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Investigation of supersonic flow in wind tunnel T-38 by holographic interferometry method

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The holographic interferometer, designed, produced and tested for wind tunnel T-38 is described. New equipment is the base for holographic interferometry tests. Investigation of supersonic flow quality is the first in a series of experiments for testing of complex flow field around different models using holographic interferometry. In this article, the experiment and results of holographic interferometry application for analysis of flow quality in the test section are presented. The experimental results are compared with theoretical ones.

Key words: **supersonic flow, wind tunnel, holographic interferometry, holographic interferometer.**

Symbols in the text

V_∞	– Free stream velocity
M_∞	– Mach number in free stream
P_s	– Static pressure
P_{tot}	– Total pressure
x,y,z	– Decart' coordinate
r	– Radius vektor
T	– Turbulence intensity
n	– Light refraction index
ρ	– Air density
t	– Flow temperature
φ	– Phase of the light
Φ	– Total phase
I	– Light intensity
K	– Gledston-Dale constante
κ	– Gas constante
Θ_c	– Top cone angle
Θ_u	– Shock wave angle
α	– Attack angle of the model
Cp	– Specific heat of air for p=const.
N	– Interference fringe number
MRe	– Rejnolds number
RSN	– Run sequence number
PMS	– Primary Measuring System

Introduction

THE research end control of the flow quality in the wind tunnel T-38 test section is the actual task from the very beginning of exploitation. For that purpose, the classic methods have been used in wind tunnels for long [1, 2].

Nowadays, the contactless methods are used more and more for aerodynamic testing, throughout the world. Optical methods are contactless and very sensitive to small changes of flow properties. Optical methods make possible visualizing and determining aero-dynamical flow parameters in total volume of test section (density, pressure, flow velocity, Mach number, show location of shock and expansion waves, nature and transformation of boundary layer, interaction of different effects in complex flow fields etc.) [3-17]. The Schlieren and interferometric methods are the methods used most often. Holographic interferometry makes possible to obtain three-dimensional image of the flow and determine numerical values of the flow parameters [6-8, 13, 14]. The greatest advantage of holographic interferometry, in relation to Schlieren method, is the fact that it provides complete information stored in a single plate, allowing a postponement selection of specific types of flow visualization.

The interferometers used in the best known wind tunnels in the world are specially designed and adapted for wind tunnel performance, methods etc. [1, 8, 10]. They are not available on the world market, but have to be designed by special producers. Two identical interferometers for wind tunnel tests do not exist in the world. To follow the contemporary tendencies in the world, a new device, holographic interferometer, has been designed especially for wind tunnel T-38. All phases from the project design overall project and components produced in MTI[1)] model workshop or others that were bought, assembling, adjustment and testing were carried out in the MTI laboratories.

In this paper, the construction of interferometer is described. The experimental results for flow quality research using cone-cylinder model are presented. The flow quality parameters have been indirectly determined using holographic interferometry of flow around, like cone and sphere (calibration models) models whose geometry is well known [3-5]. They are compared with theoretical and numerical models.

Description of holographic interferometer

The principles of holography and holographic interferometers are described in references [3-8]. The purpose of this section is to give a brief description of a new holographic interferometer. Detailed description of the holographic interferometer and part of its components made in

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MTI model workshop, is given in references [4,5].

Holographic interferometer has been designed as modular system with no standard dimensions, compatible with wind tunnel T-38 test section dimensions. It allows visualizing flow in transonic and supersonic test section. Holographic interferometer has the capacity for significant and fast changes, depending on different tests, which is its advantage.

The main holographic interferometer performances are:

- Detection range of refractive index is 10^{-7} to 10^{-4}
- Accuracy of refractive index measurement is 10^{-7}
- Optical field diameter $\Phi = 900$ mm
- Capability of easy modifications which allows application of different methods: double exposure, real time, time average, multipassing object beam, multibeams interferometry, interferometry with parallel or diffuse object beam, "sandwich" method, etc.
- Capability of holographic interferometer connection with wind tunnel control system and data acquisition and reduction system.

System for holographic interferograms recording

Fig. 1 shows the schematic drawings of holographic interferometer (top view) with pictures of different modules. The interferometer components are positioned for supersonic flow testing positions. The components where the laser is form the emitting part of the interferometer. The components situated on the other side of the wind tunnel, which direct and focus laser beams on holographic plate, represent the receiving part of interferometer. The optical and mechanical components have micro positioning screws.

Light source consists of:

- ruby pulse laser Apollo model 22 (Imatex), E = 3J, t=30·10^{-9} s, λ =693.4·10^{-9} m, $l_k \approx 1\text{m}$, He--Ne laser, Spectra Physics, $P = 5\text{mW}$, λ =633·10^{-9} m,
- diode laser, IE 109S, Iroya, $P = 3\text{mW}$, λ =660·10^{-9} m,
- mirrors, lenses, beam splitters and mechanical holders
- anti-vibration table Newport Corporation model RS 48×12.

In the wind tunnel T-38 the components of the Schlieren system are maximally incorporated into holographic interferometer. In spite of all that, the Schlieren system keeps its original purpose and it can be included in test as either Schlieren system or interferometer. The object laser beam, after passing through the beam splitter is expended, collimated to $\Phi = 900$ mm and directed across wind tunnel test section. Reference beam is conducted upside wind tunnel on 7.8 m to wind tunnel hall floor. The dimensions of interferometer can be illustrated by the length of reference beam, which is about 42 m and object beams about 43 m.

Holographic interferograms have been recording on the holo or holographic plate 8E75HD, Agfa Gevaert, which have been fixed on a special mount in receiving Schlieren cabinet.

System for reconstruction and recording of holographic images

The reconstruction setup is an integral part of the holographic interferometer. It is composed of the following major components:

- He-Ne laser, (124B, Spectra Physics),
- lenses, opto-mechanical supports,
- TV or still camera (classic or digital) etc.

Fig.1 shows reconstruction setup used in this experiment. The system for recording and digitalization and processing of holographic interferogarms consists of digital Hammamatsu camera type C 1000, PC Pentium IV, 430 MHz, with operating system Windows 98', standard PCTV card, Pinnacle. Processing of holographic images, resizing, cropping, changing brightness and contrast, increasing the gamma correction to make isodensity line (interference fringes) more visible has been made with Adobe Photoshop 6.

The new software necessary to calculate the flow parameters from holographic interferogarms (which converts the optical changes in the image to physical flow parameters) has been developed. FORTRAN has been used as program language. It makes possible using data set of digital image, determining fringe distribution, solving equations and formulas for flow quality parameters.

Models

The calibration models for wind tunnel flow quality investigation are the sphere and cone. These models are very simple, of well-known geometry. The flow around these models can be calculated and simulated with different methods of computational fluid dynamics (CFD). Those are recommended for testing efficiency of new methods (experimental and numerical).

In this experiment: model sphere $D = 50\,\text{mm}$, model cone $\theta c = 30^\circ$, $l = 93{,}5$ mm and base $\Phi = 50\,\text{mm}$, model cone-cylinder, $\theta c = 15^\circ$, $l = 300$ mm base $\Phi = 160\,\text{mm}$, $lc = 160\,\text{mm}$ have been used. The results for model cone-cylinder are presented in this article.

Experiment

The experiment was carried out in wind tunnel T-38 through these steps: mounting the model on the support system in the test section, preparing and setting parameters for wind tunnel run, setting up and adjusting holographic interferometer, wind tunnel run, holographic interferograms recording during wind tunnel run, development, fixing, bleaching, drying of holograms, reconstruction and recording of holographic image, numerical image processing, analysis of results and discussion.

During this experiment 26 wind tunnel runs were performed with $M_\infty = 1.5, 1.7, 2.0$, stagnation pressure $P_0 = 2.5, 3.0, 3.5$ bar and $M\,\text{Re}$ between 35 and 53. PMS determined only the Mach number in the free stream flow.

Results and discussion

Analyses of flow field around cone-cylinder

Fig.2 shows geometry of cone-cylinder model and coordinate system used. The test section of T-38 is 1.5 × 1.5 m square cross section, and 4.5 m length. The model dimensions are chosen to block flow less than 1%, and it cannot be taken into consideration, since there is no interaction between wind tunnel section walls and the model.

If the velocity is uniform in the central part of the test section, outside the wall boundary layers, then no interference fringes in the holographic interferogram appears in front of the shock wave. One interferometric fringe appears (in flow with $M = 1.5$) when the density change is $\Delta\rho = 2 \cdot 10^{-3}\,\text{kg/m}^3$, i.e. the velocity change is 1 m/s.

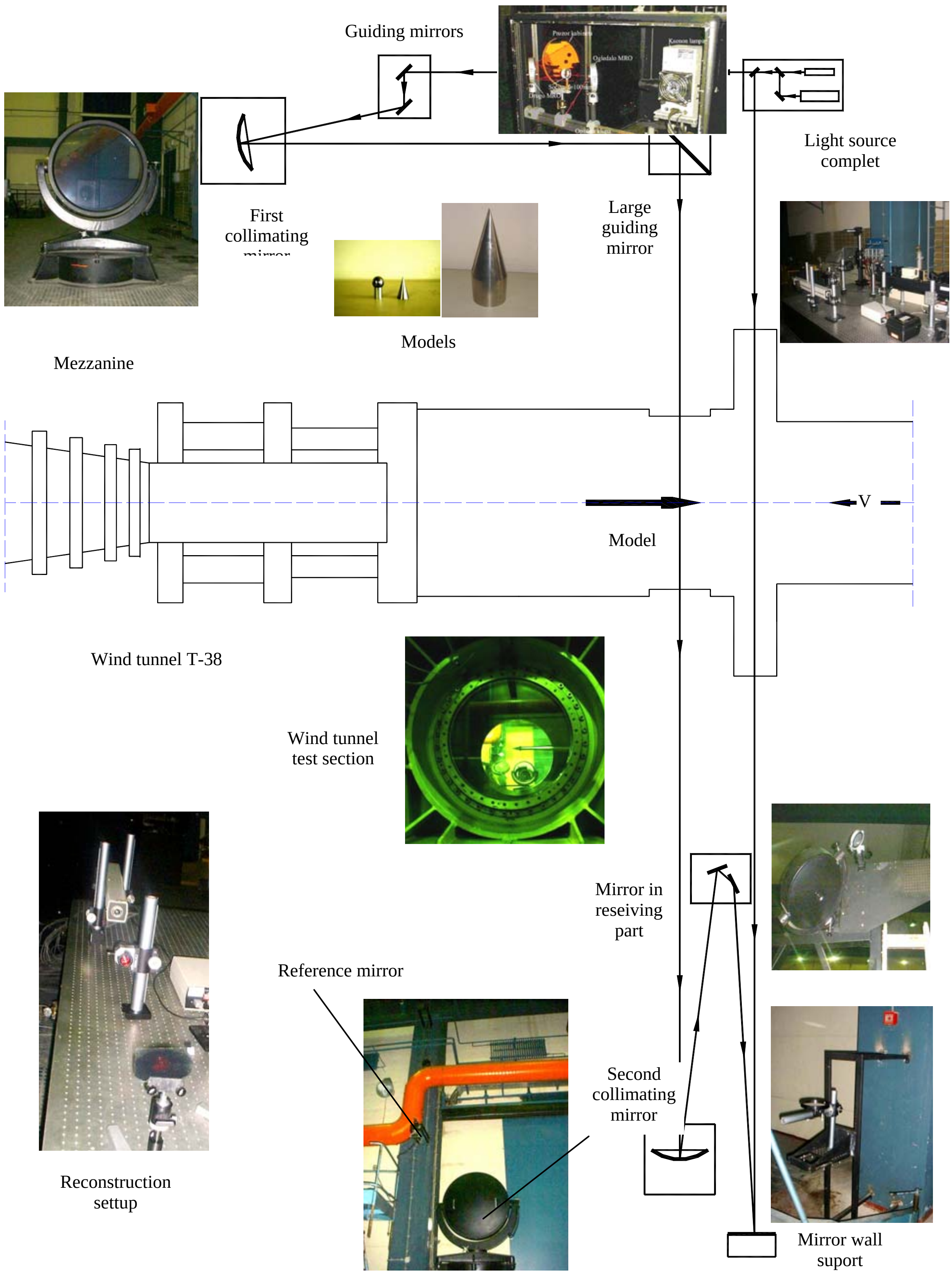

Figure 1. The holographic interferometer in wind tunnel T-38 (top view)

The interferometric fringes in the region of free stream flow demonstrate the existence of turbulence, or vibrations of optomehanical components. PMS of wind tunnel determines the M_∞.

The shock wave appears for the supersonic flow. Values for the points near the inner shock wave surface, can be calculated according to aerodynamic relations [5], or by measurement for the point on the model surface. The inverse method is possible: the conical flow parameters behind the shock wave can be used to determine the parameters in front of the shock wave, in the free stream flow. The flow parameters behind the shock are published in ref. [5, 6, 12].

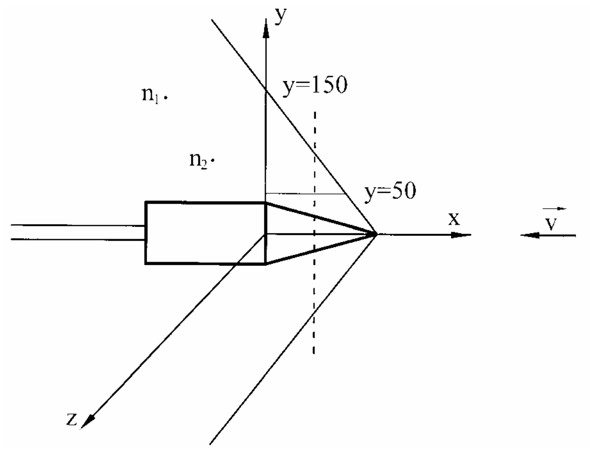

Figure 2. Cone-cylinder model and coordinate system

Quantitative flow testing, using holographic interferograms is performed by determining the number of fringes N in the field image with respect to a reference point of known density. Laser beam propagation is collinear with the z axis. The flow and the model axis are collinear with x-axis (Fig.3). The optical phase difference of the beams passing through points 1 and 2 can be represented by formula (1) [8]:

$$\varphi_2 - \varphi_1 = \Delta\Phi \tag{1}$$

$$\Delta\Phi(x) = 2\int_x^R \frac{[n(r)-n_0]r}{\left(r^2-x^2\right)^{\frac{1}{2}}}dr \tag{2}$$

if

$$f(r) = n(r) - n_0 \tag{3}$$

and

$$\Delta\Phi(x) = N(x)\cdot\lambda$$

then:

$$N(x)\cdot\lambda = 2\int_x^\infty \frac{f(r)\cdot r\cdot dr}{\sqrt{r^2-x^2}} \tag{4}$$

$$f(r) = -\frac{\lambda}{\pi}\int_r^\infty \frac{(\frac{dN}{dx})\cdot dx}{\sqrt{x^2-r^2}} \tag{5}$$

If there are no interference fringes on the interferograms, it means that $N(x) = const$ and $f(r)$ is a constant. In practice, it is very difficult to set an explicit mathematical expression for the changes $N(x)$, in the interferograms of a complex object. As a rule, function $N(x)$ is known for the finite number of points. Because of that, discretization of the tested is filed and the problem of integration reduced to summation.

Processing of axisymmetrical phase object interferograms is performed by inversion method based on Abel's transformations. Numerous articles used step function $f(r) = const.$ for refractive index in the conical flow. In ref. [13] it has been proven that the choice of the approximation is more important for the accuracy of results than the choice of number series. During complex phase object interferograms processing it is recommendable to use different approximations and compare obtained results with theoretical ones. For the case of isentropic flow, the following relations exist between index of refraction n, number of fringes N, pressure P, temperature T, velocity V, Mach number M and air density ρ:

$$n - 1 = K\cdot\rho \tag{6}$$

$$p(x_2,y_2) = p_0\left[\frac{\rho(x_1,y_1)}{\rho_0} \pm \frac{N\lambda}{KL\rho_0}\right]^2 \tag{7}$$

$$T(x_2,y_2) = T_0\left[\frac{\rho(x_1,y_1)}{\rho_0} \pm \frac{N\lambda}{KL\rho_0}\right]^{\gamma-1} \tag{8}$$

$$V(x_2,y_2) = 2C_pT_0\left[1-\frac{\rho(x_1,y_1)}{\rho_0} \pm \frac{N\lambda}{KL\rho_0}\right]^{\gamma-1} \tag{9}$$

$$M(x_2,y_2) = \frac{2}{\gamma-1}\left\{\left[\frac{KL\rho_0}{KL\rho(x_1,y_1)\pm N\lambda}\right]^{\gamma-1} - 1\right\} \tag{10}$$

where:

$$\gamma = \frac{C_p}{C_v}$$

P_0, T_0, ρ_0 are steady state values for $V_0 = 0$ m/s, for stationary conditions.

During this test, the new, original software, for converting the interferometric fringe distribution on flow image to the physical quantities of flow, was developed and tested.

The main aims of flow interferograms analysis are:

- Demonstrating the holographic interferometry possibility for flow quality testing when the calibration models are used
- Testing the new software for interferogram processing

Table 1 represents the values for air density and Mach number in the region of conical flow between shock wave and model surface, for section with $x = 150$ mm, $y = 50 - 150$ mm, $M_\infty = 1.47$, *M*Re = 37.84, RSN = 20. The first four columns give results obtained when the data input is the density from Jones tables, published in AGARD 137 [17]. The expected Mach numbers are in the third column. The experimental results are summarized in the next four columns, in Table 1. There, the data input is the number of interferometric fringe $N(x)$. The approximation $n(r) = const.$ is introduced for both theoretical and experimental calculations. The last tree columns contain values of flow parameters, obtained with computational flow dynamics, Fluent 6.0 [18] for experimental conditions. It calculates and graphically simulates isodensity lines of the flow in the wind tunnel test section, allowing comparative analysis with experimental ones. The values of density and Mach number are plotted in Figures 3 and 4. The tree methods mentioned give, for the point with $x = 150\,\mathrm{mm}$, $y = 150\,\mathrm{mm}$, the Mach numbers as follows: $M_{tab} = 1.52$, $M_{\exp} = 1.53$, $M_{fluent} = 1.47$. The PMS measured 1.474 for nominal value $M_{seting} = 1.5$. Good agreement between experiments and theory is achieved. The last two columns in Table 1 show the density differences $\Delta\rho$ between experimental and theoretical results (agard) and experimental and fluent ones. In the first case the average $\Delta\rho = 2.4\%$, in the second is $\Delta\rho = 3.6\%$.

Table 1. The flow parameters in the conical flow behind the shock wave

AGARD 137				Experiment				Fluent				E/A	E/F
y (mm)	ρ_j (kg/m3)	M_j	N (x)	y (mm)	ρ_e (kg/m^3)	M_e	N (x)	y (mm)	ρ_f (kg/m^3)	M_f	N (x)	$\Delta\rho$ %	$\Delta\rho$ %
150.	1.2250	1.52	21,0	150.	1.21837	1.53	27,0	154.89	1.2963	1.47	25,0	3,4	6,0
140.	1.2595	1.49	19,1	140.	1.24961	1.50	25,5	139.91	1.3221	1.45	24,5	0,8	5,5
130.	1.2940	1.47	17,7	130.	1.30346	1.46	23,0	129.61	1.3444	1.44	24,0	0,7	3,0
120.	1.3285	1.44	15,1	120.	1.33117	1.44	20,0	115.34	1.3714	1.42	23,0	0,6	2,9
110.	1.3630	1.42	13,4	110.	1.38659	1.40	18,5	113.61	1.3748	1.41	21,5	1,7	0,9
100.	1.3975	1.39	11,4	100.	1.47077	1.34	15,0	100.22	1.3999	1.39	19,0	5,3	5,0
90.	1.4320	1.37	9,5	90.	1.48175	1.33	11,0	91.00	1.4271	1.37	16,5	4,0	3,8
80.	1.4665	1.35	7,4	80.	1.48941	1.33	7,5	80.10	1.4568	1.36	13,0	1,6	2,2
70.	1.5000	1.32	5,5	70.	1.49005	1.32	5,0	70.62	1.4957	1.32	7,0	0,7	0,4
60.	1.5345	1.30	3,6	60.	1.50417	1.31	2,5	59.33	1.5485	1.30	2,5	2,0	2,8
50.	1.5690	1.28	1,8	50.	1.51574	1.31	1,0	50.50	1.5696	1.28	1,0	3,4	3,4
$\Delta\rho_{av}$												2,4	3,6

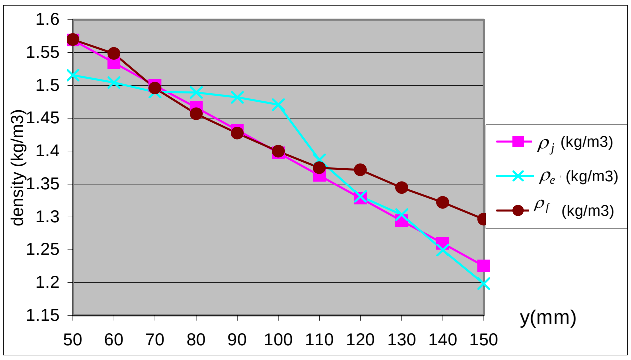

Figure 3. Experimental density distribution behind shock wave

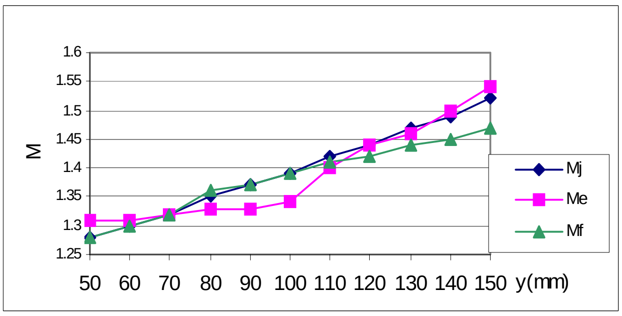

Figure 4. Mach number behind shock wave for x=150mm, y=50-150mm

Determination of Mach number by shock wave angle

The optical methods are often used for establishing the Mach number M_∞, in a supersonic free stream flow, by measuring the inclination of the attached shock wave, to the direction of the undisturbed flow. The attached shock wave appears when the wedge or cone are placed at zero incidences in supersonic flow. When the cone is used, the formulas are shown in ref. [17], for representative Mach numbers. This method is usually used with Schlieren method.

In this test, holographic interferograms are analyzed for this purpose. The holographic interferogram is three-dimensional image of the flow around cone-cylinder model. The location of the shock wave is recorded on holographic plate as superposition of shadow and interferometric effects. The shock wave is a border between uniform, unperturbed flow and flow behind the shock wave, where the density gradient is not zero and the significant interference may be seen.

The shock wave angle may be measured in two ways:

- On the hologram without reconstruction, shadow effects are recorded on the plate like a photo
- During the reconstruction of the hologram.

The first way is classical and a lot of information about it is known. The second way is more complicated, and it is not found in the quoted references. Some new problems associated with shock wave angle measurement appear during the holographic image reconstruction and recording. The form and position of shock wave and interferometric fringes depend of reconstructed image geometry, of plain where the camera is focused and of camera angle. A small change in geometrical characteristics of the reconstruction system produces significant differences in image geometry. This problem can be partially solved, when the reconstruction wave is identical with the reference one.

Table 2. Determination of M_∞ by shock wave angle

RSN	M_∞ (PMS)	Θ°_u tab.	Θ°_u (left)	Θ°_u (right)	Θ°_u (average)	M_∞	ΔM_∞ %
2	1.470	47	46.2	47	46.6	1.46	1.0
10	1.480	46.2	48	49	48.5	1.41	5.0
16	1.473	46.5	43.9	45	44.5	1.44	2.5
19	1.473	46.5	44.8	45.6	45.2	1.49	1.2
20	1.474	46.5	48	47.5	47.75	1.4	5.3
24	1.474	46.5	47.2	46	46.6	1.46	1.0
average	1.474	46.5	46.35	46.7	46.5	1.44	2.6

Table 2 gives the following values: run sequence number, RSN, Mach number M_∞ measured by PMS, values of expected shock wave angle corresponding to Mach number measured by PMS, (taken from table in ref. [17]), Θ_u tab experimental records of left, right and average values of shock wave angles on holographic interferogarm, Mach number determined using the measured average angle, relative Mach number error.

Fig.5 shows Mach number M_∞ for nominal M_∞ = 1.5, (average PMS value is 1.474). The measured angle from holographic interferograms is between 44.5° and 48.5° that gives M_∞ from 1.4 to 1.49. The average value of $\Theta_{utab} = 46.5^\circ$. The maximum error for experimental value is $\Delta M_\infty / M_\infty = 5\%$, average error value is 2.6%.

Figures 6 and 7 show the experimental recorded and theoretical simulated isodensity lines of axisymmetrical flow around cone-cylinder model. On both photos, it is evident that the angle of shock wave is the same (46°). Excellent agreement of theoretical and experimental isodensity lines is in the region between model surface and shock wave and the region of expansion fans (Fig.8). The difference exists in the region of unperturbed, free stream flow. The appearance of interferometric fringes (they are not expected in that region) indicates that there are additional sources of optical path changes of reference or object beams. These changes are not results of air density gradient in wind tunnel test section. One source can be the vibrations that exist in the wind tunnel causing the relative displacement of optical or mechanical components of holographic interferometer or wind tunnel windows, between first and second exposition (run on and run of wind tunnel). Airborne disturbance in the wind tunnel test section and hall, occurring between two expositions, can give interferometric fringes in the region before the shock wave. The additional interferometric effects can be superposed by turbulence in the free stream flow. The fringe form and orientation analysis for the interferogarm (Fig.7) suggested that they are the result of translation displacements of one or more elements of setup, caused by vibrations. The fringes are open (they are not closed); a little waved with equal orientation.

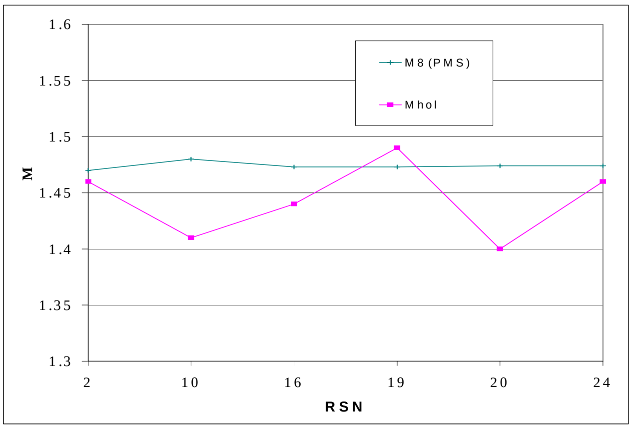

Figure 5. Determination of Mach number M_∞ by angle of shock wave

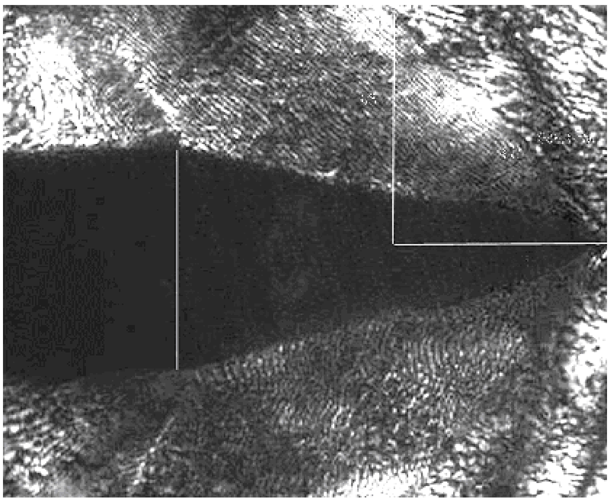

Figure 6. Interferogram of flow around model cone-cylinder with $M_\infty = 1.474$ (*RSN=20*)

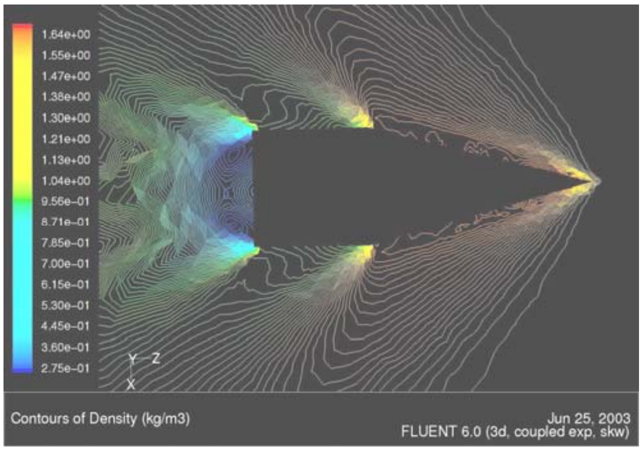

Figure 7. Theoretical simulation of isodensity lines of flow around model cone-cylinder with $M_\infty = 1.474$ (M.Zdravković [18])

The vertical and horizontal flow incidence angle in the test section is analyzed using the symmetry of left and right attached shock wave semi angle and orientation of interferometric fringes in the conical flow, recorded on holograms. This means that all the mechanical twisting of the model or model support system, model displacement and optical distortions are eliminated.

Concluding Remarks

The holographic interferometer for wind tunnel T-38 has been made with minimum investments. Part of the mechanical components were bought on the commercial market, other have been made in MTI model workshop. The components of the Schlieren system are maximally incorporated into holographic interferometer.

The holographic interferometer nowadays, is a new and significant piece of wind tunnel equipment. It can be used for transonic and supersonic flow visualization. The interferometer consists of modules. Its configuration can be easily modified according to the method used, velocity, position and tested area dimensions.

The conventional double exposure and “sandwich” techniques were employed during this experiment, to take holographic interferograms of flow in the test section. During this experiment, it was concluded that the connections between mechanical folders, walls, tables, floor, and optical elements are stable. It is not necessary to adjust components after each run. Laser and optical components adjustment is relatively easy, except coinciding the ruby and He-Ne (diode) laser beams and collimating of reference beam. Vibrations that have been registered on each part of interferometer have to be eliminated. Some modifications of interferometer are suggested [5].

The holographic interferometer performances concerning the optical field, resolution, accuracy, sensitivity of refraction index, are within the projected boundaries. Uniformity of optical interferometer field is not satisfied. Optical field is without significant aberration, because all elements are positioned in the domain of paraxial optics. The requirement for fast and easy modification of interferometer is accomplished. This interferometer may be used for other techniques: double exposition, multi passing object beam, “sandwich” method, real time method, method with parallel or diffuse object wave. It can be used for transparent or reflective object study.

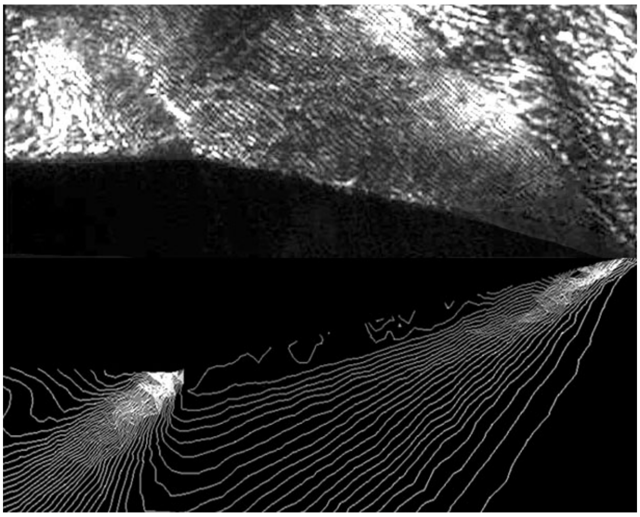

Figure 8. The composite experimental and theoretical image of flow isodensity lines

The holographic interferograms of flow around cone-cylinder model for nominal Mach number $M_\infty = 1.5$ are recorded by double exposition. The images of holographic interferograms are the bases for determining the Mach number M_∞ in free stream flow. As mentioned before, the maximum error for Mach number is 5,3% and average 2,4% (Table 2). Experimental density of flow behind the shock wave is determined with the accuracy of 2,4% in regard to theoretical, and 3,6% in regard to numerical one. Interferograms did not allow precious analysis of turbulence intensity in the free flow, because the parasitic interference, vibration and problems with quality of laser beams can not be eliminated. These problems introduced some uncertainty in Mach number determination. The aerodynamic noise and boundary layer cannot be studied using interferograms.

It can be concluded that the study of flow quality parameters by holographic interferometry has been partially made. Experimental results confirm that the combination of holographic interferometry and calibration models (cone-cylinder) is very useful for Mach number determination. They also confirm that the Mach number in the test section during runs is very close to nominal Mach number.

This experiment comprises designing, production, testing and application of new, universal holographic interferometer for visualization and study of the test section flow. The wind tunnel T-38 is equipped with a new, very powerful device for flow visualization. Behind the interferometer shortcuts, holographic interferometry can be applied for flow visualization around models of airplane and projectiles in the wind tunnel T-38.

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Ispitivanje supersoničnog strujanja u aerotunelu T-38 metodom holografske interferometije

Opisan je holografski interferometar koji je projektovan, izrađen i testiran za aerotunel T-38. Nova oprema je osnova za primenu holografske interferometrije. Ispitivanje kvaliteta strujanja u radnom delu aerotunela T-38 je prvi u seriji ispitivanja složenih strujnih polja oko različitih modela metodom holografske interferometrije. U ovom radu su prikazani eksperiment i rezultati ispitivanja primene holografske interferometrije u analizi parametara strujanja u radnom delu aerotunela. Eksperimentalni rezultati su upoređeni sa teorijskim i numeričkim rezultatima.

Ključne reči: **supersonično strujanje, aerodnamički tunel, holografska interferometrija, holografski interferometar.**

Исследование сверхзвукового потока в аэродинамической трубе Т-38 методом голографической интерферометрии

В этой работе описан голографический интерферометр, проектирован, сделан и испытыван для аэродинамической трубы Т-38. Новое оборудование представляет основу для применения голографической интерферометрии. Исследование качества потока в рабочей части аэродинамической трубы Т-38 представляет первое в серии исследований комплексных полей потока около различных моделей методом голографической интерферометрии. В этой работе показаны эксперимент и результаты исследований применения голографической интерферометрии в анализе характеристик потока в рабочей части аэродинамической трубы. Экспериментальные результаты сравниваны с теоретическими и цифровыми результатами.

Ключевые слова: сверхзвуковой поток, аэродинамическая труба, голографическая интерферометрия.

La recherche du courant supersonique dans la soufflerie T-38 à l'aide de la méthode de l'interférométrie holographique

Ce papier décrit un interféromètre projeté, réalisé et testé pour la soufflerie T-38. Le nouvel équipement sert de base à l'emploi de l'interférométrie holographique.La recherche sur la qualité du courant dans la chambre d'expérience de la soufflerie T-38 est la première d'une série de recherches des champs électriques complexes autour de divers modèles au moyen de la méthode de l'interférométrie holographique. Dans ce travail on a présenté un essai et les résultats de cet essai obtenus à l'aide de l'interférométrie holographique dans l'analyse des paramètres de courants dans la chambre d'expérience de la soufflerie.Les résultats des essais ont été comparés avec les résultats théoriques et numériques.

Mots clés: **courant supersonique, soufflerie aérodynamique, interférométrie holographique.**