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UDC 378.147

Shaping the Professional Competences of Undergraduates in Engineering Universities, Illustrated By the Investigation of Gas -Turbine Surface and Blade Via Its Axonometric Drafting

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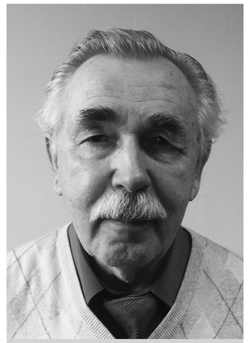

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The article describes a course example "Research-Graphic Practicum" oriented at reinforcing previous knowledge and skills in "Engineering Graphics" and further development of professional competences of undergraduates based on the illustrated investigation of the gas-turbine blade. The authors formulated assignments in designing a theoretical model and executed an axonometric draft of the gas-turbine vane.

Key words: engineering education, engineering graphics, gas-turbine blade, competences.

Introduction

One of the major requirements imposed on an engineering university graduate is professional competences. Professional competences embrace advanced knowledge level and cumulative achievement of both general professional and specialty courses. This means that in the beginning of prevocational education, a student should be able to execute theoretical models, projecting physical phenomena and understand how to apply them.

The shaping of such a competency is illustrated by the investigation of gas-turbine unit surface and blade including further axonometric drafting of the blade itself. This article describes the practical modeling of a gas turbine blade based on the gained knowledge through descriptive geometry and axonometric projection modeling rules. Surface 3-D model type based on three plotted blade plane sections was analyzed and the axonometric projection of this space blade was described. This research was conducted by undergraduates of the Power Engineering Faculty, Moscow State Technical University n.a. N. E. Bauman.

Ruled surface

Hands-on experience with ruled surfaces involves specific details of a gas turbine unit – a blade.

In this case, a ruled surface is precisely determined by 3-directional lines. Arbitrarily, there are only two directional lines. The position and configuration of the third directional line is selected so it would be within the "body" configuration itself, which, in its turn, is determined by the data of two other directional lines, i.e. two directional ruled surfaces determine the third plane.

Based on the spatial directional line configuration and position dependence a surface is derived. In this case, five types have been defined:

1. Standard surface configuration (oblique cylinder with 3 directional lines) is formed in straight-line motion involving three curvilinear directional lines (Fig. 1).
2. Double-oblique cylindroid surface is formed in straight-line motion along two directional curves, while the third is a straight line (Fig. 2).

Fig. 1. Standard surface configuration

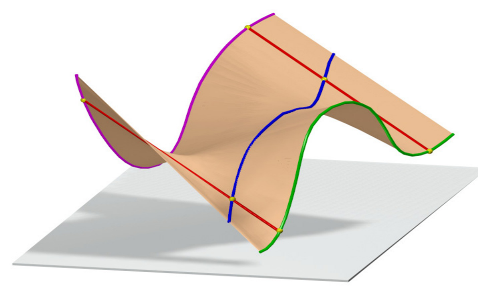
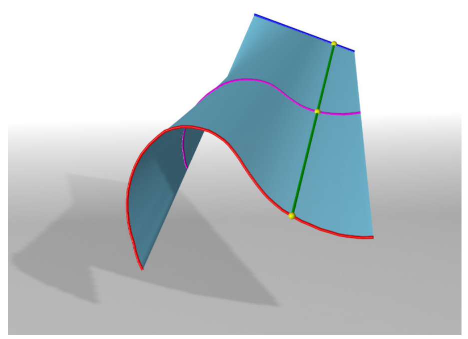
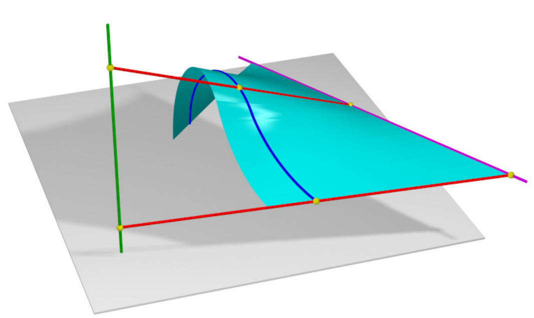


Fig. 2. Double-oblique cylindroid surface



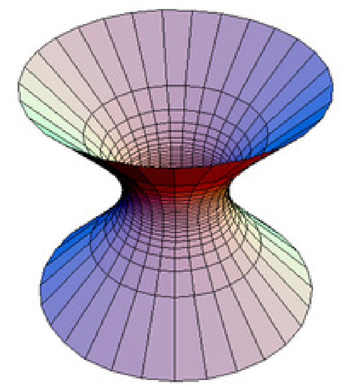
3. Double oblique conoid surface is formed in straight-line motion along the straight and curved directional lines (Fig. 3).

Fig. 3. Double-oblique conoid surface



4. Hyperboloid surface is formed in straight-line motion along three directional lines (Fig. 4).

Fig. 4. Hyperboloid surface

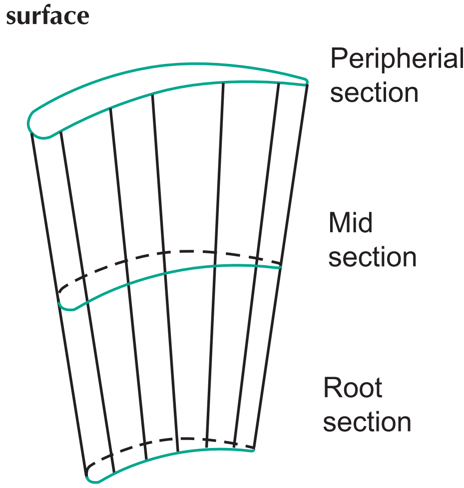


5. Ruled surface is determined by an engineering method: forming a surface intersecting corresponding points [1, p. 89-90].

Gas-turbine blade surface involves a combination of the above-described surfaces. Fig. 5 depicts a blade with limited profile surface.

Design technique of the blade channel, which is employed in engineering project course-works, provides a basis for the vane geometry itself. However, in this case, special focus is on the graphical aspects of this engineering method excluding detailed cause-effect analysis which could influence geometric parameter alternatives.

Fig. 5. Blade with limited profile surface



The major values determining the parameters of blade chord and its plane section are described in Table 1, where: b – chord rotation, mm; r_1 – entrance radius, mm; r_2 – exit radius, mm; S – chord width, mm; β_1, β_2 – angles of inlet and outlet flow, degrees; γ_1, γ_2, γ_3, γ_4 – right and tangent angles to back and pressure surface in blade entry and exit, degrees; Z – blade profile section level, mm. As an example, three actual profile versions of Z sections are illustrated: root Z = 0; midsection Z = 35 mm; peripheral Z = 70 mm.

The task procedure of 2-dimensional contour in Z – sections is illustrated in Fig. 6 and 7:

Operation 1 (Fig. 6) includes plotting graphic parameters to determine the entry and exit of blade edge centers and contact points of directional pressure surface and blade back with corresponding spherical radii;

Operation 2 (Fig. 7) includes determining tangent intersection points on the blade back and pressure side (M, N). Then grids are plotted for two square parabola, dividing the distance from points M (N) to entry and from points M (N) to exit into equal numbers of segments and further connecting conjugate points.

Profile designing should be based on a significant blockage of channel towards the exit, resulting in concentration of high velocity zones along the close-range channel itself. To check blockage of the channel, a section of the second profile is plotted at t-spacing (distance between conjugate points in given section, i.e. t = 0,8 b). Further, a circle is inscribed into the channel, centers of which are positioned on the channel median (Fig. 8).

Then the median is rectified and the line enveloping the circle is analyzed (Fig.9).

Fig. 6.

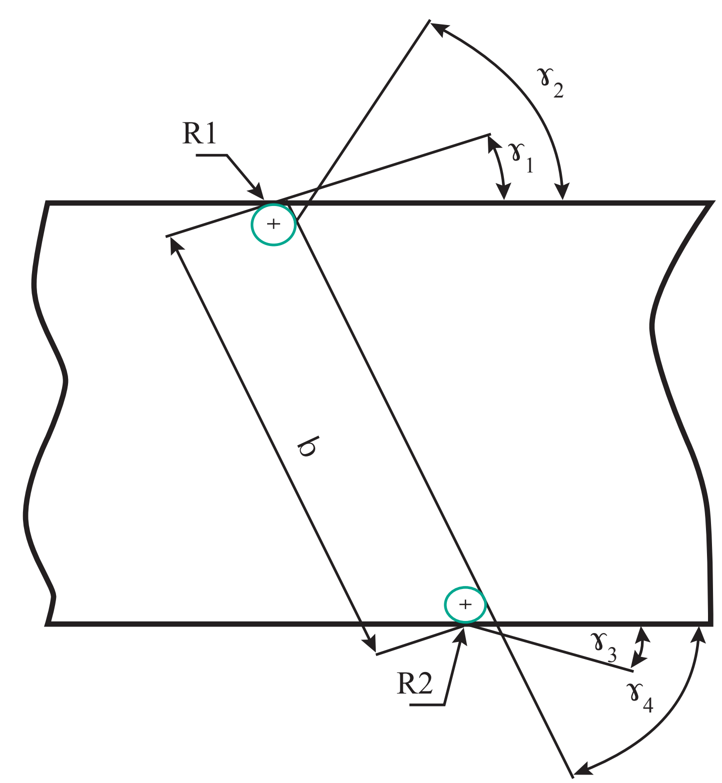


Table 1. Initial research data

Version	b	r_1	r_2	S	β_1	β_2	γ_1	γ_2	γ_3	γ_4	Z
I	26	0.37	0.23	25	35	27	22	57	22	35	0
	26	0.46	0.23	22	49	18	41	67	12	21	35
	26	0.53	0.23	19	71	23	66	76	22	25	70
II	25	0.76	0.25	24.6	31	40	28	43	32	45	0
	23	0.75	0.25	20.7	36	29	27	58	26	31	35
	26	0.55	0.25	21.6	46	21	41	59	21	21	70
III	33	0.51	0.41	31.8	47	42	34	57	34	45	0
	23	0.60	0.35	21.8	55	29	50	73	27	33	35
	34	0.37	0.27	19.9	90	27	100	96	25	29	70

Fig. 7.

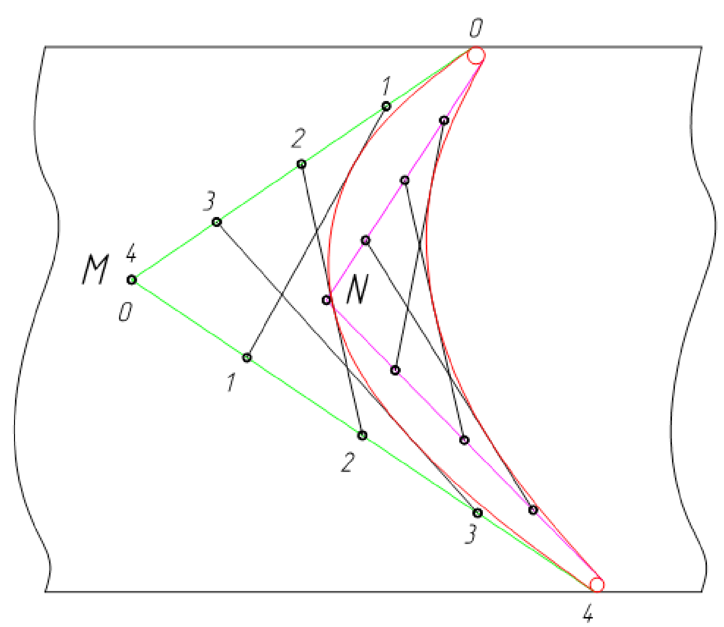


Fig. 8.

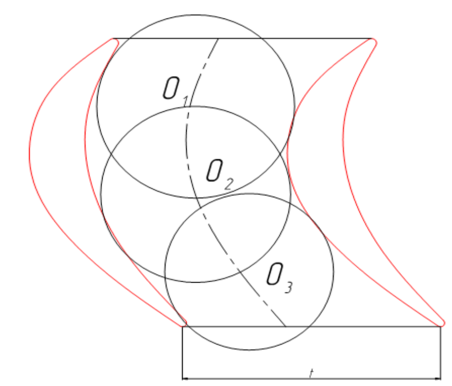
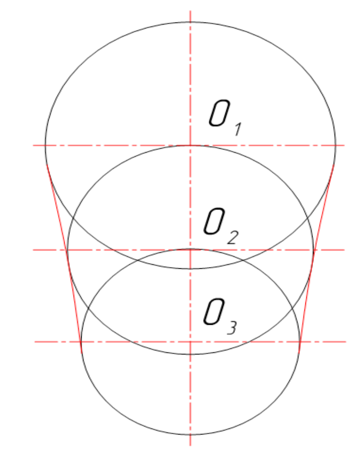


Fig. 9.



The smooth enveloping, contracting towards the exit, provides evidence of accurately selected sections.

Similarly, the surfaces on different channel sections were analyzed based on corresponding three plane sections (root, midsection, and peripheral – ref. Fig. 5). The center was determined in each of these sections. As a result of coinciding centroid section and considered angles the unit profile is a top view of operating blade nozzle (Fig.10) [2, p. 159].

Axonometric projection of a channel

It is a well-known fact that there are three basic requirements to an image: invisibility, visualization, and executive simplicity.

If it is difficult to imagine the object configuration in a complex drawing, then an axonometric drawing could be more visual, although it is rather time-consuming in execution.

Axonometric (from Greek "axon" – axis and "metric") projection-parallel projection in which an object appears to be rotated showing its all three dimensions. Axonometric projection shows how the principle axes are oriented relative to the projected surface [4, p. 169].

How to create an axonometric drawing? Let there be a point P (Fig. 11a), in space belonging to dimensional trihedral X, Y, Z with unit segments i, j, k. Plane XOY – P projection. Bond – P is coordinate axes of broken OPx P′ P called metric (broken) coordinate. P is called initial P projection.

Take plane Π^A so that it cuts all the coordinate axes and choose perpendicular S projection. On plane Π^A towards S projected coordinate axes XYZ; single scale segments i, j, k; P (initial projection and broken coordinate). Then:

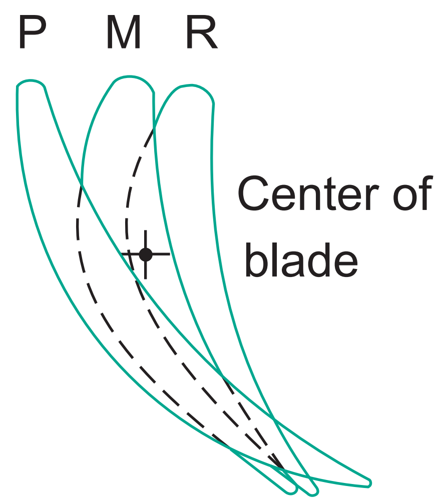
Π^A plane – axonometric projection plane;

axonometric projection of coordinate axes- axonometric axes $X^A Y^A Z^A$;

single P axonometric projection – P^A;

axonometric projection of initial

Fig. 10.



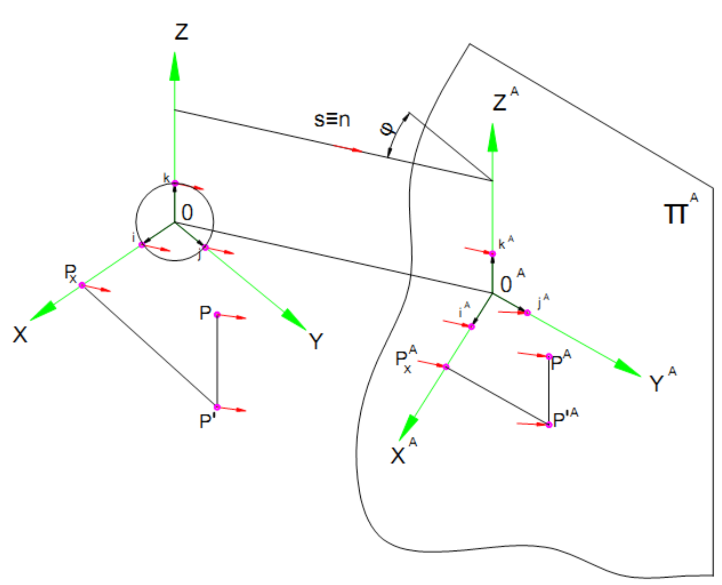
P′projection – P'^A;

axonometric projection of broken coordinates P - $O^A P^A$ x $P'^A P^A$.

All above-mentioned operations are positioned on plane π^A and create the axonometric drawing.

Relation of single scale axonometric segments to actual values is distortion factor and is expressed as:

Fig. 11a.



$u = i^A / i, \quad v = j^A / j, \quad w = k^A / k.$

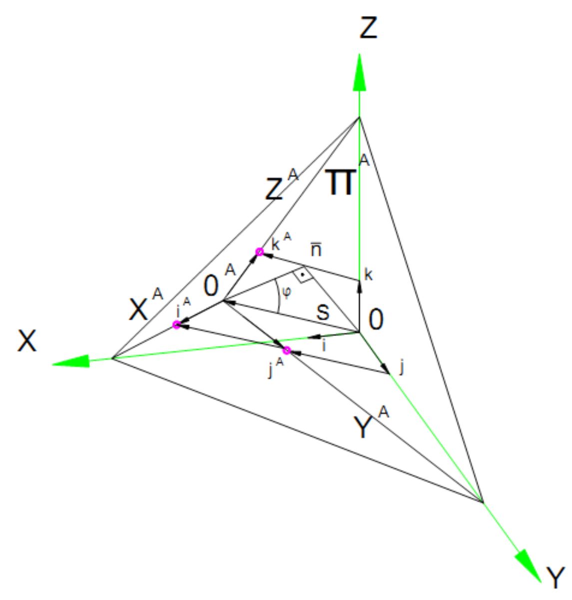
Distortion factor depends on projection direction. If angle φ is the angle between projection direction and axonometric projection plane, then we have the following dependency (Fig. 11b): $u^2 + v^2 + w^2 = 2 + ctg^2\ \varphi$.

Central projections are similar to parallel projections in that they also associate points in one set with points in another set by projection lines that pass through the associated points with the difference that the projection lines all pass through a given point. Parallel projection corresponds to a perspective projection with an infinite focal length (the distance from the image plane to the projection point).

Parallel axonometric projections are classified according to the projection direction: oblique projection – at an oblique angle, while orthographic – at a perpendicular angle ($\varphi = \pi/2$).

If each of the three axes and the lines parallel to them, respectively, have different ratios of foreshortening when projected to the plane of projection, this is trimetric projection. If two axes making equal

Fig. 11б.



angles (for example, u=v) with the plane of projection are foreshortened equally, while the third axis is foreshortened in a different ratio», this is dimetric projection. If three axes are foreshortened equally, this is isometric projection.

Orthographic axonometric projection angle $\varphi = \pi/2$ and ctg $\varphi = 0$, thus: $u^2 + v^2 + w^2 = 2$. It is obvious that in the orthographic axonometric projection neither of distortion factors can be more than 1.

In engineering only two orthographic axonometric projections are used: orthographic isometric projection and orthographic dimetric projection.

Blade channel is enclosed by the back surfaces of one blade, and the other – pressure surface; channel bottom is confined to root section, while top – peripheral section. The fixed point is the entry one on the channel axis under intake conditions. Channel root plane is plotted, then, initial point of midsection is plotted along the axis Z and 2 – dimensional channel in this section is plotted.

The same operation is executed for the peripheral section. Fig. 12 illustrates an example of an axonometric drawing of a channel.

In this case, such a configuration is the blade channel. It is enclosed to the back surface (convex profile section) and pressure section (inverted profile section). The channel bottom is enclosed by the root section, in middle-by the midsection and in top-by the peripheral section [5, p. 81].

In plotting spatial blade channel image the fixed point is a point on the channel axis under intake conditions; intersection point of axonometric axis O^A (Fig. 12).

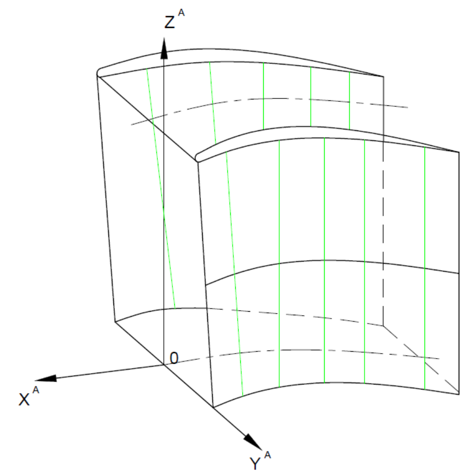
Mid profile line and spatial blade channel image is plotted for each section. Fig. 10 illustrates the mid-line in root section plane, while in Fig. 12 – one and the same line – in space.

Plotting spatial channel simplifies the problem itself, as two-dimensional lattice is being considered, i.e. a blade is on the plane. However, this does not deteriorate the relevance of this research, as the acquired skills are universal.

Conclusions

The discussed research enhances the development of undergraduate professional competences, furthers the cross-disciplinary communication in relation to modern education standards. The students are involved in research from the very first days which reveals their creativity potential. This also initiates the understanding of complex and multi-functional problems which future student-professionals will encounter in their life.

Fig. 12.



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UDC 74.584.31

Methodology of Engineering and Technical Activity Analisys for Development of Academic Content Standards

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The author addresses the issue of methodology used within the institution to modify the learning outcomes of technical education. The paper represents the methodology for manufacturing process analysis conducted to develop academic content standards for engineering education of automotive profile. The content of structural elements in the analysis of manufacturing process has been substantiated. The methodology for representing production activity parameters in the form of education standards (competences) has been suggested.

Key words: professional education standard, graduate's competence, education standards (competences), methodology, vocational training.

Introduction

The methodology of engineering and technical activities analysis is an important issue today, as the universities need to determine the competences necessary for the graduates to correspond with the requirements of the regional industries.

In Institute of Transport, State University – Education-Science-Production Complex (SU ESPC), the strategic planning of educational process is aimed at supplying the demand of the automotive industry in professionally qualified human resources. Especially important is the main objective, namely, to develop professional competences relevant to the engineering and technical staff since the university graduates usually take these positions within the first two years of their professional activities.

Both technical and technological progress in automobile service and the emergence of new enterprises (authorized distributors of well-known automotive manufacturing plants) in Orel region have caused significant changes in the regional automotive industry. As a result, the automotive industry personnel and SU ESPC academic society understand the need for changes in higher professional education system and are ready for them.

Having analyzed the employers' satisfaction with the quality of higher professional education provided at Institute of Transport, SU ESPC, it is possible to state that some professional competences of graduates, who studied at the department of "Operation of Vehicles and Production Machines and Complexes", fail to correspond with the current requirements of the automotive industry. The disagreement between the industrial needs and the professional competences is caused by the fact that the traditional system of higher professional education is characterized by the lack of the dynamic response to the current technical and technological changes occurring in the industry. In Institute of Transport, this disagreement is supposed to be overcome by setting standards for learning outcomes. These standards are based on the systemic study of engineering and technical production activities. Thus, the development of master and bachelor degree programs at the department of "Operation of Vehicles and Production Machines and Complexes" is based on the analysis of the activities