1 GENERAL

It was shown in Fig. 51 that the sharp negative velocity pulse, which has come along path 1, is splitted into two pulses propagating further along paths 1' and 1" separately. A stall cell is then developed between these two pulses owing to the appearance of a baroclinic wave in front of the inlet of the rotor (see Fig. 52). The lobe of this baroclinic wave represents the outer limit of the zone of the stall cell. Its inner limit will be determined in the present section.

It was mentioned from the experiment of Douglas, Hide and Mason (1972) that the baroclinic waves should simultaneously appear at the inlet and the outlet of the rotor, but in antiphase and in the opposite streaming direction to each other. The baroclinic wave in front of the rotor mentioned above as shown in Fig. 58a (taken over from Fig. 52 stage 3") has therefore to be associated with a further one behind the rotor, as given in Fig. 58b. The full line stands for the former, and the broken line stands for the latter. The streaming direction is indicated by arrows c_i and c_o for the inlet and the outlet, respectively. The two areas, which are enclosed by the baroclinic waves of the inlet and outlet, are denoted by A for the inlet and by B for the outlet.

The elementary recirculation loop α-β is drawn in Fig. 58c around each of the blades. The recirculation comes as a forward flow along the corner "pressure-surface/hub" (denoted by α) and turns over the outlet edge of the blade of the casing side (see arrow α' in area A) backwards along the suction surface toward the inlet (see arrow β). It turns here over the inlet edge (see arrow β') into the original blade channel again. The flows along the pressure and suction surfaces of the blade channel are drawn with full lines and those turning over the outlet and inlet blade edges (i.e. outside the blade channel) are drawn with dotted lines.

The forward flow α of a recirculation and the backward (i.e. the reverse) flow β of the neighbouring recirculation meet inside the blade channel in between as two shearing flows along a front, which generate a vortx with the same rotational sense as the rotor rotation. This vortex is designated by "low L" in the figure.

For the blade channel "a" of area A, the circulation Γ generated by the streaming velocities c_o and c_i of the baroclinic waves is in the same sense as the vortex low L. Its vorticity can then fuel the vortex low L. This vortex is thus intensified by the baroclinic waves. Hand in hand with it, the recirculation loop $\alpha-\beta$ around any one of the blades in area A is also intensified by the baroclinic waves generated in this inception stage of the rotating stall.

For the blade channel "b" of area B, however, the circulation Γ generated by the streaming velocities c_o and c_i of the baroclinic waves is against the sense of the vortex low L there. Then, this vortex low L and with it the associated recirculation loop $\alpha-\beta$ are suppressed by the baroclinic waves, which themselves are likewise weakened due to mutual induction. Thus, we have a smooth flow through the area B and its neighbourhood without any noticeable disturbance of the secondary flows. This is the unstalled region of the rotor.

If the inlet of area A is considered, the baroclinic wave streams with a very high tangential velocity c_i in the direction of the angular velocity Ω of the rotor in the outer zone near to the casing. The turning flow β' over the inlet edge of the blade generates also a tangential velocity in direction Ω in the inner zone next to the hub. Then, the surface of the inlet of area A is covered by a layer of tangential flow with high velocity. The experimental evidence will be given in Fig. 61a later on.

The outlet of area A is exposed to the tangential flow of the baroclinic wave (with high velocity c_o) in the zone near to the hub and to an additional one of the turning flow α' over the outlet edge in the zone near to the casing. These two tangential flows are opposite to the rotation direction Ω of the rotor. The experimental evidence for this will be also given in Fig. 61a. Then, the surface of the outlet of area A is likewise covered by a layer of tangential flow with high velocity, but in the opposite direction to the rotor rotation.

The two layers of the inlet and the outlet are coupled by the recirculation loops $\alpha-\beta$ to form a three-dimensionally rotating bubble enveloping the area A from inlet to outlet. The incoming flow can no langer enter this area. We have here the stalled region full filled with recirculation loops $\alpha-\beta$ and vortices "lows L".They form the stall cell (see Fig. 58d). The experimental evidence for this vortical activity will be given in Fig. 60.

The theoretical derivation given in this way will be examined by means of the experimental results compiled in Fig 59, evaluated from the investigation of Mathioudakis and Breugelmans (1988). Following diagrams are shown in this figure with the original experimental results of these authors compiled in Fig. 59':