Философия науки и техники
2022. Т. 27. № 2. С. 85–99
УДК 62.05

Philosophy of Science and Technology
2022, vol. 27, no. 2, pp. 85–99
DOI: 10.21146/2413-9084-2022-27-2-85-99

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The emergence and self-definition of philosophy of engineering

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Despite the role engineers initially played in the foundation of philosophy of technology, it took more than a century for engineering practice to become a legitimate special subject of philosophical inquiry. At the turn of the XX–XXI centuries philosophy of engineering has been emerging as a subfield in parallel in different regions (China, Europe, the USA), gradually demarcating itself from philosophy of science and technology, and positioning itself in relation to STS. The overview highlights the turning points of these developments: formation of the research programs and communities. It is argued that the emergence of philosophy of engineering is a result of a growing empirical orientation and ethical problematization in philosophy and the social studies of science and technology. In the engineered sociotechnical world, both descriptive and normative research of engineering practices is required for responsibilization of technological action. An empirically informed philosophical study of engineering includes the ontological, epistemological, and ethical aspects of engineering activity, overcoming the opposition of its context and content. Engineering is a specifically modern form of action in the world and at the same time can contribute to philosophical anthropology and the theory of human creativity. Institutionalization of philosophy of engineering becomes possible when (and where) a coalition of the interested actors has been formed, including the professional associations of engineering, academy, and policymakers. The overview concludes with deliberations on perspectives of the field in Russia, where a significant corpus of studies of engineering has been accumulated – yet, philosophy of engineering is not institutionalized, and remains an exotic label.

Keywords: philosophy of engineering, engineering ethics, engineering studies, STS

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Institutionalization of philosophy of engineering as a special subfield of philosophical inquiry started recently, which might seem strange in the light of history of philosophy of technology, which at its early stage was dominated by engineers: F. Reuleaux, E. Hartig, A. Riedler, M. Eyth, A. du Bois-Reymond, P. Engelmeier, and others. The growth of the professional reflexivity in the late XIX century, characterized as "engineering perspective" [Rapp, 1981], or "engineering philosophy of technology" [Mitcham, 1994], was a response to the processes of academization, occupational closure, and specialization of engineering sciences. On the other hand, this stage of formation of philosophy of technology as an independent branch of philosophical inquiry, written from the point of view of the new technocratic elite (or those inspired by it like E. Kapp and A. Espinas, who were not engineers themselves) may be understood as a self-reflection of the industrializing societies: their need to define the criteria, regularities, and consequences of the scientific and technological development, the transformations of sociality, material culture and ways of living in a human-made world. The epistemological distinctions between engineering and science, as well as the ethical problems of responsibility, were articulated then and became the cross-cutting topics in philosophy of technology and engineering. Characteristic for this period was identification of the technical activity with human activity in general, emphasizing its creative and emancipatory potential [Ibid.]. Be it called "praxeology" by Espinas [1897], or "activism" by Engelmeier [1898], philosophy of technology was meant to grow into philosophico-anthropological theory.

This intellectual movement received institutional support from the engineering societies, striving to define their social status in the professional stratification and in relation to the older political, economic, and cultural elites and educated groups. P. Engelmeyer advocated philosophy of technology as a basis of humanitarian education in the Russian Technical Society, Polytechnic Society, and other associations, technical universities, and their journals in Russia and Germany. A remarkable example of cultivating the professional identity was the philosophical and humanitarian discourse that unfolded in the 1920s in "Technik and Kultur" – the journal of the German Association of Engineers with University Degrees (VDDI), the elitist version of the more inclusive Association of German Engineers (VDI) [Voskuhl, 2016]. Lead by G. Weihe, the journal not only linked the philosophical legacies to the contemporary problems of engineering knowledge and practice, but also grounded professionalism in the philosophy of history and culture. Apart from P. Engelmeyer's [1928], C. Weihe published the works of E. Zschimmer [1922], F. Dessauer [1924], and other philosophizing engineers, and himself actively opposed the technological pessimism or alarmism of "thinkers and poets" (e.g., O. Spengler) [Herf, 1985]. This allowed to spiritualize technology by drawing on the earlier intellectual traditions – German Idealism, Romanticism, or "Lebensphilosophie".

After the Second World War, VDI created a new platform for collaboration between philosophers and engineers, first organized as a group "Mensch und Technik" (Human and Technology) in 1956 and later a committee "Der Ingenieur in Beruf und Gesellschaft" (The Engineer in Profession and Society), with a subcommittee for philosophy, focused mainly on engineering ethics. Having inherited the classical agenda of philosophy of technology – its "essence", conceptual history, and philosophical anthropology – they soon established a more socially and politically oriented research program. The group was characterized by theoretical pluralism, from the influences of Dessauer to the Marxist critique. However, it became a community of practice while elaborating methodological principles for Technology Assessment following the establishment of an Office of Technology Assessment (OTA) in the USA. From 1976, this community included philosophers (G. Ropohl, F. Rapp, A. Huning, H. Holz, E. Oldemeyer, H. Sachsse, H. Poser) and scientific supervisors (B. Mack, W. König, M. Mai, V. Brennecke); they organized systematic lectures and discussions with the representatives of the industry, policy-makers, and other sectors of VDI [König, 2021]. In contrast to the techno-pessimistic mindset of the "humanitarian" and critical philosophers of late industrialism (M. Heidegger, J. Ellul, L. Mumford, Frankfurt School), the community developed a more pragmatic framework for the social integration of technologies, recognizing the mutual reinforcement of technology and economy. Their approach focused on the sociological analysis and ethical reasoning on needs and values, which helped operationalizing the responsibility of engineers and other actors [Huning, Mitcham, 1993; Ropohl, 1996]. The VDI Guideline 3780 was published in 1990, providing the conceptual basis for TA. Despite its recommendatory nature, and the fact that the level of inclusiveness and engagement of the stakeholders varies in the existing forms of TA [Grunwald, 2018], the Guideline has set the standard for a pro-active approach to the effects of technological innovations and reflection on risks beyond the technical and economic evaluations.

In his "Analytical Philosophy of Technology" F. Rapp argued that with the complexity of the modern sociotechnical world, a metaphysical interpretation can only be possible "after having analyzed the philosophically relevant traits of the historical development and the empirically given systematic features of technology" [Rapp, 1981, p. xii]. At the same time when German philosophers and engineers turned to the practical expertise of socio-technical issues, parallel developments occurred in the USA, later summarized by the Dutch scholars as "an empirical turn in philosophy of technology" [Achterhuis, 2001]. It may be suggested that for American philosophy of technology, influenced by pragmatism and social constructivism (T. Kuhn), it was even easier to separate from the «classical» (mostly continental) ontologists and critics of technology (M. Heidegger, J. Ortega y Gasset, L. Mumford, J. Ellul, H. Marcuse, H. Arendt, H. Jonas), traumatized by the industrial consumerism, alienation, and warfare. In contrast to the "classics", the "empirically oriented" philosophers of technology (A. Borgmann, H. Dreyfus, A. Feenberg, D. Haraway, D. Ihde, L. Winner), were more relativist and cautious in ethical judgments, disentangling the concrete constellations of actors and technologies in their immediate social context and in the processes of design, implementation, and routinization. Logically, it implied empirical research on engineering practices. The empirical orientation of philosophy of technology, supported by H. Achterhius, P. Kroes, A. Meijers, and their colleagues in the Netherlands, led to formation of a research program in the next decades with a special focus on engineering, under the name "Dual Nature of Technical Artefacts" [Kroes, Meijers, 2002]. The guiding principle of the program is the conjoint conceptualization of the structural (physical, material) and the functional (intentional, normative) descriptions of the technical objects as they are being shaped in engineering design. The program had an immense influence in the Dutch technical universities and has been developed internationally [Kroes, Meijers (eds), 2001; Franssen et al. (eds), 2016].

While philosophy of technology was looking closer at the engineering practices, another problem was to legitimate knowledge-production in engineering as a special subject of study, that could be separated from, but also contribute to the well-established philosophy of science. Since the debate between M. Bunge and J. Agassi in the 1960s [Bunge, 1966; Agassi, 1966], equating of technology with applied science was questionable; however, engineering systematically fell into the gap between the two. The "Critical Perspectives on Nonacademic Science and Engineering" [Durbin (ed.), 1991] reflected this demarcation problem in the early 1990s. There were actually two sides to the problem: on the one hand, to elaborate on the peculiarities of engineering epistemology compared with natural sciences (the methods of idealization, modeling, approximation; the standards of experimentation, quantification, and visualization; systems thinking, prediction and risk assessment, etc.); on the other hand, to explore the other elements of engineering activity beyond engineering knowledge [Blockley, 1980; Koen, 1985; Vincenti, 1990; Durbin (ed.), 1991]. The process of formalization and the role of personal, tacit, or embodied knowledge became an issue with the rapid computerization of engineering design – the trust in and limitations of algorithmizing were problematic both for management and education [Ferguson, 1992]. At the same time, with the coming of "technoscience", engineering became visible in the philosophy and history of science and supplied more fuel for internalist-externalist and realist-constructivist debate. As Goldman suggested, with the revaluation of objectivity, "philosophy of engineering should be the paradigm for philosophy of science, rather than the reverse" [Goldman, 1990, p. 140]. Still, the critique of science as a context- or value-free production of knowledge left open the question of the difference between scientific and engineering rationality and ethos.

Two related fields of research were accelerating in the late XX century: Engineering Ethics and Engineering Studies. In parallel with the socio-ethical expertise of VDI in Germany, engineering ethics was booming in the USA, where the century-long debate within professional engineering societies, starting in the 1910s with the early ethical codes of the American Institute of Electrical Engineers (now IEEE), American Society for Civil Engineers (ASCE), and American Society of Mechanical Engineers (ASME), culminated in the educational Criteria of the Accreditation Board for Engineering and Technology (ABET) in 2000. Preoccupation with ethical codes may be seen as a peculiarity of history of professionalization – while in the more etatist modernization models even the non-military engineering was self-legitimated as a service for the state (Russia) and through an elitist education (France) – American engineering societies were keeping up in their social prestige with the other groups of trained practitioners (lawyers and physicians) [Layton, 1986; Mitcham, 2019]. The ethical codes had to balance corporate loyalty, professional solidarity, and public recognition, and gradually extended from the imperative of obedience to commitments to public welfare, safety, health, and social and ecological responsibility. ABET's requirement of responsible engineering had an international impact, and at the same time stimulated a boom of publications on methodological issues, e.g., limitations of the ethical codes as such; applicability of the traditional ethical approaches for engineering, micro- and macroethics, multiculturalism, relationships with social sciences, etc. [Davis (ed.), 2005; Mitcham, Englehardt, 2019; Kazakova, 2020; Martin, Conlon, Bowe, 2021]. The European standards of EUR-ACE include reflection on ethical and social issues, but also do not specify the forms and methods for training. On the other side, in Europe engineering ethics research evolves within a wider field of ethics of technology, intersecting with TA and Responsible Research and Innovation (RRI) [Ribeiro, Smith, Miller, 2017].

The cases from the textbooks on engineering ethics often focus on disaster analysis and articulated sociotechnical conflicts. However, engineering studies strive for "unblackboxing" not only the renowned or politically problematic projects but also the "normal" engineering practices and routines. A large corpus of research was accumulated by the end of the XX century, which allowed to speak of engineering studies as a subfield of STS with a focus "on the case studies of life on the constructed social boundaries between science and society and between labor and capital" [Downey, Lucena, 1994, p. 167]. The boundaries of the subfield itself were quite wide: it inherited the long-established research in sociology and history of the engineering profession and education [Noble, 1979; Glover, Kelly, 1987; Gispen, 1988], and, in line with the general trend in STS, turned to the ethnographies of the communities of practice [Downey, 1998; Vinck (ed.), 2003], as well as different forms of critical participation. Positioning engineering studies within STS is ambivalent: on the one hand, there has been a consistent effort to explore "heterogeneous engineering" [Law, 1987], that is, the engineering activities of non-engineers and their coalitions; on the other hand, engineers retain a special position among these actors having their "sociology" [Law, Callon, 1988] and "politics" [Winner, 1990] reified in the design of artifacts. The shift from predominantly macrosocial (Marxist or Weberian) study of engineers in the class structure, expert systems, and industrial bureaucracies, to their "laboratory life", microcultures and communication in the last decades reflects the aspiration to overcome the division between the social context and the content, and examine "the interrelations among knowledge and power" in engineering [Downey, Lucena, 1994]. With this orientation, engineering studies can be seen as containing philosophical inquiry, or as an empirical source for it, as long as they touch upon the ontological (the "object worlds" of engineers, including material culture and symbolic systems) [Bucciarelli, 1994], the epistemological (knowledge production process and thinking styles) [Petroski, 1992], or ethical problems (professional ethos and values, worldview and volition) [Florman, 1996].

In parallel and in exchange with the Western studies, the developments that took place in "dialectics of nature" and STS in China led to formation of a research program of "philosophy of gongcheng", which has a few characteristic traits. Firstly, the semantics of "gongcheng" does not completely coincide with that of "engineering", for which it was used somewhat contingently: etymologically, it is related to the notions of artisanry and rule, or measurement, and was applied to the large civil projects – without the military connotation of the early modern engineering in the West [Zhu, 2010]. The notion of gongcheng highlights its collective nature as a complex of social activities that include both technical and non-technical factors, and more than an application of natural sciences. Secondly, it is argued that the philosophical tradition in China – e.g., the Confucian rules of social action – was more interested in the "real-world problems" in comparison to the metaphysical Antiquity and the science-centered modern philosophy, and paid attention to individual technologies. In PRC, the Marxist "philosophy of jishu" (philosophy of technology) was grounded in interdisciplinary research of labor and production before the "empirical turn" in the West [Yin, 2021]. Moreover, the engineers-philosophers (e.g. Liu Zeyuan) actively implemented dialectics of nature in engineering practices and education, with respect to both epistemology and social reasoning, thus trying to overcome the opposition of "engineering vs humanitarian" philosophy [Zhu, Mitcham, 2020]. Finally, the institutionalization of "philosophy of gongcheng" in the late XX century was actively supported by Chinese Academy of Engineering (founded in 1994), the members of which had a significant influence in the political system [Wang, 2020]. The demand for theory of engineering management and expertise of sociotechnical projects in the growing economy has stimulated communication between humanities and technocracy, and between academia, industry, and the state. The research center for Engineering and Society was founded at University of Chinese Academy of Sciences in 2003, and in 2004 a sector for the "philosophy of gongcheng" was created in the Chinese Society for Dialectics of Nature. At the same time, the Chinese, Japanese and Korean Academies of Engineering issued a "Declaration on Engineering Ethics", including the "Asian Engineers' Guideline of Ethics". The journal "Engineering Studies: Engineering in Interdisciplinary Perspective" was published the same year (five years earlier than that of the International Network of Engineering Studies), co-edited by Li Bocong, who was actively promoting both philosophical and social studies of engineering internationally since the early 1990s.

The developments described above took place in different regions and under different disciplinary categories: philosophy of engineering defining its subject in relation to philosophy of science and technology, basing on the empirical resources of STS and engineering studies, and examining the ontological, epistemological, anthropological and ethical aspects of engineering practice. In the last two decades, the field was booming in terms of publications and projects. Firstly, there has been a steady growth of publications with more and more explicit thematization. A few individual monographs on philosophy of engineering appeared since the beginning of the century: by Li Bocong [2021] (published in Chinese in 2002), L.L. Bucciarelli [2003], P. Dias [2019], C. Mitcham [2019]. A few collective works were published in China and Europe [Yin, Wang, Li, 2007; Christensen, Meganck, Delahousse 2007; Wang (ed.), 2013]. Since 2010, a series "Philosophy of Engineering and Technology", directed by P. Vermaas (Delft University of Technology), has been issued by Springer, comprising about 40 regional and international collective and individual volumes by the end of 2021, 13 of which had "engineering" in their titles. A Handbook on Philosophy of Engineering was published by Routledge [Michelfelder, Doorn (eds), 2021]. Secondly, the academic conferences were organized in China, Europe, and the USA by the leading universities, such as the University of Chinese Academy of Sciences, TU Delft, and MIT. They have been promoted by Chinese Academy of Engineering, Royal Academy of Engineering in England, National Academy of Engineering in the USA, and other professional associations. A biannual forum on Philosophy, Engineering, and Technology (fPET, initially a Workshop on Philosophy of Engineering) became an international platform since 2008. Thirdly, some educational and research centers were institutionalized: e.g., the Engineering Philosophy Committee in the Structural Engineering Institute of ASCE, or a research group "Philosophy of Engineering, Technology Assessment, and Science" in the Institute of Technology Assessment and Systems Analysis in Karlsruhe. To sum up, in the last 20 years, the field was constituted by the international research community with an explicit identity, including engineers, philosophers, and social scientists, and by a network of research institutions, universities, professional associations, and publishers.

An overview of the developments that have led to the formation of philosophy of engineering in the East and West allows us to see some similarities and peculiarities in the Soviet and Russian contexts. The production of engineers as a mass profession under socialism, their social standing as "scientifico-technical intelligentsia", dependent on the state but legitimated by its progressivism, and their identity and work cultures were naturally quite different in comparison with Western societies. By the last decades of the XX century, Soviet engineering enjoyed a relatively high social prestige, and still was more inclusive than the predominantly "white male middle-class" professional group of corporate capitalism. Engineering was a special research interest for the Soviet social scientists since the 1970s, while their methodologies were similar to that of the Western sociology of professions and industrial sociology, studying the professional values, responsibilities, and functions of engineers, public attitudes and representations in the mass culture, social origin and mobility, etc. [Tsiukhai, 2017]. After the post-Soviet crisis of profession against the background of neoliberalism and de-industrialization, this line of research has intensified in the last years with the growth of production of both industrial and IT specialists, as well as globalization and migration [Kozina, Vinogradova, 2016; Mansurov (ed.), 2017; Bychkova, 2022]. Quite recently, engineering studies have been complemented with the reconstructions of the everyday practices and life worlds of the engineers [Kolchanova, 2017; Bychkova et al., 2019; Abramov, 2020]. Still, the ethnographic work is limited in comparison to the scope of laboratory studies globally.

It should be noted that there was a tradition of action-oriented sociotechnical research, or co-engineering, during the Soviet period – starting from the Central Institute of Labor, headed by A. Gastev in the 1920s, and, most notably, in the All-Soviet Scientific Institute of Industrial Aesthetics (VNIITE) in the 1960–1970s, where a community of engineers, philosophers, systems analysts, and psychologists conducted experimental research in ergonomics [Zinchenko et al., 1974]. At the same time, the TRIZ (theory of inventive problem solving) movement was gaining popularity, the founders of which tried to enhance engineering heuristics with dialectics [Altshuller, 1979]. While it might be questioned, whether dialectical materialism was deeply incorporated into the engineering design or systems thinking, the very notion of "engineering activity" became common then. In fact, "engineering" is more often used in Russian as an adjective than as a noun, and in combination with "activity", it is a theoretically laden term. The meaning of "activity" ("deyatelnost") goes back to Hegelian and Marxist notion of "Taetigkeit", developed in the Soviet psychological activity theory (L. Vygotsky, S. Rubinstein, A. Leontyev) and later in philosophy of science and systems theory (E. Ilyenkov, E. Yudin, I. Blauberg and others) [Blauberg et al., 1977]. Activity was both a subject of empirical study and an explanatory principle, implying the unity of subject and object, mediated by socio-historical means (language and tools). Not unlike "gongcheng", the notion of "engineering activity" highlights its collective and transformative nature, which was subject to "methodological" analysis [Schedrovitsky, 1995; Rozin, 2014]. The philosophical activity approach was systematically applied in the socio-historical studies of engineering by V.G. Gorokhov [2006; 2014; 2015a; 2015b]. He was the most active proponent of philosophy of technology and TA in Russia and its internationalization, reconstructing the history of the field from the XIX century, with a particular focus on P. Engelmeyer, and presenting Russian audience with German and American literature. Though Gorokhov categorized them as "philosophy of technology", his studies were centered on the theory of engineering activity, its historical epistemology, and socio-ethical implications. He was the head of the Research Center for Philosophy of Technology and Engineering Ethics in the Institute of Philosophy of Russian Academy of Sciences and created a network of philosophers, social scientists, and engineers, which remains connected after his death.

While the term "philosophy of engineering" is still rarely used in Russian even by those who are actually doing it, engineering ethics is an active field, mostly due to the influence of technical universities, which had relatively numerous humanitarian faculty since the Soviet period – a remarkable example is the Research Institute of Applied Ethics of the Industrial University of Tyumen [Bakshtanovsky, Bogdanova, 2021]. Engineering education is both the field of study and intervention for humanitarians, promoting engineering ethics together with elements of RRI and TA [Seredkina, Chernikova, Kolesova, 2015]. However, the field research of engineering practices, which informs philosophy of engineering both in the East and West, is insufficient – seemingly, due to the lack of access to and interest from the industry. It requires more collaboration between the professional community, scholars, and educationalists to institutionalize the empirically grounded and practically meaningful philosophy of engineering in Russia.

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Становление и самоопределение философии инженерии

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Хотя основы философии техники были исторически заложены инженерами, инженерная практика как таковая лишь недавно стала предметом специального философского изучения. Философия инженерии формируется на рубеже XX–XXI вв. как самостоятельная дисциплина в разных регионах – Китае, Европе и США, – самоопределяясь по отношению к философии и социальным исследованиям науки и техники. В работе рассматриваются ключевые точки этого процесса: оформление исследовательских программ и сообществ. Демаркация философии инженерии как отдельной предметной области связывается с эмпиризацией и этизацией философских и социальных исследований технологий, требующих соотнесения дескриптивных и нормативных описаний их производства. Она изучает онтологические, эпистемологические и этические проблемы инженерной деятельности. Эмпирически ориентированная философия инженерии стремится преодолеть разрыв между социальным контекстом и содержанием технологий. Исследуя специфически модерновый способ отношения к миру и исторически конкретные формы человеческой агентности, коллективных субъектов и сети взаимодействия, она в то же время является источником для философской антропологии и праксеологии. Институционализация самой субдисциплины, однако, становится возможной при условии формирования коалиции заинтересованных акторов: профессионального и гуманитарного сообществ и разработчиков научно-технической политики. Обзор зарубежных исследований завершается кратким описанием состояния и перспектив отрасли в России. Несмотря на то, что накоплен существенный корпус исследований инженерной деятельности, он отличается фрагментированностью; философия инженерии не институционализирована, и само название остается экзотическим для русскоязычной литературы.

Ключевые слова: философия инженерии, инженерная этика, engineering studies, STS

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