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Axial compressors air bleeding schemes of gas-turbine engine.

Article deals with ways of air bleeding in axial compressors of modern gas turbine engines. Shape of air intake hole of typical variable bleed valve and characteristics of air flow passing through it is studied. Recommendations for construction of new type of air intake device for bleed valve in accordance with best flow passing is given.

During operation of gas turbine engine variable bleed valves is used for providing engines gas dynamic stability at all its operational modes. Amount of air which is required to be transferred out of particular compressor or turbine stage is in the range from 10 to 15%. For providing of such air transition, the cross sections sizes of bleed valve system must be calculated. First it is necessary to choose construction of bleed valve and then in accordance to its inlet and outlet shapes the hydraulic calculation must be performed.

Air intake from axial compressor can be performed in many ways but generally exist three following ways:

1.Air intake between guide vanes, shown on Fig.1 is the simplest type, but since the pressure on the leading edge of the blade is higher than on its trailing edge the air overflow appears, which leads to reducing of general efficiency coefficient of compressor.

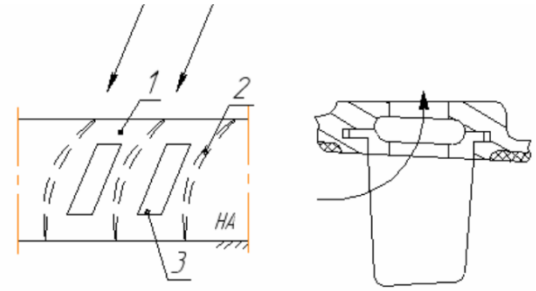

Fig.1 Chart of air transfer between compressor guide vanes:

1.- Upper outer view on guide vanes; 2.- Guide vanes; 3.- Windows of transfer

2. Air transfer behind rotor blades stage is shown on Fig.2. Air transfer to intake holes with turning on 90 degrees, flow goes with twisting and high speed, the

effective cross-section of intake holes decreases. All this leads to high losses because of hydraulic shock and efficiency of such air bleeding decreases.

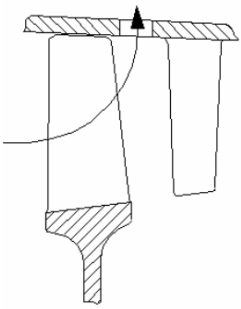

Fig. 2 Air transfer behind compressor rotor blades.

3. Air bleeding before compressor rotor blades stage (Fig.3). This scheme of air intake shows that speed of flow overcoming is less; its angle is less too, so the losses connected with flow turning will be smaller. But flow redirection before leading edges of compressor rotor blades leads to increasing of angle of attack at the periphery which may cause separation of flow at next stages and reducing of efficiency. The conditions of blades disturbances may also appear which will cause vibrational loads on compressor. In order to illuminate such problems the axial clearances is increased and the leading edge of rotor blades is safely covered on some angle which is experimentally obtained.

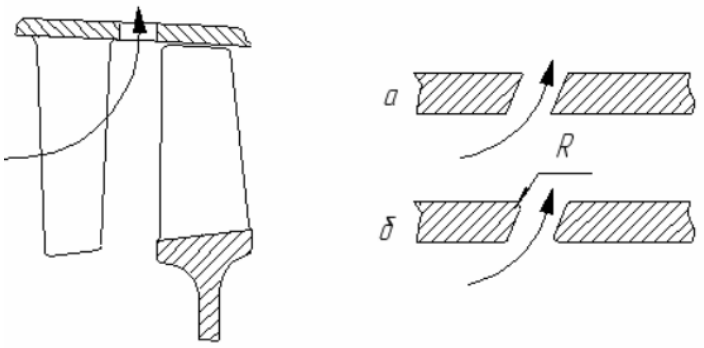

Fig.3 Air bleeding before compressor rotor blades stage

In all sets like as in separate zones the part of total flow pressure which goes for overcoming of hydraulic resistance is lost, because of presence of molecular and turbulent viscosity. General energy of flow including heat energy is remains the

same because of absence of heat transfer through channel walls. It is known two types of total pressure loss in pipeline (Hydraulic resistance).
-Resistance on friction
-Local resistance

Hydraulic friction is caused by viscosity (molecular and turbulent) of real gases and it is result of amount of motion exchange between molecules during laminar flow. Local total pressure losses appear at local disturbances in normal flow, presence of vortexes and intensive turbulent mixing of flow. This phenomena increase exchange of motion between particles of gas increasing dissipation of energy. In modern hydraulic calculations it is useful to apply dimensionless coefficient of hydraulic resistance. It is applicable for dynamically similar flows where similarity of geometrical form of channels and Reynolds number is same.

Conclusion

Summing it all up it is necessary to notice that all present solutions of air bleeding in axial compressors of gas turbine engines have lot of problems which must be solved by application of new air intake devices. Phenomena of flow overcoming and hydraulic shocks during air transfer must be illuminated in order to perform air bleeding in most accurate and safe for compressor operation way. Dynamic of flow during air transition must be studied and the most accurate shape of air intake hole for particular case of air transfer must be modeled. Such air intake device must provide air transfer with less as possible hydraulic losses which will increase the accuracy of air transition which will increase gas-dynamic stability of compressor due to more accurate air transition which is aimed to prevent compressor abnormal operation.

References

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