manufacturer. A diagram is then used to calculate the polytropic pressure of the gas, then calculate the discharge temperature and then the actual power required thanks to formula 1 above. References and discussions of industrial compressors with experts May be referred to by the reader to the following company (no MyEngineeringTools.com) : www.continental-industrie.com 3. Example of lowering pressure output The compressor shall produce 2000 Nm3/h of air at 6 bar g of air at atmospheric pressure and 20 °C. The effectiveness of the compressor is known and is 0.72. Step 1: calculate the mass flow The compressor is to produce 2000 Nm3/h of air. Normal conditions are defined here as 101325 Pa and 0°C [1], this pressure gas ideal is mostly verified, so the specific gravity is PM/RT/1000 = 1,294 kg/m3. This gives a mass flow rate of 2000 * 1,294 = 2587 kg/ h. temperature The emptying temperature of the Isentropic compression can be calculated as follows: In this case, Tdischarge = (20+273.15)*(((101325+6*100000)/1 013 25)^(((1.4-1)/1.4) = 509.5 K Which gives 509.5 - 273.15 = 236.4c PHASE 3: calculate tropical power requirement Use the above formula : Pis = 2,31 * 1,4 / (1,4-1)*(236,4-20)/29 * 2587 / 1000 = 156 kW STEP 4: calculate the actual power demand Compressor efficiency must be taken into account and is 0,72, giving the required power of 156/0,72 = 216,8 kW. Note: for centrifugal compressor, the same calculation shall be made as above, but the isentropic coefficient shall be replaced by a polytropic coefficient, found in the diagrams, knowing the source provided by the manufacturer of the gas isenthropic odds and compressor polytropic odds [1] [Perry] Section 10 of Perry's Chemistry Engineer Handbook Transport and Storage of Liquids, page 10-45, McGraw-Hill, 2008 More than two hundred years have existed piston compressors have been widely used for only 100 years. The use can be both household-oriented, such as pneumatic tools supplied by compressed air and a professional, such as industrial machinery supplied with compressed gas, and the release of heavy cooling units. Detail pages can help you select a compressor unit ready for practical use. Information pages play a key role in designing and calculating the right compressor unit, tools, pneumatic devices and related power. Compressors are commonly used in industry to transfer various media and are mainly mechanical devices that compress the tool in gas form. There are many types of compressors, so proper selection and calculation of compressors is necessary to best suit industry-related application requirements. In general, the compression of the tool is handled in the compressor either with rotating blades or in a cylinder through the pistons. Compressors used with rotating blades are used for flow flows with high volume and low discharge pressure, while piston compressors are intended for high pressure. There are a lot of operating conditions, including current standards and practices. Thus, the choice of compressor is an important process with many aspects. To select the right compressor, the actual purpose and design values such as pressure, temperature, flow rate and compressor type must be distinguished. Information on gas, required flow flow rate, suction agent, temperature and discharge pressure are key values for the selection of compressors. The choice of compressors shall be in accordance with the general principles of thermodynamics applicable to gas compression theory, comparison of several types of compressors, calculation and selection theory and compressor calculation. visualize computing theory. Selection of compressor units. Types of compressor units The basics for selecting the compressor unit. The term compressor refers to a unit used to increase the pressure of a compression platform by reducing the specific volume of the Middle Age passing through the compressor. The level of inlet and output pressure shall range from deep vacuum to overpressure according to operating needs. This is one of the prerequisites for the type and configuration of the compressor. Compressors are usually separated in two large subgroups: dynamic and positive transition. Different compressors can be selected for a specific application, which are best suited for structural special features. Features of the tool. A gas compressor can compress different gases. The thermodynamic or compressive gas mixture characteristics of the gas shall be supplied to the seller in order to correctly determine the compressor unit. For the calculation of the compressor unit, the full contents, generic name and chemical formula of the gas are required. The information sheets of the compressor units shall clearly indicate the gas testing data listed the name, molecular weight, boiling point and etc. of each component. This information is very important for identifying compressor values. The ratio of general gas values (pressure, temperature and volume) is called a gas equation. The simplest gas equation is the ideal gas equation. P · V = R · T where: P – pressure, V – molecular weight, R – gas constant, T – temperature. This equation applies only to gas with a temperature higher than the critical temperature and a pressure much lower than critical pressure. Air must comply with this law under atmospheric conditions. The actual gas differs from the ideal gas with a compression factor (Z). The term compression is used in thermodynamics to explain deviations in the thermodynamic properties of real gases from those of ideal gases. P · V = Z · R · Value T Z — functional ratio of gas content, pressure and temperature. Compression process Compression ratio (R) – is the ratio of pressure when discharged to suction pressure: R = Pd/Ps (where Pd and Ps are absolute). One phase compressor has only one R value. The R values of the two-phase compressor are 3 R. R = total compression ratio R1 = first stage compression ratio R2 = second stage compression ratio. R = Pd/Ps R1 = Pi/P R2 = Pd/Pi Ps – suction pressure Pd – discharge pressure Pi – pressure between phases When compressing air in a compressor unit, the molecular weight decreases, reducing inter-molecular spacing. As the number of gas molecules increases in solid volume, its weight and the density of fixed volume also increase. The increase in density leads to an increase in pressure. Vertical line from point 1 to point 2 indicates that the isenthropic compression process requires minimal compression 1–P2 in the figure below. The actual packing process follows the entropy rising from point 1 up and to the right to reach point 2 in the isobar for the P2. Compressor operations focus on gas pressure and temperature increases, as well as heat removed from the compressor. In most cases, it must increase gas pressure with low capacity values. If the compression process is adiabatic, no heat is transmitted between the compressor and the environment, which reduces the activity for isenthropic compression. This does not assume the loss of compressor, which is indeed possible; however, it may be used in the indicative packing performance index. The isenthropic compression power index is identified during the isenthropic process as operational compression divided by actual action used for gas compression. The compression power index is often reported as an isenthropic performance index. However, it is possible to make a compressor with more than 100% isentropic performance indices. The functions of the reversible isothermal process are less than in the isenthropic process. The gas temperature in the reversible isothermal process is maintained by reversible heat transfer during suction temperature compression. This process must not have any losses. However, the capacity consumed is almost always more than isenthropic capacity; Therefore, the isenthropic performance index is used to classify the compressor. Two types of compressors - transition and dynamics - are currently different in the principles of tool compression. Compressors compress the gas so that it can retain significant amounts of gas in a closed environment, reducing volume. Compression begins when a certain amount of gas enters the process chamber of the device and then reduces the internal volume of the process chamber. The dynamic compressor type is used to compress gas using mechanically operated blades or impellers to transfer gas speed and pressure. A larger impeller diameter, higher molecular weight of gas or higher laps produce more pressure. In general, exclusion compressors are selected with less gas and higher pressure values. Dynamic compressors are selected for higher quantities of gas and lower pressure values. The basics of choosing a compressor include 1. Calculate the compression ratio. 2. Choose whether a single- or multi-phase compressor is required. 3. Clear the temperature calculation. 4. Identify the required volumes. 5. Specify the required activity amounts. 6. Select the compressor model. 7. Identify the minimum rotation of the selected compressor. 8. Select the actual rotation torque. 9. Calculate actual usage quantity. 10. Calculate the required capacity. 11. Select the appropriate configurations. 12. Select the correct compressor. Compressor device information sheet The main information forms for compressor devices are highlighted below: atm disks and bars. Latest Latest household compressors produce a pressure of 6-8 bar; pressing units can cause pressure of 25 bar. Pressure means that any compressor model can generate pressure internally and disassemble the air mass into a closed cavity. The pressure index is calculated according to the category and capacity of the compression unit. The use of high-pressure compressors for household needs is not necessary. A small unit with a working pressure of up to 10 bar is sufficient. Large industrial plants must not always operate at such values; in this case, more efficient pressing machines or units shall be used. On average, the compressor's working pressure is between the maximum stop pressure of the discharge process and the compressor's starting pressure. Normally, the pressure difference is 2 bars between the compressor stopping and starting. Due to this index, all compressors are divided into low, medium and high pressure pressing machines. Not all compressors have sufficient capacity to compress air during high pressure production; in fact, only heavy piston units can reach a pressure index of 30 atm. Screw-type compressor versions shall not operate with such high indices; Inlet/output pressure. The least input gas flow shall be reported in the compressor units data sheet. This is necessary to ensure compressor capacity. Pressure can be absolute or in surplus. A relative note shall be made to the data sheet and to the units of the declared pressure. Inlet temperature. The volumetly flow rate, pressure requirements and required power may affect the input temperature. Therefore, the maximum inlet temperature must also be indicated. Emptying temperature. The discharge temperature (Td) depends on the input temperature, compression index, gas-specific heat and compression power indicator. This temperature is important for compressor mechanical design, pressing phase selection, cooler and piping calculations. Absorbent or de-venting (amount of air caused or forced by the outlet). Manufacturers of compressor equipment regularly reported the first value in technical passports, as the use of compressors loses capacity when discharge due to air loss and suction capacity is always slightly higher. Compressor capacity is the volume of compressed air flow over a given period of time and is expressed at m3/hour or l/min. Different types of compressors vary in capacity depending on the specific application of compressor equipment. Unit capacity is also considered to be the amount of supply air consumed during a certain period of time prior to compression. Otherwise, this parameter is called airflow. The truth is, there's a difference between two parameters. So you have to rely on output capacity. When choosing the right compressor, account must be taken of approximately 30% of the oversuppassed size capacity. The engine power shall be measured in kWh. The engine can: turbine or electricity. Engine power is one of the key parameters to ensure control of the compressor's air burst. The higher the capacity, the more power is consumed. If the power is not calculated correctly, the result may be power consumption without effect. In general, heavy-duty engines are installed in high-power units that require this station; Compressor weight and total dimensions. These values can range from typical compact units that are easy to transport and easy to use in the garage to heavy units that require more space for installation. Large spaces do not pay serious attention to weight and dimensions, since the equipment is attached and installed in a separate engine room. The dimensions and weight of the compression unit always refer to its properties. Alternatively, the household compressor is quite compact, so most dimensions refer to a receiver of 50, 100, 200 liters and more. Alternatively, compressors used with rotating blades can be used for continuous emptying without receivers. Sure, without receivers, the installed weight and compressor dimensions are significantly less, making the unit easy to move; An air receiver is also an important parameter for allowing idle. Air receivers are tanks designed to collect compressed air. The volume of the receiver enables continuous off-line operation of pneumatics. It saves energy. Another advantage is that the compressor unit can decompress air with given pressure parameters. Corrosivity of transferred gas. The composition of the corrosive gas shall be identified under all conditions of use. It is important because corrosion becomes cracks under pressure in a strong material. Liquid in the gas stream. The liquid in the gas must be avoided. Otherwise, it may cause the compressor to malfunction. The separator must be installed on the drainage base. the electronic tracing and insulation of the inlet port shall be carried out when the outdoor temperature is below the dew point of the gas or the hydrocarbon components heavier than thethany are compressed. In some industries, such as nutrition, compressed air does not allow inaccurate substances. In this case, when selecting a compression unit, the power parameters shall be less advantageous than the design characteristics. The information pages of the compressors shall meet the purity criteria for compressed air and the unit compression to be treated without lubricants spreading on the work surface. For the design of compressor equipment, the compressor design information is as follows: Station type. ICE or electric motor; Phase numbers of the air squeeze. This parameter is justified and important for the selection of piston compressors so that the gas can be compressed in several cylinders in stages; Cooling system (oil, air and water). Mobility. Compressors are attached to a special base or trailer for transport Arrangement of the sub-element. All components of the compressor unit may be receiver parts for frame or receiver parts Receiver installation: vertical or horizontal. The mains power is also notable because some tyre shops do not have 380 V power supply points. In some cases, a power supply of up to 220 V can be unstable. The choice of compressor is closely related to the preliminary calculation of the above technical data. Before calculating compressor data, certain subtle details must be highlighted. The air mass to be transferred with the compressor is constant depending directly on the features of the compressor design. However, it is common practice to identify capacity by volume rather than mass values. This often leads to failure of calculations and manufacturing calculation errors. This is because the air is pressed like all gases. As a result, one and the same air mass fills a different volume depending on the pressure and temperature values. The exact relationship between these values can be explained by a complex power dependency or a polytrophic equation. The compressor unit fills the receiver for increased pressure and loss of volume shift. Thus, the compressor's volume source is variable. What value should then be reported in the compressor unit information forms? According to industry standards and codes, compressor capacity is calculated from air volume at output after recalculation of physical conditions in the suction process. In general, the physical conditions of the compressor inlet are typical for regular operation: the temperature is 20 °C, the pressure - 1 bar. According to industry standards and codes, deviations of the actual values of the compressor unit ±5 % are allowed from the values specified in the technical passports. The values of consumers of compressed air shall also be recalculated according to the characteristics of the compressor unit. For example, the rated current is 100 l/min, so the pneumatic tool consumes air volume per minute, which would be 100 l under normal conditions. Foreign manufacturers are not familiar with Russian industrial standards and codes, so their capacity calculations vary due to calculation errors. The information from the technical passports of compressor units is based on theoretical capacity (absorbent capacity). The theoretical capacity of the compressor is determined by geometric measurement of air in the work area over a single suction period. This volume is then multiplied by the number of periods (periods) per time unit. This theoretical capacity is greater than the actual capacity of the compressor unit. The theoretical and actual capacity difference shall be compensated by a capacity factor (Cf) depending on the suction conditions and the design of the compressor unit (valve losses: suction and drain, volume not fully transferred) in order to reduce volume efficiency (piston compressor). Industrial design compressors have a capacity factor between 0.6 and 0.8. The difference between theoretical and actual between entry and exit can be significant value. If the theoretical capacity of the compressor unit is indicated on the data sheet, it shall be recalculated for output capacity, in which case the value shall be calculated by 30 to 40 %. Compressor design The compressor information sheet shall report in every way the maximum working pressure. In accordance with the maximum permissible temperature values, manufacturers shall use this information when designing the compressor body and main parts to withstand the maximum working pressure and temperature. The maximum working pressure of centrifugal and piston compressors has been calculated by adding the maximum inlet pressure in the compressor under more complex conditions. In piston cylinders and compressors with rotating blades, the maximum working pressure of the hull shall be greater than the rated discharge pressure of 10% or 25 psi, whichever is the higher. The maximum permissible temperature shall be the maximum discharge temperature of centrifugal and impact compressors during operation to include some deviation values. The maximum permissible temperature of the cylinders of piston compressors and rotating blade compressors shall be higher than the nominal emptying temperature. Pipe pallets and nominal value End-to-end dimensions, nominal laop value and type shall be clearly indicated on the data forms at all inputs and pass-throughs of the compressor. The shaft seal and piston arm shall also be clearly indicated in the data forms. Oil lubrication system and lubricating oil The primary system function is the undisturbed supply of clean and cooling lubricant for laurels and seals, compressor gears and operating devices. As the calculation of these systems is important, it must be clearly indicated in the data forms. Compressable material gases can help select compressor materials; That's especially for touch elements. For example, during the pressing of H2S, cracking of sulphide of strong material may occur. The materials suitable for operation are considered heat-treated and the yield point less than 90000 psi. Process compression phases Compression ratio (R) is the ratio of compressor discharge pressure (P2) to suction pressure (P1), P2/P1. When compression to higher pressures is necessary, several compression steps are assumed in the compressor calculation; in some cases, refrigeration machines are required to remove heat between compression phases. Additional pressing steps are required, such as: Temperature reduction at the end of each compression phase to the level allowed by intermediate cooling to ensure the proper functioning of the compressor. Reducing the temperature during the inlet packaging phase to reduce the flow required to reach the set compression ratio. Different compressor types' different pressure differential limits, such as axial load limits for centrifugal compressors, load limit for piston compressors rod, axial compressors with rotating blades. Reduces the compressor use of power consumption due to the use of a temporary cooling between phases and maintains safe temperature limits. Choice of one- or multi-phase compressor The choice of the correct number of packing steps is largely based on the compression ratio. The emptying temperature and operating mode shall also be taken into account when determining the correct number of packing steps. Comparison of one- and two-phase compressors, both of which are installed in the same application (same capacity, gas and pressures): As with many technical decisions, a suitable compromise must be found between initial costs and operating/maintenance costs. 1. Initially, all air consumers Q, l/min shall be counted. The air consumed by all consumers is a summary. This is based on technical passport characteristics so that Q-ratio (l/min) pneumatics consumes airspace volume. This ratio is close to the maximum parameter if a large number of consumers are involved. It can be reduced by a load factor because not all consumers are involved at the same time. The aim is to carry out reduction repairs that are at the sole consideration of the owner of the compressor unit in order to ensure sufficient airspace in the pneumatism. 2. The next calculation parameter is compressor capacity A (l/min). A lot of error calculations are made by mis-identifying the A parameter and understanding compressor capacity. All compressor manufacturers report the highest supply air consumption in technical passports or lists. This parameter must not be used as output compressor capacity because this parameter does not include compressor performance and design. In this respect, the capacity of the compressor shall be calculated as follows: A = Q · (β/η) where Q — total air volume consumed by all consumers of the pneumatic system to be measured (l/min); β — the factor calculated for the design specifications of the compressor unit by the manufacturer;; η – compressor unit performance index. β and η (reference) values are given for compressor operation at operating pressures of 6-8 bar. 3. The last but not least value of the compressor selection is the volume of receiver V (l). Manufacturers recommend the following area A when selecting the volume of the receiver: V = (1/2 ÷ 1/8)· A Selecting the correct receiver and volume ensures pressure compensation and leveling to make the pneumatic system more flexible towards loading. 4. When selecting compressor pressure, the regulation that the pressure produced by the compressor shall be greater than that of consumers of compressed air shall be complied with. Any compressor pumps air up to maximum operating pressure up to Pmax and then switches off. The compressor then starts when the pressure dropped on Pmin. The difference between the maximum and min pressures of the compressor is 2 5. It is important to determine the actual use of the compressor: to decide how and what the purpose of using the compressor is. It is important to define the time interval for continuous operation, maximum compressed air volume, working pressure and other technical parameters as described above. Compressor type: this is the core parameter of the above features, which depends. In order to calculate the total power required, it can be concluded that if a compressor is needed for a spray unit or other compressed air tool with low working pressure values, the best option is a piston compressor. In the case of high capacity and several air consumers, a rotating or rolling compressor unit shall be considered. It should also be noted to what length the medium is supplied to, i.e. the pressure air. 6. Compressor properties, especially capacity values, are affected by above-sea level altitude, ambient temperature and atmospheric pressure. The higher the height, the lower the temperature and ambient pressures. This is notable when the compressed air compressor is used under such conditions, as these conditions affect the capacity values of the compressor and the nominal consumption of compressed air. Therefore, if the compressor is used at high heights, the output characteristics differ in a certain way from those specified in the technical passport. In fact, the air erupts at heights, which leads to a deterioration in the cooling of the compressor's electric motor and its heat. Engine operating with nominal characteristics above sea level at altitudes not exceeding 1000 m and a maximum temperature of 40 °C (see table below, which indicates the values of the different engines in certain height and temperature parameters). Some types of compressors are equipped with electric motors with high capacity losses. The compressor shaft shall be given a correspondingly lower capacity. Algorithm for selecting an air compressor based on capacity and pressure values. Compressor selection system The appropriate compressor type can be selected according to the plan below on the basis of general preliminary data. Below the properties of the compressor, the compressor type is based: When choosing an air compressor, you need to be accurate; Otherwise, the time saved during preliminary calculations may result in precalculation errors and then the selection of an inappropriate compressor type that is unable to work. An example of choosing a piston compressor The piston compressor is a positive transition compressor. When selecting a compressor, basic parameters such as discharge pressure, suction temperature, mode of operation and gas composition and required capacity should first be identified. The selection should also focus on the relative humidity, costs and Compressors may have similar piston function when used for different uses. For example, long-paced compressors tend to be slower than short-paced compressors in operation. In general, short-paced compressors are lightweight and their load values are less allowed. The speed of the compressor and the length of impact depend on the required power. Light and fast short-paced compressors require less power when used. At the same time, long-paced, low-speed compressors require more power when used. Heavy compressors are connected directly to the drive gearbox if necessary. As a result, speed parameters in the gearbox can also affect the choice of compressor. Next, you need to select the number of steps. The allowed emptying temperature, piston compression ratio and performance index are key factors to consider. If the estimated discharge temperature is too high in one phase, it is assumed that there is more phase. The isenthropic discharge temperature can be pre-selected; But if certain stages led to a dead end, the discharge temperature should be lowered more accurately. A similar compression ratio is expected to be used at all stages, roughly calculated. In practice, it is always advisable to choose a higher compression ratio for low pressure phases to reduce critical high pressure phases. All applications where multiple steps are required for operations should be used by inter-hackers. In this case, increasing the number of steps would lead to an increase in the compressor unit performance index. Due to intermediate packaging, the compression process is considered to be close to isothermal compression, resulting in less power consumption. If the work material condenses in the inter-cooler, the liquid shall be separated from the gas, while the compression gas mass to discharge shall be reduced in order to reduce the power consumption. However, by adding steps, valves, intermediate pipes and cooling platforms are added. When using several phases, pressure losses in valves and piping would reduce the benefits and efficiency of intermediate logging. The cost of the compressor increases as the number of phases increases due to the need for a radiator, valves, piping and additional cylinders. Cylinders should be selected for each phase when the number of phases is selected. To select the correct cylinder opening, you need to know the entry conditions, capacity, speed and stroke length. The nominal cylinder pressure values shall be correctly selected for safe operation to take into account loads, losses and power. The unbalanced force supplied from the compressor to the frame, any vibrations leading to damage to the crankshaft and drive gear, and the sound level shall also be taken into account; compressor position, performance index and costs shall be optimised. Optimized.