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exist for the publication of theoretical and experimental investigations of all aspects of the mechanics and thermodynamics of fluid-flow with special reference to fluid-flow machines

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PRACE INSTYTUTU MASZYN PRZEPŁYWOWYCH

poświęcone są publikacjom naukowym z zakresu teorii i badań doświadczalnych w dziedzinie mechaniki i termodynamiki przepływów, ze szczególnym uwzględnieniem problematyki maszyn przepływowych

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The destabilisation of vortices interacting with small flat plates in the air stream

The interaction of vortices with small flat plates placed on their way has been studied experimentally in the air stream. The effects of the vortex destabilisation were examined with the aid of the Fourier transformation applied to velocity signals recorded downstream of the plates. The examined interaction most often led to the suppression of the velocity signals resulting from the destabilisation of vortex cores. Apart from that, for some plate locations significant amplification of the velocity fluctuations was recorded, due to the generation of strong secondary vortices.

Nomenclature

b – vortex generator dimension in the direction parallel to the flow,
c – plate chord length,
d – distance between two neighbouring street vortices constituting one row,
f – vortex shedding frequency,
g – plate thickness,
$G(f)$ – energy spectrum,
h – vortex generator dimension in the direction perpendicular to the flow,
l – distance between vortex generator and plate cross-section centres,
v – free-stream velocity,
κ – vortex strength.

1. Introduction

Experimental studies of vortices interacting with blade-shaped bodies have been carried out for about twenty years. The extremely extensive development of these studies was observed in the early 80's, which was connected with some theories pointing at the generation of vortices and their further interaction with blades as a possible source of noise recorded, in some circumstances, in helicopter rotor motion. It was also well known that the vortices flowing past a blade decrease the efficiency and reliability of its operation. The general goal of early experiments on the blade-vortex interaction was to recognize the nature of this phenomenon, (qualitative visualization studies – [1-4]), as well as to obtain certain quantitative data about possible ranges of blade load fluctuations [5-6] and

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other flow parameters, like velocity and vorticity distributions [7-8]. The data collected in these experiments made it possible to take the next step, quite obvious in this circumstances, namely to try to get the interaction process under control in order to obtain certain final results. Perhaps the earliest realization of this idea were the LEBU (Large Eddy Break Up) devices, the first reports of which were published in 1984 [9]. They had a form of small and thin flat plates which, when located at a selected place in the boundary layer of an examined body, suspended the laminar-turbulent transition of the layer. The LEBU experiments have proved that flat and relatively small aerodynamic bodies can be used effectively for breaking up vortex structures, with simultaneous little or no effect on the main flow. However, due to extremely difficult measuring conditions in the fully developed boundary layer they brought little information on the physics of the phenomenon. To understand better the operation of the LEBU devices, (Świrydczuk et al. [10]) examined the interaction of relatively big free-stream vortices with flat plates, the chord length of which was comparable with vortex core radii. The experiment was carried out in a water stream the mean velocity of which was equal to 12.5 cm/s. Unlike the majority of the earlier experiments, in which the blade-vortex interaction, especially in the case of head-on collisions, led directly to the complete break up of the vortex, here the plate imposed only an initial, relatively weak impulse to the vortex core. The role of this impulse was to destabilize slightly the inner structure of the core, thus initiating its spontaneous break up. The results obtained in this experiment have proved that the use of small and flat devices for breaking up coherent vortices is possible, but the final result depends strongly on the dimension of the plate in relation to the vortex core radius. This, together with the fact that the experiment was carried out in water and at relatively small velocities, automatically raised the question how far these results are valid in other media, and other flow conditions. The goal of the experiment reported in the present paper was to provide data helpful in answering this question.

2. Experimental facility and apparatus

The experiment was carried out in an open circuit wind tunnel in the Institute of Fluid-Flow Machinery, PASci. The measuring section had a shape of a rectangular prism, with dimensions $75 \times 12 \times 12$cm. The velocity range of the flow generated in this section was within the limits of 1 to 40 m/s. The main experiment was proceeded by a series of preliminary experimental works aimed at selecting a technique of the vortex generation which would secure high repeatability and regularity of generated vortex structures. Generally, this preliminary stage makes very important part of all experiments on the vortex interaction, and a great variety of published solutions shows that the problem has not been, so far, solved in the way which can be directly applied in arbitrary flow conditions. Moreover, the variety of techniques used suggests some influence of outer individual conditions in which the particular experiments were carried out. This made it purposeful to select a technique most appropriate for the geometry and flow conditions of the experiment to carry out. A number of generators with regular cross-sections were tested: a triangle, even-armed and uneven-armed trapezoids, a circle and a series of rectangles. As a result, a vortex generator with rectangular cross-section was selected as revealing the lowest frequencies of vortex shedding and relatively high energy spectrum peaks corresponding to these frequencies. The length of the longer side, h, of the generator was equal to 10 mm, and the side length ratio, b/h, was equal to 0.7.

The experimental stand is shown in Fig. 1, with marked some elements of a measuring line used for recording the data. The basic elements were: the vortex generator 1 and a series of thin flat plates, 2, the role of which was to impose the initial disturbance to the vortex cores. During the experiment the distance between the generator and plate cross-section centres, l, was constant, and the ratio l/h was equal to 7.0. According to Nakagawa at al. [11], this distance was long enough to allow the vortices form well defined structures before they approached the plate.

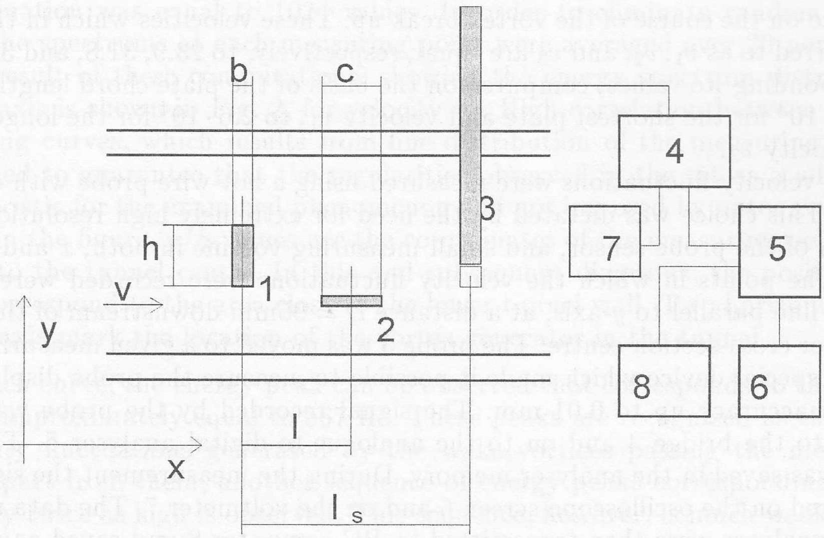


Fig. 1. Experimental facility and apparatus: 1 – vortex generator, 2 – plate, 3 – hot-wire probe, 4 – bridge, 5 – analogue-to-digital analyser, 6 – oscilloscope, 7 – voltmeter, 8 – computer.

Changeable parameters of the experiment were: the relative height of plate location with respect to the tunnel centre, y/h, the plate length, c, and the free-stream velocity, v.

The height of the plate location was changed in such a manner as to lead to different types of the vortex-plate interaction. On the basis of the velocity analysis in the wake behind the generator, given in detail in the next chapter, three locations of the plate were selected:

1. Outer location L $y/h = 1.5$;
2. Central location K $y/h = 0.9$;
3. Inner location H $y/h = 0.3$;

Three plates used in the experiment had the following chord lengths:

1. plate B $c/h = 1.00$;
2. plate M $c/h = 0.50$;
3. plate S $c/h = 0.25$.

The lens-like shape of the plate cross-section, with sharp leading and trailing edges, was chosen after Świrydczuk et al. [10]. Such a plate does not generate much disturbances in the uniform flow, and at the same time produces strong vorticity from the leading edge when interacting with the approaching vortex. The relative thickness of the plate, g/c, was within the limits of $0.1 \approx 0.15$ which resulted from technological limitations. In order to protect the plate against bending during the experiment, its mounting in the tunnel produced small preliminary tension.

Basing on technological abilities of the flow-generating mechanism of the tunnel, three levels of the free-stream velocity were selected in order to examine its influence on the course of the vortex break up. These velocities which in the paper are referred to as v_1, v_2, and v_3 are equal, respectively, to 23.9, 31.8, and 39.0 m/s. Corresponding Re values, computed on the basis of the plate chord length ranged from $4 \cdot 10^3$ for the shortest plate and velocity v_1, to $2.6 \cdot 10^4$ for the longest plate and velocity v_3.

The velocity fluctuations were measured using a hot-wire probe with one-wire sensor. This choice was dictated by the need for extremely high resolution of the location of the probe sensor, and small measuring volume in both, x and y directions. The points in which the velocity fluctuations were recorded were located along a line parallel to y-axis, at a distance $l_s = 95$mm downstream of the vortex generator cross-section centre. The probe 3 was moved to a given measuring point using a special device which made it possible to measure the probe displacement with an accuracy up to 0.01 mm. The signal recorded by the probe was transmitted to the bridge 4 and on to the analogue-to-digital analyser 5. There the signal was saved in the analyser memory. During the measurement the signal was monitored on the oscilloscope screen 6 and on the voltmeter 7. The data recorded by the analyser were then transmitted to PC computer 8 and saved as a file for further processing.

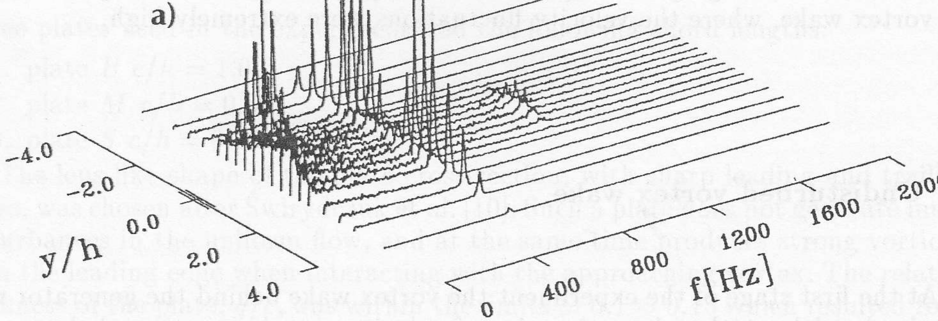
In the first, preliminary part of the data processing the voltage signal was transformed into the velocity signal, basing on the probe test curve. The next, main processing part based on the spectrum analysis (for definitions, see, for example, [12], pp. 51-52). This technique is, generally, highly sensitive to outer accidental disturbances which worsen the repeatability of the phenomenon of interest, thus making the discussion of the results extremely difficult. The recording procedure which was applied in this particular case took this aspect into account, mainly by selecting a sufficient number and locally refined distribution of measuring points. Thus, the procedure made it possible not only to create a consistent and reliable distribution image of examined parameters, but also to recognize the range of deviation of results recorded at an individual point from their general distribution observed at its neighbourhood. Such an approach, when supported with standard averaging techniques, was especially useful in the regions inside the vortex wake, where the velocity fluctuations were extremely high.

3. Undisturbed vortex wake

At the first stage of the experiment the vortex wake behind the generator was examined, without the plate. A series of velocity signals was recorded at each point located along the measuring line defined in the previous section. Then the energy spectra of all these signals were computed using the Fourier transformation. The basic length of the velocity data section used for computing the Fourier transformation was equal to 1024 values. In order to eliminate random fluctuations, the spectrums at each measuring point were averaged over 20 periods. A sample result of these computations, showing the energy spectrum distribution along y-axis is shown in Fig. 2, for velocity v_3. High correlation between the neighbouring curves, which results from fine distribution of the measuring points, is assumed to guarantee that the regularities observed in the set as a whole are characteristic for the examined phenomenon and not imposed by outer accidental agents. In the figure, y/h-values are the co-ordinates of the measuring point with respect to the tunnel centre. In this and subsequent diagrams, the positive y/h values correspond to the area close to the lower tunnel wall. Two horizontal lines along y-axis mark the location of the vortex generator in the tunnel.

In each curve, the energy peak can be observed that corresponds to the frequency, f, approximately equal to 567 Hz. These peaks are recognized as the peaks of velocity fluctuations generated by the wake vortices passing the measuring point. Apart from them, another sequence of energy peaks corresponding to the frequency twice as high is observed. This sequence, however, is much weaker than the previous one and is limited to the central region of the tunnel, $y/h \cong 0.0$. These peaks are most likely the result of combined action of the both series of vortices constituting the vortex street. Finally, in the same central region a number of relatively strong peaks are recorded in low fluctuations ranges, which may be the effect of high irregularity of the flow velocity here.

To give some evidence for the correctness of the above interpretation, a similar energy spectrum distribution was computed for a simplified theoretical model of the von Karman vortex street in which the vorticity was evenly distributed within a circular core of each vortex. The geometrical and dynamic parameters of this vortex street, determined on the basis of the free-stream velocity and vortex-shedding frequencies recorded in the examined flow, were the following [13]:



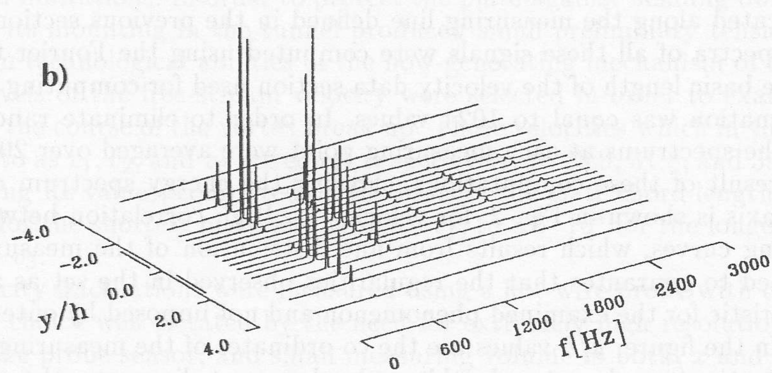


Fig. 2. Experimental (a) and theoretical (b: $r_v/h = 0.6$) distribution of the energy spectrum along the measuring line.

$l_v = 68.4$mm	average distance between two neighbouring vortices in one series of vortices having the same rotation sign;
$h = \pm 9.6$mm	y-coordinate of the core centres of the two rows of vortices constituting the vortex street;
$\kappa = 24.6 \cdot 10^{-3}\text{m}^2\text{s}$	strength of an individual street vortex (sign neglected).

The results are shown in Fig. 2b, for the assumed vortex core radius, r_v, equal to 6.0 mm. In the diagram, the hypothetical location of the street vortices in the tunnel is marked as two line sections along the y/h axis. What is noticeable here is a relatively high similarity of the general image of the energy peak distribution to that recorded in the experiment. First, the location and y/h-distribution of the highest peaks, corresponding to the vortex shedding frequency, is close to that from Fig. 2a. Then, the peaks recorded for the doubled frequency are even more visible here, most likely because of the absence of irregular disturbances which were recorded in the experiment in this region. All this testifies that the previous interpretation of regularities observed in the experimental energy spectrum distribution is true.

The y/h-distribution of relative heights of the energy spectrum peaks corre-

Table 1. Vortex-shedding frequencies for examined flow velocities.

Flow velocity, v [m/s]	Frequency, f [Hz]	Distance between wake vortices, l_v [$\text{m} \cdot 10^{-3}$]
$v_1 = 23.9$	349	68.7
$v_2 = 31.8$	465	68.4
$v_3 = 39.0$	567	68.3

sponding to the vortex shedding frequency, which from now on will be referred to as vortex frequency peaks, will be used as a basic tool in further analysis of the vortex-plate interaction. On the basis of qualitative changes observed in this distribution, certain conclusions will be drawn about the possible course and results of the examined interaction. The sample vortex frequency peak distribution which has been recorded in the undisturbed wake and thus can be considered as the reference datum for further analyses, is shown in Fig. 3a. The peak values shown in the diagram were taken as average from a fixed number of frequency intervals (4 at each side) surrounding the maximum value frequency, and not only from that point alone. This procedure has smoothing effect upon the data obtained, thus reducing the influence of accidental agents on the actual value and location of the vortex frequency peak in each distribution curve. Besides, since only the relative values of the vortex frequency peaks, and not the absolute values, are of certain importance for the needs of the analysis, the curves shown have a dimensionless form, as fractions of the maximum peak value, G_{max}, recorded at the left local maximum.

The curves shown in the diagram are relatively regular and reveal, generally, no visible dependence on velocity changes. Each of them has two local maximum points located approximately at $y/h \cong 1.2 \div 1.5$. Again, for correct interpretation of these maximum points, a similar diagram of the theoretical distribution of the vortex frequency peaks was prepared basing on the vortex street model described above. The results are shown in Fig. 3b for four versions of the vortex core radius. The location and extent of each vortex core is marked by one of four horizontal lines close to the upper part of the frame. It can be seen that for each core radius the location of the local maximum closely corresponds to the outer boundary point of the core. That means that in the real flow the highest velocity fluctuations indicate the location of the outer boundary of the vortex core. This conclusion was used for selecting the locations of the plate for its interaction with vortices in the further stages of the experiment. As it was said before, three plate locations were selected:

1. Outer location L $y/h = 1.5$. The plate is located outside, or at most, touches the vorticity area occupied by the vortex core. The vortex-plate interaction

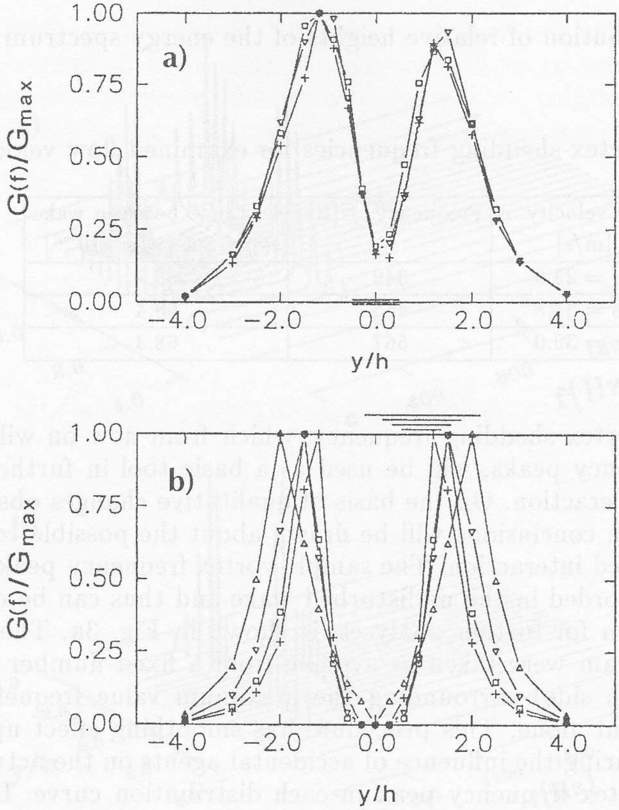


Fig. 3. Vortex frequency peak distribution in undisturbed flow: a) experimental: $\bigtriangledown - v_1$, $+ - v_2$, $\Box - v_3$, b) theoretical: $+ - r_v/h = 0.4$, $\Box - r_v/h = 0.6$; $\bigtriangledown - r_v/h = 0.8$; $\bigtriangledown - r_v/h = 1.2$.

does not affect directly the vortex core whose inner structure remains initially undisturbed.

2. Central location K $y/h = 0.9$. Here the head-on vortex-plate collision takes place. The plate destroys immediately and totally the inner structure of the vortex core.
3. Inner location H $y/h = 0.3$. The plate is located in the area where the doubled frequency of vortex shedding is recorded and it interacts with the both series of vortices constituting the vortex street.

4. The interaction of vortices with plates

4.1. Central location K, y/h = 0.9

The basic location of the plates in the tunnel was that denoted by $y/h = 0.9$, which was, approximately, the assumed location of vortex centres in the theoretical vortex street, described in the previous section. Such a plate location should lead to its interaction with the oncoming vortices which is described in the literature as the head-on collision. During this interaction the cores of the vortices are, generally, split apart by the plate. Fig. 4 shows the vortex frequency peak distribution being the result of the of the vortex head-on collision with all three plates examined. Apart from the markings and notations from Fig. 3, here a short vertical line crossing the upper frame stands for the y-coordinate of the plate location in the tunnel. The peak distribution recorded for the undisturbed wake is also shown as the reference data. In the diagram, the curve recorded for the longest plate, B, shows the most significant changes. First, it has its right maximum visibly displaced, approximately to $y/h \cong 0.0$, and its value is equal to about 50% of that in the curve for the undisturbed flow. Moreover, the left row of wake vortices is also affected in this case, and its maximum peak value is reduced as much as the right one. Looking at the shape of the peak distribution curve in the vicinity of the plate location, and bearing in mind the course of the similar interaction described in [10], one may interpret it as the result of the creation of secondary vortices, with the rotation sign opposite to that represented by the primary wake vortices. If so, the reduction of the left maximum would be the possible effect of the interaction of the two vortex rows: the right row of the secondary vortices and the left row of theoretically undisturbed primary vortices.

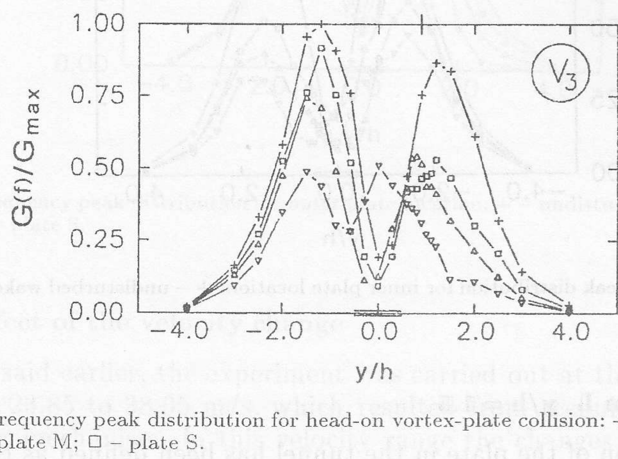


Fig. 4. Vortex frequency peak distribution for head-on vortex-plate collision: + – undisturbed wake, ▽ – plate B; △ – plate M; □ – plate S.

The curves obtained for the remaining plates reveal the scale of reduction of the right maximum very close to that observed for by plate B, while the left maximum is reduced visibly less, and for the shortest plate, S, it is almost identical as for the undisturbed wake. This similar scale of reduction of the maximum velocity fluctuations, recorded for all plates examined independently of their length, makes a distinguishing and important feature of the examined phenomenon.

4.2. Inner location H, y/h = 0.3

The inner location of the plate in the tunnel was close to the symmetry axis of the flow. In this location the plate was in the shadow of the generator, in the region in which the energy spectrum in Fig. 2a revealed peaks for the doubled frequencies. The vortex frequency peak distributions, obtained, as in the previous case, for the fundamental frequencies of the vortex shedding, are shown in Fig. 5. Two regular tendencies are observed in the shape deformation of the curves, namely stronger reduction of the right peak than the left one, and stronger peak reduction for longer plates. What is irregular here is the location of the local minimum point in the vicinity of the flow symmetry axis. For plate B, this point is displaced to the right, while for plate M – to the left, and for the smallest plate the curve has its minimum approximately at the same point as for the undisturbed flow. This tendency was observed in the curves obtained for all three examined velocities, see Fig. 7a, and is unlikely to be accidental. Its explanation, however, is impossible on the basis of the data available, as the flow in this region has very complex and thus unpredictable nature which results from the interaction of the plate with the two rows of wake vortices.

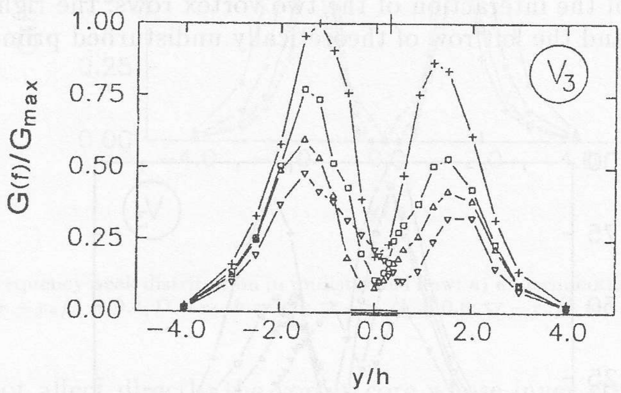


Fig. 5. Vortex frequency peak distribution for inner plate location: + – undisturbed wake, ▽ – plate B; △ – plate M; □ – plate S.

4.3. Outer location L, y/h = 1.5

The outer location of the plate in the tunnel has been defined as the location, in which the plate does not come, generally, into direct contact with the vortex core. In Section 3 it was shown that the outer point of the vortex core crosses the measuring line at $y/h = 1.5$. This coordinate was selected as the outer location of the plate. The results obtained for this case are shown in Fig. 6, for velocity v_1. In the region close to the plate, substantial deformation of the vortex frequency peak curve is observed, which is strongly amplified on one side ($y/h < 1.5$) and reduced on the other side ($y/h > 1.5$). These changes are stronger for longer plates. Similar tendency was observed at the central plate location and it was interpreted as the result of the formation of the secondary vortices from the vorticity generated during the interaction. This effect is also recorded here, but in a much more dramatic form. Unlike the central location, however, where the total effects led to the reduction of peak maximum values, here we can see their strong amplification to the values much higher than those represented by the undisturbed wake curve. This tendency to amplify the vortex peaks was recorded for all examined plates and velocity levels, although its scale varied. The amplification of the vortex peak values suggests the relative big strength of the secondary vortices created downstream of the plate, and/or their high repeatability.

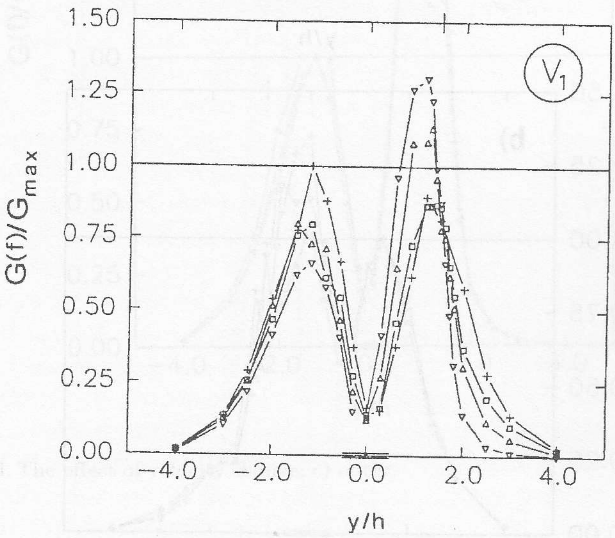


Fig. 6. Vortex frequency peak distribution for outer plate location: + – undisturbed wake, ▽ – plate B; △ – plate M; □ – plate S.

4.4. The effect of the velocity change

As it was said earlier, the experiment was carried out at three velocity levels, ranging from 23.85 to 38.95 m/s, which resulted from technical abilities of the tunnel driving mechanism. In this velocity range the changes of the free-stream velocity did not lead, generally, to visible qualitative changes in the course of the vortex-plate interaction. Moreover, for a majority of combinations of the plate sizes and locations the quantitative changes were also very small. Three diagrams in Fig. 7 show changes in the general shape of the vortex frequency peak distribution recorded for plate B in its all three locations. The changes observed for this plate were the biggest. The curves shown in these diagrams were normalized with respect to the peak maximum, G_{max}, recorded for the left row of vortices. Such a normalization may seem to be a bit risky, as the results presented previously reveal that for some plate locations the left row of vortices is also affected by

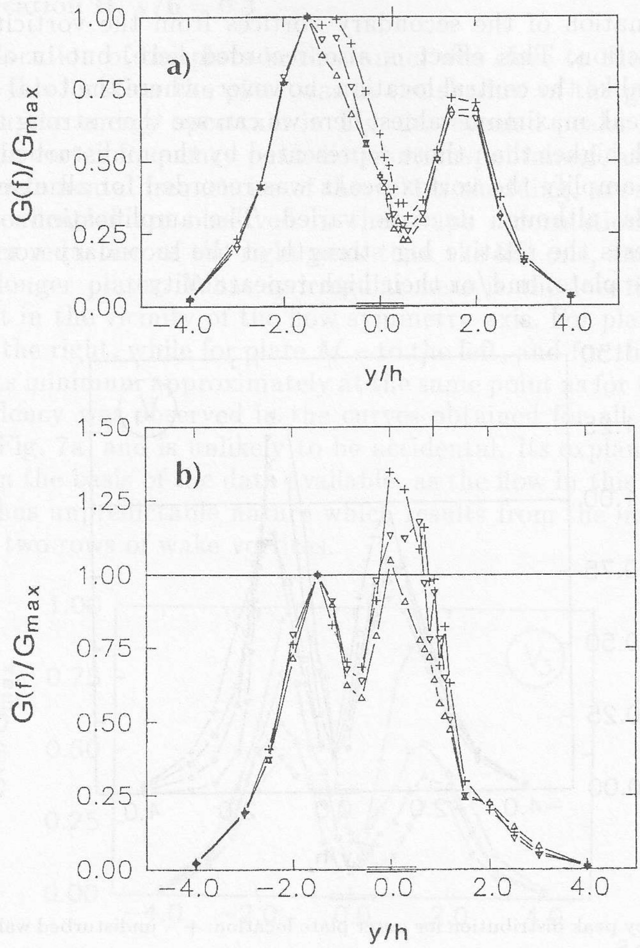


Fig. 7. The effect of velocity change: + – v_1, $\bigtriangledown$ – v_2, $\triangle$ – v_3. Plate B, locations a) inner, b) central, c) outer.

the interaction with the plate, but it is justified as a comparison of the effects recorded for the same plate location. The results shown here present, generally, surprising independence of the free-stream velocity. The curves shown in Fig. 7a have been obtained for the inner plate location H – this is the case in which led to the displacement of the local minimum point, described in the previous section. The only visible difference in the curve shape is recorded in the vicinity of the left maximum, for the theoretically less disturbed row of vortices. The location of the maximum points and general shape of the curve for the right row are almost identical.

The next diagram, Fig. 7b, shows the vortex frequency peak curves obtained for the central location. Here, what is not surprising, the most significant changes are observed in the region close to the plate location. This can be explained by

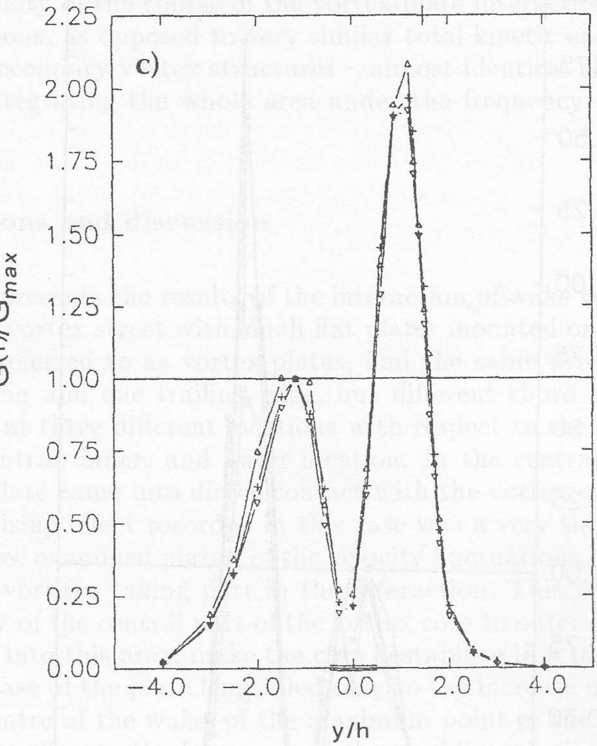


Fig. 7 continued. The effect of velocity change: c) outer.

the fact that this interaction leads to immediate distortion of the vortex core, parts of which may then interact with each other and with the secondary vorticity generated by the plate. In such a complex vorticity distribution even slight changes of initial conditions may end up as incomparably different final results.

In the last diagram, Fig. 7c, the vortex frequency peak distributions obtained for the outer location are shown. The similarity of shapes of all three curves is very high. The comparison of these curves with those from Fig. 6 shows that in the whole examined velocity range the vortex-plate interaction amplifies the velocity fluctuations in the region of the right row of vortices, reducing at the same time those generated by the left row. The scale of amplification and reduction is obviously different for different plates, and is the minimum for plate M, but for one and the same plate the range of amplification of the fluctuations in the right row and their reduction in the left one is very similar. This effect is explained as the result of the secondary interaction of the vortices in the wake.

Although not imposing significant effects in the general course of the vortex-plate interaction, the change of velocity level worsens its repeatability. As it was said earlier, the vortex frequency peaks shown in the diagrams were computed as average values from 9 sections neighbouring the maximum point (the central

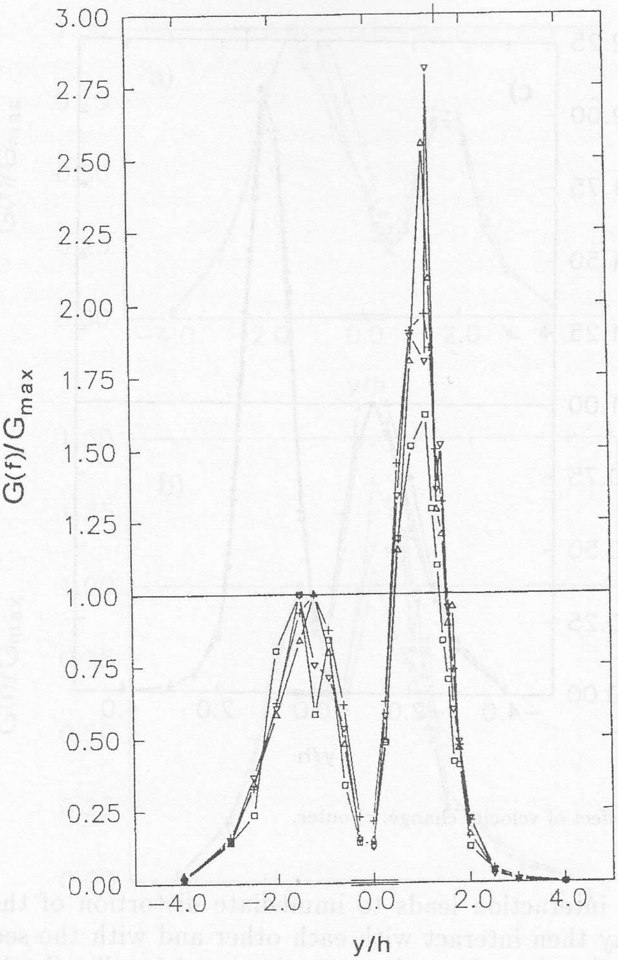


Fig. 8. Vortex frequency peak distribution for outer plate location, one-point peak representation: + – v_1 (smoothed), ▽ – v_1; △ – v_2; □ – v_3.

section in which the maximum was recorded, and 4 sections on each side). Having certain advantages connected with smoothing accidental irregularities, this procedure, however, can obscure the image of the phenomenon repeatability. To make this point more clear, in Fig. 8 a set of peak curves is shown for the three velocity levels, as computed from one-point peak values, without using the smoothing procedure. What can be observed here is significant difference in the level of the right maximum peak value for different velocities. As a comparison, a smoothed curve obtained for velocity v_1 is also shown – marked by crosses. As it was shown in Fig. 7c, this last curve is almost identical with those obtained for the two remaining velocities and can be well used as a reference for all rough curves presented in Fig. 8. The decreasing difference in the peak values between the smoothed and rough curves, as recorded for increasing velocity, can be explained as lower repeatability of the course of the vortex-plate interaction – lower one-point peak distributions, as opposed to very similar total kinetic energy carried by the primary and secondary vortex structures – almost identical shapes of the curves obtained by integrating the whole area under the frequency peak in the energy spectrum.

5. Conclusions and discussion

The paper presents the results of the interaction of wake vortices constituting a von Karman vortex street with small flat plates mounted on their way. A series of the plates, referred to as vortex plates, had the same prismatic cross-section with one leading and one trailing edge, but different chord lengths. The plates were mounted at three different locations with respect to the vortex trajectories, namely the central, inner, and outer location. In the central, most spectacular location, the plate came into direct contact with the vortex cores, splitting them apart. A surprising effect recorded in this case was a very similar scale of reduction, for all three examined plates, of the velocity fluctuations in the area occupied by the row of vortices taking part in the interaction. This result may testify to high sensitivity of the central part of the vortex core to outer disturbances which, when imposed into this area, make the core destabilize in a fast and uncontrolled way. The increase of the plate length led only to the increase of the displacement, towards the centre of the wake, of the maximum point in the energy peak distribution corresponding to the frequency of the shedding vortices. Moreover, longer plates caused stronger reduction of the velocity fluctuations in the second, theoretically unaffected row of the wake vortices. In the central location, the plates caused proportional reduction of the vortex frequency peaks in the both rows of vortices, with some displacement of the central local minimum recorded for the longest plate. The origin of this regularity is not entirely clear due to a complex nature of the flow pattern in this area.

Unlike the two previous cases, in the outer location of the plates their interaction with the vortices led to strong amplification of the vortex frequency peaks, which was especially dramatic for the longest plate. This effect was accounted for the formation of strong, and regular secondary vortices from the vorticity generated at the plate leading and trailing edges.

The effect of changes of the free-stream velocity on the course of the plate-vortex interaction was proved to be very small in the examined velocity range, worsening only the repeatability of the phenomenon in higher velocities.

As it was explained in Introduction, the origin of the present study on the vortex-plate interaction was a similar experiment carried out in water which had demonstrated the possibility of controlled destabilisation of a vortex structure executed by locating objects having certain shapes and dimensions on its way. Those results, although promising, raised questions about possible application of this method in other media, like air and other, more rough flow conditions. From this point of view, the results obtained here answer this question positively. Moreover, the data recorded for the shortest plate seem to be very promising for its further use. First of all, during the head-on collision with the vortices this plate revealed almost identical reducing potential as longer plates. Moreover, when its location was moved off the vortex trajectory the plate produced the smallest side effects, as it did not generate secondary vortices when contacting with outer layers of the vortices. This may lead to the conclusion that for any flow conditions an optimum dimension of the vortex plate can be found which will be the most effective in destroying the inner structure of vortex cores using the minimum effort.

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Destabilizacja wirów oddziaływujących z płaskimi płytkami o niewielkich wymiarach w strumieniu powietrza

Streszczenie

Oddziaływanie wirów z płaskimi płytkami o niewielkich wymiarach, umieszczonymi na ich trajektorii było badane eksperymentalnie w strumieniu powietrza. Przeanalizowano efekty destabilizacji wirów, poddając transformacji Fouriera sygnały prędkościowe rejestrowane w przepływie za płytkami. W najczęściej spotykanych przypadkach badane oddziaływanie wirów z płytkami prowadziło do zmniejszenia sygnałów prędkościowych wskutek destabilizacji rdzeni wirowych. Oprócz tego, dla określonych konfiguracji wir-płytka zarejestrowano silne wzmocnienie fluktuacji sygnału prędkościowego, co było interpretowane jako efekt generacji silnych wirów wtórnych.