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ON THE HISTORY OF THE DEVELOPMENT OF PULSATING AIR-BREATHING JET ENGINES: A HISTORIOGRAPHICAL REVIEW

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Abstract

Background. The pulsating air-breathing jet engine (pulsejet engine) is one of the historically earliest classes of air-breathing reaction propulsion, possessing a documented development trajectory that spans more than a century. A systematic historical understanding of this trajectory is a precondition for the well-founded evaluation of present-day proposals to apply pulsejet technology in unmanned and small-scale aviation.

Aim. The article aims to analyse the historical process of pulsejet engine development, to identify key dates, organisations, individuals, and engineering decisions that shaped the technology, and to characterise the principal directions of recent research.

Materials and Methods. The study is a qualitative historiographical review based on Russian and international published sources, including journal articles, encyclopaedic entries, NASA technical memoranda, and four recent dissertations on pulsejet engine modelling and design. Sources were analysed using a chronological–thematic approach and cross-checked against existing literature.

Results. The review reconstructs the principal stages of pulsejet engine development: mid-nineteenth-century patents, German pre-war and wartime work (Schmidt, Argus As 109-014, V-1), post-war Soviet and American trials (La-9RD, P-51D with Ford PJ-31-1), the establishment of pulsejet aeromodelling records in 1949–1958, and four recent dissertation studies (Seifetdinov, Minin, Bogdanov, Borisoglebsky) addressing working-process modelling, design optimisation for unmanned aerial vehicles, and efficiency improvement.

Discussion and Conclusion. The historical record indicates that pulsejet engines have retained niche relevance because of their structural simplicity, low manufacturing cost, and tolerance for low-grade fuels. These properties remain pertinent to contemporary research on energy-efficient propulsion for small unmanned aerial vehicles, providing a justified historical and engineering basis for further investigation.

Keywords: Aircraft engines; aviation propulsion; pulsejet engine; pulsating air-breathing jet engine; history of aviation technology; unmanned aerial vehicles; propulsion systems; technological development.

1. Introduction

In contemporary engineering practice, the state of engine manufacturing has acquired strategic importance. This significance is determined by considerations of national technological sovereignty and by the broader objective of achieving full import substitution in the engine-building sector.

The development of engine manufacturing as a whole represents an evolutionary process. Examining the history of the pulsating air-breathing jet engine (hereafter pulsejet engine) makes it possible to systematise the experience accumulated in addressing the scientific and technical challenges of propulsion design, and to identify key directions for the development of next-generation pulsejet engines. Such a historical perspective serves as a productive instrument for the formation of new ideas and approaches in the modernisation and design of engines of this type.

The pulsejet engine is one of the oldest documented forms of air-breathing reaction propulsion. Its history extends from mid-nineteenth-century patents through the V-1 weapon system of the Second World War, post-war experimental aircraft, sport aeromodelling, and contemporary work on small unmanned aerial vehicles (UAVs). Despite this long history, a consolidated overview combining the early development of the technology with recent dissertation-level research has remained limited in the international literature. The present article addresses this gap on the basis of Russian-language and international sources.

1.1. Aim of the Study

The aim of the article at the present stage of the authors' research is to analyse the historical process of pulsejet engine development, to identify selected key dates in the history of pulsating air-breathing jet engines, and to highlight the engineering decisions and scientific ideas that influenced their creation and refinement. This historical analysis is intended to serve as a foundation for the next stage of the research, in which the role of historical factors in shaping current concepts and future prospects of the technology will be examined in more detail.

1.2. Research Questions

The study is guided by three research questions:

(1) What are the principal chronological stages of pulsejet engine development from the mid-nineteenth century to the present?

(2) Which engineering decisions, organisations, and individual researchers contributed most substantively to each stage?

(3) What directions are pursued in recent dissertation research, and how do they relate to contemporary applications, particularly small unmanned aerial vehicles?

The topic has been addressed in a number of recent scientific works, each of which has made a particular contribution to its examination [1, 2, 3, 4, 5, 6 and others].

2. Materials and Methods

The study is designed as a qualitative historiographical review. The methodology comprises three components: source selection, source analysis, and synthesis.

2.1. Sources

The source base consists of four categories of materials:

(4) Russian-language secondary literature on the history of pulsejet engines, in particular the consolidated review by Ivannikov, Efremov, and Belyaeva [3];

(5) Encyclopaedic and reference-type online sources on the V-1 weapon system and German rocket-weapon programmes [7, 8];

(6) Russian dissertation studies on pulsejet engine modelling, design, and efficiency improvement [1, 2, 4, 5, 6];

(7) International technical literature on pulse-detonation and air-breathing propulsion concepts, including NASA technical memoranda, conference papers, and a U.S. patent [9, 10, 11, 12].

2.2. Analytical Approach

Sources were analysed by means of a chronological–thematic procedure. In the first step, individual factual statements (dates, names of engines, organisations, persons, numerical performance figures) were extracted and tabulated. In the second step, statements were grouped into thematic clusters corresponding to identifiable historical stages: nineteenth-century patents; pre-war German work; Second World War applications; immediate post-war Soviet and American experiments; aeromodelling practice; and modern dissertation research. In the third step, each cluster was examined for internal consistency, and statements were cross-checked against more than one source where possible. Statements supported only by a single secondary source are explicitly attributed to that source in the text.

2.3. Limitations

The study has three explicit limitations. First, the source base relies predominantly on secondary Russian-language literature, and primary archival materials (for example, original Argus, Fieseler, OKB-301, or Ford engineering drawings and reports) were not consulted. Second, several biographical and performance details, particularly those relating to aeromodelling records of the 1950s, could not be independently verified against primary records and are reproduced from the cited secondary source. Third, the discussion of recent dissertations is based on the dissertations' own published abstracts and full texts, not on independent technical replication of their results. These limitations are reflected in the editorial verification flags placed in the body of the article.

3. Results

3.1. Origins: Nineteenth-Century Patents

According to Ivannikov et al. [3], the origins of the pulsejet engine are dated to the mid-nineteenth century. The first patents related to a pulsating air-breathing jet engine were granted in the 1860s to Charles de Louvrié in France and to Nikolay Afanasyevich Teleshov in Russia [3]. These early proposals laid a conceptual foundation that would not be implemented in practical form until the following century.

3.2. Pre-war and Wartime Development in Germany

On the eve of the Second World War, Germany was regarded as one of the international leaders in the development of pulsejet engines. As early as 1931, the engineer Paul Schmidt designed an efficient pulsejet configuration based on a modification of intake valves. In 1939, the Reichsluftfahrtministerium (RLM) involved a number of German aero-engine manufacturers in jet-engine development; the Argus Motoren Gesellschaft was assigned work on pulsejet technology. Argus based its development on Schmidt's earlier work, and Schmidt himself was subsequently brought into the Argus design effort. The resulting refined pulsejet engine received the official designation Argus As 109-014 [7].

The first major German achievement employing pulsejet propulsion was the V-1 flying bomb. The V-1 was equipped with a pulsating air-breathing jet engine and carried a warhead with a mass on the order of 750 kg to 1,000 kg. According to the cited sources, its operational range reached approximately 250 km, and in some sources up to 400 km; the overall length is reported as 7.75 m, and the wingspan as approximately 5.3–5.7 m [8]. The V-series projects (V-1, V-2) were associated with the work of Wernher von Braun [Author verification required: in the standard historical literature, von Braun's direct leadership is firmly established for the V-2 (A-4) ballistic missile programme at Peenemünde; the V-1 was developed primarily at Fieseler, with Argus and Askania involvement].

In 1941, the design of the V-1 flying bomb (German: Vergeltungswaffe-1) was completed. In the V-1 configuration, the engine was mounted above the warhead and the fuselage. Serial production of the missile began in 1942.

According to Ivannikov et al. [3], Robert Lusser, a leading designer at Heinkel and subsequently at Fieseler [Author verification required: Lusser's affiliation at the time of his work on the V-1 is more commonly given as Fieseler], simplified the V-1 layout and equipped it with a single pulsejet engine in place of the two engines envisaged in earlier configurations. Serial production of the engine in the V-1 missile began at the end of 1942 on the island of Usedom in the Baltic Sea, opposite the mouth of the Oder River. Because of the simplicity of the design and the correspondingly low manufacturing labour cost—which was acceptable given the mass production of single-use weapons—more than ten thousand units were produced in less than a year, between June 1944 and March 1945 [3, p. 133].

3.3. Post-war Experimental Aircraft Programmes

After the Second World War, research on pulsejet engines became international in scope. Studies in this area intensified in a number of leading countries, including Germany, France (the SNECMA company), the United States (Pratt & Whitney, General Electric), and the Soviet Union.

In the immediate post-war period, in 1946, an experimental aircraft based on the La-9 fighter was developed in the Soviet Union. The work was carried out at OKB-301 in Khimki, under the leadership of S. A. Lavochkin [3]. Mounting two pulsating air-breathing jet engines beneath the wings of an existing piston-engined airframe proved to be a complex engineering task. As noted in [3], even without modifications to the pulsejet engines themselves, the conversion required changes to the fuel supply system, reinforcement of the airframe structure, the design of engine mounting hardware, and a reduction in airframe mass through the removal of armour plates and two NS-23 cannons [3, p. 134].

These structural modifications adversely affected the take-off, landing, and manoeuvring characteristics of the aircraft, substantially reduced its endurance, and complicated its overall operation. As the cited source observes, the gain in speed achieved through this modification amounted to only approximately 70 km/h [3, p. 134]. The configuration was nevertheless useful for the in-flight testing of ramjet-type and pulsating engines and was demonstrated at public aviation displays. The aviation parade held at Tushino in 1947, at which nine La-9RD aircraft performed a fly-past, is identified in [3] as a culminating demonstration of pulsejet engines of the V-1 type adapted for Soviet use.

The United States also conducted active testing of pulsating air-breathing jet engines during this period. A number of surplus piston-engined airframes remaining after the war provided convenient platforms for such trials. In 1946, an experimental project was implemented in which two Ford PJ-31-1 pulsejet engines were suspended beneath the wings of a P-51D Mustang fighter [cited after 3]. American engineers encountered difficulties of essentially the same nature as those documented in the Soviet experience. It became evident that pulsejet engines required substantial further development, but post-war resource constraints limited the scale of such work.

3.4. Pulsejet Engines in Aeromodelling

During the late 1940s and 1950s, pulsejet engines found their principal application in aeromodelling rather than in manned aviation. Their simple design, low manufacturing cost, and tolerance for inexpensive fuels made them an attractive choice for model aircraft and for experimental work by amateur designers [3].

By 1948, reliable designs of aeromodelling pulsejet engines had been developed, and in 1949 the first records were set by model aircraft powered by such engines [cited after 3]. A model designed by M. Sharov and powered by an engine designed by A. Anisimov reached a speed of 110 km/h. In 1950, two further All-Union records were established—one for flight duration and one for distance—using a model designed by R. Sadovsky and

V. Popel with an engine designed by V. Davydov (Leningrad); this model covered 3,000 metres and remained airborne for 14 minutes and 15 seconds. In 1951, the pulsejet engine designed by A. Anisimov was again used, this time in a model designed by E. Smirnov (Leningrad), which is reported to have covered 16 km, remained airborne for 31 minutes, and reached an altitude of 600 metres [3].
In 1953, a control-line model of flying-wing configuration designed by M. Vasilchenko (Moscow) reached a speed of 264.776 km/h, which is reported as an absolute world record for its class. Subsequently, the master of sports I. Ivannikov is credited with establishing further world speed records of 275.004 km/h in 1955 at international competitions in Czechoslovakia, and 301 km/h in 1958 [3]. [Author verification required: the names and dates of these aeromodelling records, including the apparent recurrence of the surname Ivannikov in both the cited modern source [3] and as the recordholder, should be confirmed against primary Soviet aeromodelling records.]

3.5. Recent Dissertation Research

The early twenty-first century has seen a noticeable increase not only in journal publications addressing pulsejet engines [3 and others] and in monograph-length studies [5 and others] but also in the appearance of dissertation research of considerable interest [1, 2, 4, 6 and others]. Four of these dissertations are summarised below.

3.5.1. R. B. Seifetdinov: Modelling of the Working Process

The research of R. B. Seifetdinov [5, 6] provides one of the most complete treatments of the known performance characteristics of pulsejet engines and of the methods used to model the processes that occur during their operation. The author also examines pulsejet engines in the context of unmanned aviation applications and articulates the task of developing new, efficient, technologically robust, and reliable pulsating air-breathing jet engines. The author's published work describes the mechanisms of the working process, offers a detailed analysis of the principal existing modelling methods, and outlines their respective advantages, disadvantages, and ranges of applicability. With regard to modelling, classifications are proposed for in-chamber processes, structural configurations, fuel-supply schemes, and overall computational approaches. Selected features of the working process are investigated numerically, and a modelling procedure based on the inverse method of characteristics is proposed [for further detail, see 5, 6].

3.5.2. N. V. Minin: Combined Pulsejet Engines for Small UAVs

The dissertation of N. V. Minin [4] takes as its object of investigation a combined pulsating air-breathing jet engine with a thrust in the range of 50–70 N. The author develops procedures for determining optimal design parameters for the design and construction of combined pulsejet engines intended for small-sized unmanned aerial vehicles (UAVs) [4]. The proposed procedures address the parameters of the combined pulsejet engine as a propulsion system for a small UAV, the calculation of optimal parameters for the cooling of internal heat-loaded units by means of fuel-mixture purging, and design variants of the propulsion system [4]. The author further substantiates a method for increasing the propulsive efficiency of the pulsejet engine through the addition of secondary mass in an ejector thrust augmenter. The developed methodology makes it possible to consider an unconventionally configured combined pulsejet engine as a candidate propulsion system for UAVs of up to 50 kg in mass, and to determine the optimal parameters of the purging process, the permissible piston velocity, the geometric dimensions of the installation and its components, and the thrust at various flight altitudes [4].

3.5.3. V. I. Bogdanov: Efficiency Improvement and Constant-Volume Combustion

In the doctoral dissertation "Improving the Efficiency of Pulsating Jet Engines" [1], V. I. Bogdanov addressed the following principal research tasks:

(8) refinement of the conditions under which the thermodynamic advantages of a cycle with heat addition at constant volume can be efficiently realised;

(9) the development and study, both on an experimental installation and by means of a physical–mathematical model, of a high-frequency constant-volume combustion chamber equipped with a self-rotating valve of simple design and high throughput;

(10) the conduct of investigations aimed at improving the efficiency of the expansion process through new design solutions, and at improving propulsive efficiency through refinement of the process of attaching secondary mass (i.e., reducing losses in mass interaction under optimal parameters of the working pulsations);

(11) conceptual and structural elaboration, together with calculation-based investigation, of engines based on the constant-volume rotary-valve combustion chamber and on the obtained research results [1].

The results of this work were applied at JSC "NPO Saturn" (Rybinsk) in the creation of an experimental pulsejet engine, and at JSC "ADS" (Zavolzhye) in the development of an external combustion chamber for a prospective multi-fuel internal combustion engine.

3.5.4. A. V. Borisoglebsky: Mathematical Modelling of Unsteady Gas-Dynamic Processes

The dissertation research of A. V. Borisoglebsky, entitled "A Mathematical Model of the Pulsating Air-Breathing Jet Engine" [2], aimed to develop a mathematical model of the unsteady gas-dynamic processes in a pulsating air-breathing jet engine, with a discrepancy between calculated and experimental parameters of less than 35%. The author developed a procedure for describing the unsteady gas-dynamic processes in pulsejet engines, based on integration of the original equation of motion for a small control volume. The procedure makes it possible to perform numerical experiments, to estimate the variation of gas-dynamic parameters during the unsteady operation of the pulsejet engine, and to evaluate engine characteristics without first conducting full physical experiments.

4. Discussion

4.1. Continuity of Engineering Constraints across Historical Periods

The results presented in Section 3 reveal that the principal engineering constraints associated with pulsejet engines have been remarkably consistent across more than a century of development. The German wartime, Soviet post-war, and American post-war programmes all encountered the same core trade-off: the structural simplicity and low manufacturing cost that make pulsejet engines attractive are accompanied by limited thermodynamic efficiency, high noise and vibration, and integration difficulties when retrofitted onto airframes designed for other powerplants. The minimal speed gain (approximately 70 km/h) reported for the La-9RD in [3], and the parallel difficulties encountered with the P-51D / Ford PJ-31-1 combination, illustrate that the limitations of pulsejet propulsion in manned aviation became evident in two independent technological contexts.

4.2. The Niche Established in Aeromodelling and Its Implications

The aeromodelling history of the 1949–1958 period is significant beyond its immediate sporting interest. It demonstrated that, at small scales, the disadvantages of pulsejet engines became less restrictive while their advantages—simplicity, low cost, and fuel tolerance—were preserved. This scaling effect is consistent with the application focus of recent dissertation research, in particular the work of Minin [4], which targets the same small-scale regime in the form of UAVs up to 50 kg.

4.3. Convergence of Recent Research Directions

Although the four dissertations reviewed in Section 3.5 address different problems—working-process modelling [5, 6], UAV propulsion system design [4], efficiency improvement through constant-volume combustion [1], and unsteady gas-dynamic modelling [2]—they converge on a common underlying programme. Each addresses one of the historical weaknesses of pulsejet engines: predictability of operation (modelling), suitability for a defined application (small UAVs), thermodynamic efficiency, and design-stage performance evaluation without expensive physical prototyping. Together, these directions describe an engineering response to the historical limitations identified in Section 4.1.

4.4. Relevance to Contemporary Propulsion Engineering

The historical record suggests that pulsejet engines retain relevance not as a universal propulsion solution but as a specific technological option whose attributes match the requirements of certain application domains. Small unmanned aerial vehicles, expendable or low-cost systems, and research platforms for unsteady combustion and pulse-detonation propulsion are among the application areas most consistent with the historical and recent evidence reviewed here. The connection to broader topics in energy-efficient propulsion and technological modernisation in aviation is grounded in this specific engineering profile rather than in a general claim of pulsejet superiority.

4.5. Limitations of the Present Review

As noted in Section 2.3, the review relies on secondary sources for several biographical and performance details, and primary archival materials were not consulted. Editorial verification flags have been placed at points where claims could not be independently confirmed against authoritative literature, particularly the leadership of the V-1 programme, the institutional affiliation of Robert Lusser at the time of his V-1 work, and the aeromodelling records of the 1950s. These flags are intended to delimit the historiographical confidence of the present review and to indicate directions for the further archival study envisaged by the authors.

5. Conclusion

The pulsating air-breathing jet engine possesses a well-defined history that extends from mid-nineteenth-century patents, through wartime and immediate post-war applications, to a sustained tradition of aeromodelling and a body of recent dissertation research. The international experience accumulated in the development of these engines—across the work of designers, research institutes, and individual researchers in several countries—offers a substantial basis for further investigation.

Three principal conclusions follow from the review. First, the engineering constraints of pulsejet propulsion have proved remarkably stable across different national programmes and historical periods, indicating that any future application of the technology must be evaluated against this consistent profile. Second, the technology has demonstrated robust applicability at small scales, as evidenced by both the aeromodelling tradition and the recent UAV-oriented dissertation research. Third, recent Russian dissertation research forms a coherent programme directed at the principal historical weaknesses of pulsejet engines—predictability, efficiency, and design-stage analysis.

On the basis of these conclusions, the authors envisage continuing the investigation by integrating the historical findings reported here with the further engineering analysis of pulsejet technology in unmanned aerial vehicle and energy-efficient propulsion applications. The investigation is ongoing.

References

1. Bogdanov, V. I. Povyshenie effektivnosti pulsiruyushchikh reaktivnykh dvigateley [Improving the Efficiency of Pulsating Jet Engines]. Doctoral dissertation (Candidate of Technical Sciences specialty 05.07.05, "Thermal and Electric Rocket Engines and Power Plants of Aircraft"). Moscow, 2003, 293 p. EDN: UIMPZT.
2. Borisoglebsky, A. V. Matematicheskaya model pulsiruyushchego vozdushno-reaktivnogo dvigatelya [A Mathematical Model of the Pulsating Air-Breathing Jet

Journal Zone Publishing, Ilford, United Kingdom

Engine]. PhD dissertation abstract (Candidate of Technical Sciences specialty 05.07.05). Kazan, 2008, 14 p. EDN: NKQSQB.

3. Ivannikov, N. M., Efremov, A. V., and Belyaeva, A. S. Pulsiruyushchiy vozdushno-reaktivnyy dvigatel. Istoriya sozdaniya i perspektivy [The Pulsating Air-Breathing Jet Engine: History of Development and Prospects]. In: Nauchnye mezhdistsiplinarnye issledovaniya: Proceedings of the XIV International Scientific and Practical Conference, Saratov, 20 May 2021. Moscow: KDU, Dobrosvet, 2021, pp. 132–135. EDN: DKXSSL.
4. Minin, N. V. Metodika vybora proektnykh parametrov kombinirovannogo pulsiruyushchego VRD so svobodnoporshnevym nagnetatelem dlya malorazmernykh BPLA [Methodology for Selecting Design Parameters of a Combined Pulsating Air-Breathing Jet Engine with a Free-Piston Supercharger for Small Unmanned Aerial Vehicles]. Candidate of Technical Sciences dissertation (specialty 05.07.05), 2017, 136 p. EDN: JEXMMI.
5. Seifetdinov, R. B. Rabochiy protsess pulsiruyushchikh vozdushno-reaktivnykh dvigateley [The Working Process of Pulsating Air-Breathing Jet Engines]. Saarbrücken: LAP LAMBERT Academic Publishing, 2011, 132 p. ISBN-10: 3845410184. [Source verification recommended: the ISBN as printed in the original ("384541018") appears to be incomplete; the standard ISBN-10 format requires 10 digits.]
6. Seifetdinov, R. B. Razrabotka metodov modelirovaniya rabochego protsessa pulsiruyushchego vozdushno-reaktivnogo dvigatelya s aerodinamicheskim klapanom [Development of Methods for Modelling the Working Process of a Pulsating Air-Breathing Jet Engine with an Aerodynamic Valve]. PhD dissertation abstract (Candidate of Technical Sciences specialty 05.07.05). Samara, 2008, 16 p. EDN: NKOIDB.
7. V-1 (krylataya raketa) [V-1 (cruise missile)]. In: Bolshaya Rossiyskaya entsiklopediya [Great Russian Encyclopedia] [Online resource], 2024. Available at: https://bigenc.ru/c/fau-1-krylataia-raketa-7c7c9f (accessed 10 October 2025).
8. Raketnoe oruzhie Tretego reykha [Rocket weapons of the Third Reich]. Available at: https://cyclowiki.org/wiki/Ракетное_оружие_Третьего_рейха (accessed 10 October 2025). [Source verification recommended: cyclowiki is a non-peer-reviewed online resource; replacement with a peer-reviewed historical source is advisable.]
9. Whitlow, W., Jr., Blech, R. A., and Blankson, I. M. Innovative Air-Breathing Propulsion Concepts for Access to Space. NASA/TM-2001-210564, 2001, 14 p.
10. Wintenberger, E., and Shepherd, J. E. A Model for the Performance of Air-Breathing Pulse Detonation Engines. Pasadena, CA: Graduate Aeronautical Laboratories, California Institute of Technology, 2003.
11. Pegg, R. J., Couch, B. D., and Hunter, L. G. Pulse Detonation Engine Air Induction System Analysis. NASA-AIAA-96-2918, 1996, 16 p.

12. Hunter, L. G., and Winfree, D. D. Pulse Detonation Engine. U.S. Patent No. 5,345,758, 1994.

[Editorial note for the authors: the main body of the article cites references up to [24]; however, the bibliographic list provided in the original manuscript ends at item [12]. The authors are kindly requested to supply the missing references (13–24) or to revise the in-text citations accordingly.]