

# TOWARDS ENGINEERING 4.0: A CONTEMPORARY EXPRESSION OF BIOCOSMOLOGY AND NEO-ARISTOTELISM<sup>1</sup>

Xiuhua ZHANG<sup>2</sup>

**ABSTRACT.** Facing contemporary crisis of existence in pollution of environment and ecological deterioration, we have to reflect human engineering again and question that how engineering paradigm ought to be selected, in order to let artificial world can organically be embedded natural ecological system. According to methodologies of phenomenology and morphology, general human modes of engineering evolution can be described in the positions of organism, holism and process theory as follows: being-in-itself engineering, being-for-itself engineering, being-in-itself and being-for-itself engineering. With the trend of developing Industry 4.0, it is necessary that Engineering 4.0 will be present, because industry is grouping on engineering projects. Therefore, we can describe above general human modes of engineering evolution as: Engineering 1.0, Engineering 2.0, Engineering 3.0 and Engineering 4.0. Moreover, the both of general human modes of engineering evolution are consistent. These engineering modes respectively have shaped agricultural civilization complying with nature and industrial civilization dominating nature, and will enable mankind enter ecological civilization seeking to harmony between man and nature. Chinese practice of engineering is shaped by the general modes of engineering evolution in the way of time-space compression from 1840 to nowadays, and it is facing challenge of new industrial revolution. Matching with the Self-Aware Industry 4.0, Engineering 4.0 or being-in-itself and being-for-itself engineering will insist the principle of ethical priority and transcend Engineering 3.0 or being-for-itself engineering only seeking to utility and benefits, so it is a new expression of contemporary Biocosmology and Neo-Aristotelism. Then, we should pay attention to interaction, inter-interpretation and inter-response between engineering modes and ethical modes, select two paths of engineering ethics studies from engineering to ethic and from ethic to engineering, and construct whole system of engineering ethic including micro, middle and macro engineering ethics from different ethic subjects. Meanwhile, we regard engineering ethics as paradigm of practical ethics, and see engineering ethical praxis as a key research project to guide social shaping of Engineering 4.0.

**KEYWORDS:** phenomenology; morphology; Engineering 4.0; engineering mode; engineering evolution; engineering ethic; Biocosmology; Neo-Aristotelism

---

<sup>1</sup> Fund Project: The Project of Philosophy and Social Science Supported by Beijing City Government of “A Philosophical Comparative Study between Marx and Whitehead” (ZXB001) and The Fund Project of National Social Science of Returning Humanistic Nature of Engineering: A Critique of Modern Engineering (14FZX026).

<sup>2</sup> School of Marxism, China University of Political Science and Law, Beijing CHINA.

## Contents

### *Introduction*

1. From Engineering 1.0 to 4.0: The Evolution of General Engineering Modes
2. Promoting in Contextualization: Modern-Contemporary Changes of Chinese Modes of Engineering
3. Ethic Priority: A Key for Shaping Engineering 4.0

### *Conclusion*

## **Introduction**

Facing contemporary crisis of existence in pollution of environment and ecological deterioration, according to the positions of holism, organism, evolutionary theory and process theory [Whitehead, 1978], I had made a strong judgement in my academic book of *History and Praxis: Introduction to Engineering Existentialism* [Zhang, 2011:1–32] in the perspective of phenomenology and method of morphology, namely, comparison with science and technology as ways of holding the world, modern engineering gradually begins from hidden backstage to apparent proscenium, so 21 century will be an age of engineering. However, the engineering has to be a new engineering mode which transcends traditional engineering only seeking to utility and benefit in the logic of capital. In general, nowadays contemporary engineering is still in the stage of engineering 3.0, then with the incoming forth industry revolution – Industry 4.0 as a kind of great trend [Sendler, 2014], Engineering 4.0 will become a new mode of engineering in 21 century. This situation is decided by internal relationship between industry and engineering, because industry is grouping on engineering project (by Yin Ruiyu). Therefore, facing to this great trend of Industry 4.0, China as a huge state of engineering has to catch up with, and hard work in order to transcend Engineering 3.0 and consciously goes toward Engineering 4.0, thereby seeks to the harmonious relations between man and man, human beings and nature, and realistically promotes construction of ecological civilization. Therefore, we can say that Engineering 4.0 is not only necessary expression of engineering ethic but also a contemporary expression of Biocosmology and Neo-Aristotelism. It is very clear that any organic cosmology can't be actualized, if we are lack of organic engineering in human practice. This means that how to construct organic artificial world and embed it into whole ecological system by organic engineering is becoming an extreme important and urgent.

### **1. From Engineering 1.0 to 4.0: The Evolution of General Engineering Modes**

Engineering is the closest human way of existence. We always create our own all life necessities by organized order labor according to engineering way. Moreover, human beings transform objective world and also change themselves in the practice of engineering. Meanwhile, people constantly confirm and promote their own

essential power in the activities of engineering, as well as construct and shape the universal civilization. Tracing back to human engineering history, we can find that engineering has been being in the process of movement and development, and possesses organic and evolutionary characters. Seeing from larger scale, human engineering development generally possesses some regularity, according to morphology, human engineering evolution can be described as follows:

- (1) Being-in-itself engineering complying with the nature in pre-industry society, pre-modern times or agricultural age.
- (2) Being-for-itself engineering dominating and controlling the nature in industry society, modern or industrial times.
- (3) Being-in-itself and being-for-itself engineering seeking to harmonious relation between man and nature in post-industrial society, post-modern or information age.

These engineering modes respectively have shaped agricultural civilization and industrial civilization, and will enable mankind enter ecological civilization in the future.

Not only that, we also can divide general human engineering modes in the perspective of relation between engineering and technology, namely:

- (1) Attached on technology, weak or as a life substitute and complementary Engineering 1.0, this is an initial engineering mode. Of course, the technology is not modern technology here, but refers to technique or art of experience in the pre-modern society.
- (2) It want to differentiate with technology (modern technology) and emphasize the uniqueness of engineering, but it is regarded as technological application or extension, so that technology also plays dominant role on aspect of engineering, thus it is a kind of engineering mode in the perspective of engineering view of technicalization which enter into next stage of Engineering 2.0 as self-knowledge.
- (3) It lets all things belongs to engineering, and insists on the preferential principle for utility and benefit of engineering, moreover, and selecting technology is emphasized in engineering but technology is applied, then engineering has been entering new context from technological behind to foreground, this is contemporary arrogant Engineering 3.0 from dark place to bright position.

(4) With Engineering 4.0 coming on the stage, demand of technological personalization will become actual, so engineering no longer purely pays attention to technological dimension, and it also considers non-technological humanistic factors, such as ethical and aesthetic aspects, and so on. In other word, Engineering 4.0 will care for various factors in engineering, and it not only cares and tolerates the other, but also regards ethical principle as first principle, so it is whole engineering rather than segmentary, because it possesses ability of consciously reflection and autonomy.

Obviously, above two kinds of expression of general modes of engineering evolution, namely, the first expression, being-in-itself engineering→being-for-itself engineering→being-in-itself and being-for-itself engineering, is internal consistent with the second expression, Engineering 1.0→Engineering 2.0→Engineering 3.0→Engineering 4.0. Engineering 1.0 belongs to being-in-itself engineering, Engineering

2.0 and Engineering 3.0 is in the stage of being-for-itself engineering from self-knowledge to self-leading, and Engineering 4.0, as reflective engineering of freedom, keeps consistence with being-in-itself and being-for-itself engineering.

In the fact, evolutionary modes of engineering are all consistent with industry modes, both have relationship of twinning. In other word, change of industry modes – industry revolution be nothing more than outside presentation of engineering modes transition. According to time order, conception of Industry 4.0 is raised earlier than Engineering 4.0 (This concept is given by myself in the paper of *The Engineering 4.0 in the Perspective of Philosophy of Engineering* published by *Guangming Daily* at Nov 14, 2015), however, the latter enables the former actualization. Thus, toward Engineering 4.0 is necessary for promoting Industry 4.0 nowadays.

## **2. Promoting in Contextualization: Modern-Contemporary Changes of Chinese Modes of Engineering**

The above evolutions of general engineering modes are more consistent with engineering ways of western capitalist countries of original modernity in logics and time. Due to Chinese modernization is passively involved in the movement of modernization in the process for history entering the world history and logic of globalization. Then Chinese modernity possesses following features and posteriority, as well as particularity in time and space, unique modernity, and it has been undertaken by Chinese modern and contemporary engineering since 1840. The evolution of Chinese engineering is only more than a century and a half, but it has gone through whole process of western engineering evolution in a lot of hundred years, unfolded all general engineering modes. Therefore, it is a kind of speedy changes in contextualization compressed time and space, moreover, contains individual (personality) in universality (common character).

In general, Chinese engineering can be distinguished following several stages:

(1) From 1840 to end of Qing dynasty, the movement of westernization had advocated reform in implements, and it had been displayed Engineering 1.0 in the technological view of engineering.

(2) From the republic of China (1912–1949) to earlier of new China, for desiring and pursuing west countries of modernization so that engineering consciousness and will was strengthened, then the mode of Engineering 2.0 in autonomic view of engineering was presented.

(3) From the reform and open to raising the view of scientific development, the upsurge of engineering building was promoted by guiding of thought of development as absolute principle, especially, engineering superiority and gesture of controlling and conquering the nature from engineers and workers, so Engineering 3.0 as the being-for-itself view of engineering was formed.

(4) From setting up the scientific view of development to putting forward the construction of ecological civilization, Chinese engineering facing new turn again and possessing new chance towards a new engineering mode as Engineering 4.0 with being-in-itself and being-for-itself or reflective view of engineering.

It is urgent for how to grasp this new chance and consciously to transcend

Engineering 3.0 into Engineering 4.0. There are two aspects of causes: on the one hand, this new mode of engineering possesses containment, reflectivity and a prior ethic principle, and no longer regarding consumers, social publics and environment as outside objects, then outside relation turning internal relationship, and fully considering the benefits and demands of the other, all will help to improve our life way and consciously construct ecological civilization. On the other hand, this is also a necessary selection for facing Industry 4.0, developing new technologies of cyber-physical-system, big data, and actively responding and welcoming new industry.

Just like director Lijie said: so-call Industry 4.0 is just a future blueprint about manufacture defined by German Government and industrial circle. They thought that application of devices of machine manufacturing in 18 century marks an age of Industry 1.0. The electrification and automation in 20 century symbol a time of Industry 2.0. Arisen informatization in 1970s of 20 century shows an age of Industry 3.0. Nowadays, mankind is going an age of Industry 4.0, namely, fusion of reality-physical world and virtue-network world, and Cyber-Physical System (CPS) is a core technology of industry revolution in new age [Lee, 2015: XII].

It is very clear that the evolutionary veins of industry modes of Industry 1.0 → Industry 2.0 → Industry 3.0 → Industry 4.0 are consistent with above logic of engineering evolution. Merely, the distinguishing for engineering modes mainly is based on technological update, and transition of engineering modes considers not only technological factor but concerns ethic dimension. According to the synchronism of evolution of industry and engineering, with coming of age of Industry 4.0, presence of Engineering 4.0 will be appealed.

### **3. Ethic Priority: A Key for Shaping Engineering 4.0**

How do we go and construct Engineering 4.0? It is a key for consciously insisting on the principle of ethic priority in engineering, and the principle of ethic priority in engineering is also internal demands of engineering.

The fundamental differences from Industry 4.0 and previous industrial and engineering modes lie in: [Lee, 2015: VIII].

Industrial community no longer regards manufacture as starting point but sees user's demands as starting point for Industry 4.0; industrial community no longer selects the model of movement from production or upstream to consumption or downstream but starting with user's demand of value and offering productions and services of customization which is seen as common purposes in order to realize a synergy and majorization for various links in industrial chain. There are three supporting points for Industry 4.0:

(1) Manufacture itself is valualized (evaluated by value), that is, not only should produce good productions but reduce waste as lower as possible and realize the matching between design, making process and user's demands.

(2) A function of Self-Aware for system will be actualized based on original robotization.

(3) It will be realized for taking fault-free, eliminating hidden trouble, accident and pollution, this is the highest realm in manufacturing system.

Hence, it can be seen, Industry 4.0 is a synthesis with ethic and idea allocations. It gives up the idea of production for only pursuing higher productivity and efficiency but cares for the benefits of users or audiences, environment protecting, resources economizing, and engineering community as subject of action consciously undertakes social and environmental duties. Therefore, this attitude from Engineering 4.0 is not pure naturalism and one-sided position of humanism, but a new humanism which pays attention to Tao of the Haven (Tian Tao) or Aristotle's nature or essence [Aristotle, 2005:122–123] of nature itself and respects nature (essence) of thing itself, then realizes the unity between heteronomy (necessity) and autonomy (freedom). This is a kind of deep existence with universal roots in the perspective of Biocosmology.

Thus, according to Industry 4.0, Engineering 4.0 has to mean that fully considers limitations and constrain in the aspects of nature, environment, energy sources, logistics (material flow), stream of people, etc., so it is different from Engineering 3.0 which benefits and utilities are preferential, but keeps the principle of ethic priority, becomes a mode of consciousness-freedom engineering with reflective and self-restraining abilities.

Thereby, it will be gradually eliminated for engineering alienation in the logic of capital, dominating and controlling nature, ignoring public benefits, and it will fully be embodied that engineering subject releases benefits to the other and loves the other, as well as seeks human and universal Common Good (by John Cobb), in order to let all things keep and realize their own nature in the universe. Consequently, human engineering no longer is an action of invading and depriving the nature in the way of mechanical enclosure ecosystem, and it is an organic becoming and ecological imbedding; this kind of engineering will be not only construct somewhat or things but create human civilization by responsible engineering belonged human actions to realize the universal harmony. This is also an engineering expression of contemporary Biocosmology and Neo-Aristotelism.

We can say, according to the path of research from engineering to ethic, the ethic requiring of very higher realm is raised in the mode of Engineering 4.0, and it will shape the mode of engineering ethic for regarding virtue ethic as leading, normative ethic as foundation, and utility ethic as base. Undoubtedly, the principle of ethic priority of Engineering 4.0 is a key and guarantee for the core value of Industry 4.0 with the function of Self-Aware. In this meaning, we can understand real meaning and ethic constraint of those new given words such as Cyber-Physical System (CPS), Internet of Things (IoT), Big Data, Industrial Internet, Intelligent Manufacture, 3D-Print, etc. Moreover, we can confirm that the forth industry revolution will change human life way in fundamental meaning and promote mankind going to new civilization.

Meanwhile, this also show the meaning and value of researches for engineering ethics in the situation of contextualization, especially inquiry for contemporary Chinese practice of engineering in the perspective of ethic morphology, we have to firstly research the modes and characters of Chinese engineering. It is possible that we construct morphology of engineering ethic in the context of China if only comply

with interaction, inter-interpretation, inter-response between engineering modes and ethic modes. In other words, the researches for contemporary engineering ethic morphology need to cognize Engineering 4.0 and consciously transcend Engineering 3.0.

The situation is calling another research approach of engineering ethics, namely, from ethic to engineering. That is, various ethic requirements for different engineering subjects or ethical subjects including individual, organization or group, state or society are proposed according to the existing theoretical resources of ethical modes, then engineering ethical codes concerning micro, middle and macro levels and fields are set up in order to construct whole system of engineering ethic, such as, we not only possess professional ethics of engineers, but also professional ethics about investors, entrepreneurs, managers, workers and other stakeholders in engineering community will be built; there are not only micro engineering ethics but middle responsibility ethics and system ethics for institution or enterprise, as well as macro state or social engineering ethics concerning politics, social public and ecological benefits. Robert C. Hudspith also argues that we should broaden the scope of engineering ethics: from micro-ethics to macro-ethics [Hudspith, 1991: 208–211].

In addition, we also have to regard engineering ethics as Practical Ethics (Pinkus 1997), moreover pay attention to researches of praxis of engineering ethic to serve and guide actual praxis of engineering ethic, for example, drafting agenda of praxis of engineering ethic in the 21<sup>th</sup> century, engaging in ethic education for engineers and other members in engineering community, carrying out engineering critique, environmental and social evaluation and assessment of engineering, etc. Thereby, it is possible for real toward “Engineering 4.0” and promoting the civilization of the cosmos.

## Conclusion

According to the inquiry of phenomenology and morphology of engineering, we confirmed and analyzed above human general modes of engineering evolution in the perspectives of holism, organism and process theory [Whitehead, 1978]. Obviously, it is time that human beings transfer being-for-itself engineering mode or Engineering 3.0 as carrier of modernity in traditional industry mode which only seeks to growth of GDP in the violent logic as well as dominates and conquers the nature. Thus, our the first task is shifting the way of thinking of subject-object dualism, in the position of inter-subjectivity, let philosophy of engineering go back the life world and emphasize the humanistic feature and ethical dimension of engineering concerning the other such as social public and natural things in the world. In addition to we should grasp opportunity of new industrial revolution developing Industry 4.0, and consciously construct Engineering 4.0 with the characters of ethical priority and reflection, in order to actually promote ecological civilization and human sustainable development in the contextualization of different states.

## References

- Aristotle. (2005). *Physics* [M]. Translated by Li, Zhen. Shanghai: Shanghai People Press.
- Hudspith, Robert C. (1991). *Broadening the Scope of Engineering Ethics: From Micro-Ethics to Macro-Ethics* [J], on Bulletin of Science, Technology and Society, vol.11:208–211.
- Lee, Jay (2015). *Industry Big Data: The Revolutionary Transformation and Value Creation in Industry 4.0 Era* [M]. Beijing: China Machine Press.
- Pinkus, Rosa Lynn (1997). *Engineering Ethics: Balancing Cost, Schedule, and Risk-Lessons Learned from the Space Shuttle* [M]. New York: Cambridge University Press.
- Sendler, Ulrich (2014). *Industry 4.0: The Challenge Coming from the Forth Industrial Revolution* [M]. Beijing: China Machine Press.
- Whitehead, Alfred North. (1978). *Process and Reality* [M]. Griffin, D. R. Ed. New York: The Free Press.
- Zhang, Xiuhua (2011). *History and Praxis: Introduction to Engineering Existentialism* [M]. Beijing: Beijing Press.