KNOWLEDGE TRANSFER INDUSTRY 4

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Abstract: *In this article we consider the need to work with all knowledge. For Industry 4.0, in particular for micro-companies (family) is compulsory transfer of the knowledge to them. This revolutionary change will free many works places. Create new jobs for mathematicians and physicists Mathematical Physics i.e. digitalization of business by "smart factories" and we introduced these ideas to micro-foundry.*

Keywords: INDUSTRY 4, DIGITALIZATION OF BUSINESS, MATHEMATICIANS AND PHYSITIANS, ECONOMY

1. Introduction – Horizon 2020: European, global thinking and openness to the world [1, 2, 3, 4].

The knowledge is open system: 1. The results of all sciences complete knowledge continuously throughout the history of mankind; 2. Fundamental scientific results are the basis for innovation technologies and products; 3. The full history of knowledge to the modern point of time limits of knowledge. Development of knowledge through, because research done at its borders, often called - border.

2.1 Three pillars developing of the Knowledge – History: philosophy, mathematics and physics [12].

Greek: *φιλοσοφια*, from *φιλεῖν* — I love and *σοφία* — wisdom) it is the study of general and fundamental questions concerning man and the world. **History of Philosophy:** Main areas and object of study: ***Metaphysics*** – Nature and Origin of the existing and the world; ***Ontology*** – Being; ***Epistemology*** – Knowledge of nature and the possibility of a cognitive process; ***Ethics*** – Morality - how to act human, correct behavior and "good life"; ***Political philosophy*** – Governance and respect for human and communities to the state; ***Aesthetics*** – beautiful, sublime, art, pleasure; ***Logic*** (mathematical and philosophical) – Forms and laws of thinking; valid forms of argumentation; ***Philosophy of Language*** – Beginning, development, use and attitudes towards thinking; ***Scientific methodology*** (academic disciplines) - Grounds and subject: science; history; mathematics; physics; psychology; anthropology, etc. **History of Mathematics Before Christ:** to ~ 2500y. necessary: count + measurement and verbally counting; ~2500y. Mesopotamia was introduced and developed decimal-sixty positional notation; ~2000y. Mesopotamia – solving algebraic equations of second degree (square equations); mathematics developed in Ancient Egypt; ~ 550y. Pythagoras – theorem for countries in right triangle (known before in China, Mesopotamia and ancient Egypt); ~450y. Ancient Greece Hipas (Hipazos) – some numbers are irrational; ~300y. Euclid - the laws of geometry taught today; ~230 magnetism y. Eratosthenes – finding all primes (sieve of Eratosthenes); ~190y. China – use rates of 10 to express values; ~100y. China – began using negative numbers; **After Christ (Anno Domini)** ~210y. Diophantus – first treatise on algebra; ~600y. India – began to use the decimal positional system; 829y. Persia Mohammad ibn Musa al Khoresm – use decimal notation, which get to know later and liaison with European scientists; ~876y. India – symbol for zero. ***1000-1599*y.:** 1202 Italy Leonardo Fibonacci – numerical series: 1, 1, 2, 3, 5, 8, 13, 21, … , $n_i = n_{i-1} + n_{i-2}$; 1550 Germany G. von Lauhen – a seven trigonometric tables (for 1st time + sekansi); ***1600-1699*y.:** 1614 John Napier – logarithms; 1623 Germany W. Schickard – mechanical computer with (+, −, ×, :); 1637 R. Descartes – analytical geometry; 1654 Blaise Pascal and Pierre de Fermat began construction of probability theory; 1666 England I. Newton – differential calculus as a method for calculating the instantaneous speed; 1675 G. Leibniz – differential and integral calculus + mathematical signs and symbols used today; 1679 G. Leibniz – binary arithmetic; 1684 G. Leibniz – essay on differential calculus; ***1700-1799*г.:** 1713 J. Bernoulli – 1-st law of large numbers of probability theory; 1718 J. Bernoulli – common definition of functionм 1744 Switzerland L. Euler – variational calculus; 1747 J. d'Alembert – partial differential equations in the problems of physics; 1798 Denmark C. Wessel – vector representation of complex numbers; 1799 C. F. Gauss – the base algebra theorem: the number of solutions to algebraic equation is the degree equation; ***1800-1899*г.:** 1810 J. Fourier – presentation of functions by trigonometric lines; 1812 P. Laplace – First complete and detailed statement of probability theory; 1822 United Kingdom Ch. Babbage – began construction of the 1st mechanical computer Difference machine to calculate logarithms and trigonometric functions, introduced (1834) and recording mechanical The apparatus and punch card tabulator; 1827 C. F. Gauss – beginning of differential geometry of surfaces; new geometric system of N.I. Lobachevski – non-Euclidean geometry hyperbolic, with the validity of the axioms of Euclid without parallel lines; E. Galois created the theory of groups with basic terms used today; 1844 France J. Liouville – the existence of transcendental numbers; Germany H. Grassmann – 1-st systematic survey of vectors with more than 3D; 1854 United Kingdom J.K. Bull – symbolic formal logic (Boolean algebra); 1858 England A. Cayley developed calculus rectangular tables called it matrixes; Germany A. F. Möbius – sided surface (Möbius strip); 1859 B. Riemann - Basic analytic number theory; 1892 G. Kantor – different types of infinity and explore transfinite numbers; 1895 H. Poincaré – 1st article on topology; 1899 D. Hilbert – complete axiomatic justification of Euclidean geometry; ***1900-1999*г.:** 1914 F. Hausdorff – axiomatic definition of topological space; 1931 US K. Gödel proved that any axiomatic system strong enough to include arithmetic of natural numbers, it is incomplete or, or contradictory; 1932 Poland S. Banach – basics of functional analysis; 1933 A. Kolmogorov – First axiomatic justification of probability theory; 1937 France – group N. Bourbaki and issues (1939) multi-volume treatise "Elements of mathematics"; England A. Turing – Mathematical theory of computation (explaining the concept of algorithm gives transformation algorithms and programs, etc.); US J. Atanasov define the basic principles of computer and elaborate schemes electronic lamps units for various mathematical operations; 1942 J. Atanasov and K. Berry – 1st specialized electronic digital computer "ABC" (with integrating capacitors and 300 tubes); introduction and putting the information is punched; 1944 US J. Von Neumann and O. Morgenstern established game theory; 1946 US University of Pennsylvania – 1st universal electronic digital computer ENIAC (with 18 000 vacuum tubes); 1948 N. Wiener – Cybernetics; 1961 In the US, E. Lorenz – chaos, meteorology, computer, mathematical chaos theory; 1962 In the US, the French mathematician B. Mandelbrot introduced geometry of fractals; 1963 US P. Cohen proved the independence of the hypothesis of G. Cantor continuum of other axioms of set theory; 1975 USA M. Feigenbaum – new constant (≈ 4, 6692016…) with an important role in chaos theory; 1976 USA K. Appel and B. Haken – decision, a 4-colors are sufficient to color any planar map; 1980 Ends 35-year labor of hundreds of mathematicians from around the world – classification of all final and simple groups results hold over 14 000 pages; 1989 Group of mathematicians Amdal Corporation, California, is the largest known prime number so far (containing 65 087 digits); 1994 United Kingdom A. Uaylz – evidence (about 150 pages) of Fermat's Last Theorem, one of the biggest challenges of pure mathematics; 1996 The proof of A. Uaylz (in revised form) is recognized. History of physics Before Christ: ~450г. Leucippus – ancient atomistic; ~400–450г. Democritus – develops of atomistic Leucippus; ~250–450г. Archimedes – Law hydrostatic pressure; **After Christ:** 9-15 century Arab scientists – Alhazen optics; mechanics, static and dynamics; ***Physics – independent science*** 1600y. W. Gilbert – magnetism and many и electrical phenomena; ~1610y. G. Galilei – law on free fall of bodies; 1642y. B. Pascal – principles of hydraulics; 1643г. E. Torricelli – mercury barometer; 1657y. K. Huygens – clock with pendulum; 1662y. R. Boyle – ideal gas law (relationship between volume and pressure at a constant temperature (Boyle-Marriott)); 1687y. I. Newton – "Mathematical principles of Natural Philosophy", foundations of classical mechanics; 1690г. K. Huygens – wave theory of light; ***Physics – intensive development*** 1704y. I. Newton – corpuscular theory of light; 1714y. D. Fahrenheit invented the mercury thermometer; 1771y. L. Galvani – experimental electrophysiology; 1787y. J. Charles formulate the ideal gas law – the relationship between pressure and temperature constant; 1801y. Thomas Young – principle of interference of light; 1811y. A. Avogadro – ideal gas law (relationship between volume and amount of molecules in it); 1818y. O. Fresnel – theory of diffraction of light; 1820y. H. Oersted – magnetic effect of electric. current; A. Ampere – laws of electromagnetism; 1826y. G. Ohm – law of electrical resistance; 1827y. R. Brown observed Brownian motion explained later by Albert Einstein between molecular interactions; 1831-34y. M. Faraday – electromagnetic induction, inductance and the laws of electrolysis; 1842 y. J. Meyer – low of conservation energy; A. Fizo measured the speed of light in earthly conditions; 1851y. G. Foucault demonstrates around-founded rotation of the Earth through the experience with the Foucault pendulum; 1854-59y. R. Bunsen and G. Kirchhoff – spectral analysis; 1873y. J. Maxwell – electromagnetic field theory, classical electrodynamics; 1880y. P. Curie – piezoelectric effect; 1886-89y. H. Hertz experiment – There are electromagnetic waves; 1892y. A. M. Lyapunov – theory sustainability of balance and movement of a mechanical system with a finite number of parameters; 1895y. W. Röntgen – X-rays (Röntgen rays); 1896y. A. Becquerel discovered natural radioactivity; 1897y. J. Thomson discovered the electron; 1899y. A. Rutherford – nature of α- and β-rays; ***Modern physics*** 1900y. M. Plank – explanation of the law on radiation blackbody by hypothesis: energy exchange of small packets (quanta) i.e. quantum mechanics, in large part is based on the quantization of matter and Energy + wave-particle duality (de Broglie hypothesis). Quantum theory was developed by Planck, Einstein, Bohr, Schrodinger, Heisenberg, Ehrenfest, Bourne and others. It proved fundamental to the progress of physics and technology in the 20th century. Without it, it would be unthinkable learning and understanding the atomic nucleus (with applications in energy, medicine, and of course, fundamental science), semiconductors, lasers, interstellar medium, compact stars (white dwarfs and neutron stars) and the early universe. 30% of US GDP comes from industry applications of quantum mechanics. 1903 y. — A. Rutherford and F. Soddy – theory of radioactive decay; 1905y. A. Einstein – special theory of relativity; 1911y. A. Rutherford – planetary model of the atom; 1913y. N. Bohr developed the quantum theory of the atom; 1915-16г. A. Einstein – general theory of relativity; 1919-21y. A. Rutherford – proton, predicts the existence of neutron; 1926y. E. Schrödinger – wave interpretation of quantum mechanics; 1927y. W. Heisenberg – uncertainty principle in quantum theory; 1932y. J. Chadwick – the neutron; K. Anderson – the positron; 1933-34y. I. and F. Joliot-Curie – artificial radioactivity; 1937y. P. L. Kapitsa – superfluidity of liquid helium; 1938y. O. Hahn and F. Strassmann – division of atomic nucleus; 1942y. E. Fermi – the first controlled nuclear chain reaction; 1947-48y. D. Gabor – method of recording, conversion and reproduction of wave fields (holography); 1954y. Ch. Townes (US), N. G. Basov and A. M. Prokhorov (USSR) – the first laser; 1956y. K. Cowan and F. Rayns – neutrino; 1958y. R. Mössbauer – elastic nuclear resonance absorption of γ-raise; 1964y. M. Gell-Mann and J. Zweig – quark theory; J. Cronin and V. Fitch – theory of breaking the law of symmetry in the combined inversion; 1983y. K. Rubin – gauge boson W± and Z^0 –carriers of the electroweak interaction; 1986y. K. Muller and J. Bednorts – superconductivity in ceramic materials at T = 35 K (high-temperature superconductivity); 1989y. Comes into play large electron-positron collider (LEP) at CERN (European Organization for Nuclear Research); 1995y. At CERN – the first atom of antimatter (antihydrogen); K. Viman and E. Cornell – condensate Bose-Einstein; 2009y. Comes into play Large Hadron Collider (LHC) at CERN.

1.2 Ecology in the Knowledge [12].

Greek philosophers Hippocrates and Aristotle laid the foundations of ecology in their study of natural history. The concept of ecology (ecology) (Ökologie) t was introduced by the German scientist Ernst Haeckle in 1866y. From Greek: οἶκος, "house", or "environment"; -λογία, "study of". Modern ecology becomes science in the late 19th century. Environmental thought is derived from the established currents in philosophy, especially ethics and politics. ***Ecology** is the scientific analysis and study of interactions among organisms and their environment. It is an interdisciplinary field*: **Hierarchy of life:** Biosphere > Ecosystem > Community (Biocoenosis) >Population > Organism > Organ system > Organ > Tissue > Cell > Organelle > Biomolecular complex > Molecular (Macromolecule, Biomolecule) > Atom; **Foundations:** Cell theory, Ecology, Energy Transformation, Evolution, Genetics, Homeostasis Synthetic biology Taxonomy; **Principles**: Evolution, Adaptation, Genetic drift, Gene flow, Macroevolution, Microevolution, Mutation, Natural selection, Speciation; **Ecology**: Biodiversity, Biological interaction, Community, Ecosystem, Habitat, Niche, Population dynamics, Resources; **Molecular biology**: Cell signaling, Development, Epigenetics, Gene regulation, Meiosis, Mitosis, Post-transcriptional modification; **Biochemistry**: Carbohydrates, Lipids, Metabolism, Nucleic acids, Photosynthesis, Proteins.

1.3 History of XIX and XX century and it influence on developing of the Knowledge [12].

Politics influence on the developed of the knowledge by interaction knowledge-technology: 1. Knowledge-technologies and standard of living; 2. Knowledge-technology and problems of security. Challenge – sustainable society, the world and nature.

Introduction is a short picture of **KNOWLEDGE** to transfer.

2. Digitalization of Business by Smart factory [2-4]

The subject of Industry 4 is Smart factory – based on: integration of cyber-physical systems that create virtual copies of the physical world in the design, monitoring physical processes in the production and take your-self decentralized solutions.

2.1 Knowledge Transfer – Industry 4

The innovations are product of the fundamental results, which show on Fig. 1 – transfer of the full knowledge (see Introduction)

K N O W L E D G E		⇨ TRANSFER
PHYLOSOPHY - Methodology of Science		↓
Mathematics and Foundation of Mathematics	Fundamental Experiments and Mathematical Physics	INNOVATION ↓ TECHNOLOGY
Ecology	History and XXI Century	

Fig. 1 *Subject of Knowledge Transfer → Innovation → Technology*

Knowledge: Philosophy – Methodology of Science; Mathematics and Foundation of Mathematics; Fundamental Experiments and Mathematical Physics; Ecology; History and XXI Century.

On Fig.2 is shown scheme Office of knowledge transfer

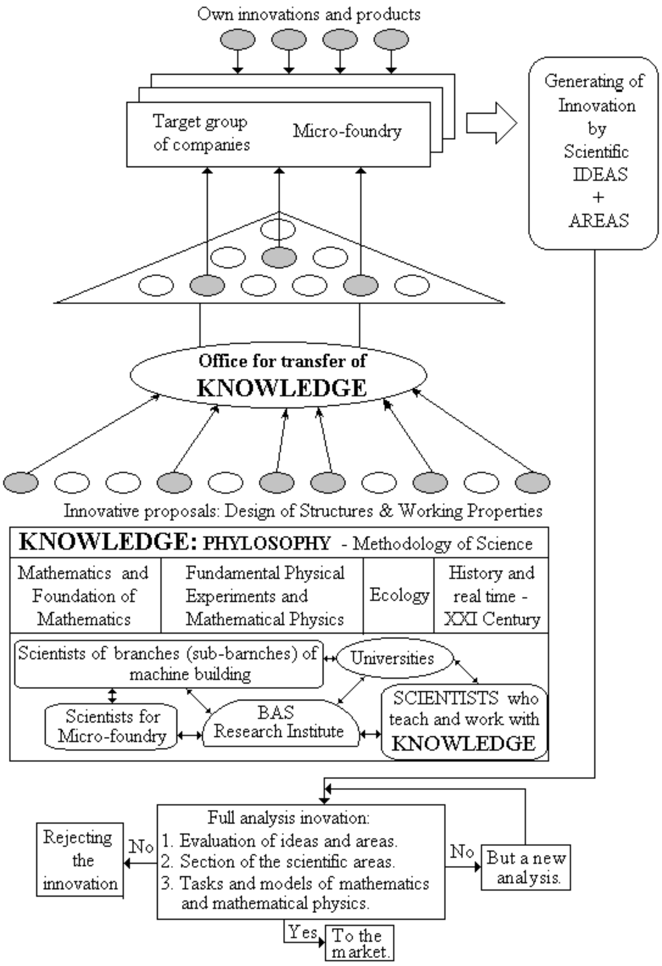

Fig. 2 *Principle scheme of office of knowledge transfer to innovation the subject of cast technology – Design of structures & Working properties*

Knowledge: philosophy – methodology of science of: Mathematics and Foundation of mathematics; Fundamental experiments and Mathematical Physics; Ecology; History and real time of XXI century; Scientists, who teach and work with knowledge; Institutions - Universities and thoroughly Researches Institutes of the Bulgarian academy of sciences; Business branches; Office for transfer of knowledge; full knowledge are whites ⬭ and ⬬ innovations ideas + areas of our transfer are the grays; Target group of companies; Full analysis of generated innovation – micro-foundry.

Sustainable development of the world is necessary to ensure homogenization of standard of living and security, but modern technology cannot provide “renewables” as there is in nature.

2.2 Knowledge Transfer – micro-foundry [7, 8, 9]

Development of knowledge is strongly influenced by ecology and politics, and further hinders research to create new technologies. **Ecology complexity**: everything is connected and its multidisciplinary field of research between model and process in natural systems. **Politics**: History of the World in the 19th and 20th century is very instructive about the impact of policy on the development of knowledge. The achieved standard of living is the biggest confirmation interaction knowledge technologies. Security issues are another impetus to the development of knowledge. Interaction knowledge technologies in the economy provide a reduction of costs of labor, energy, materials and resources.

The structures are obtained in phase transitions of first and second order and winner of working properties of cast materials and products. On Fig.3 is shown: Knowledge transfer for micro-foundry according to Design of structures & Working properties

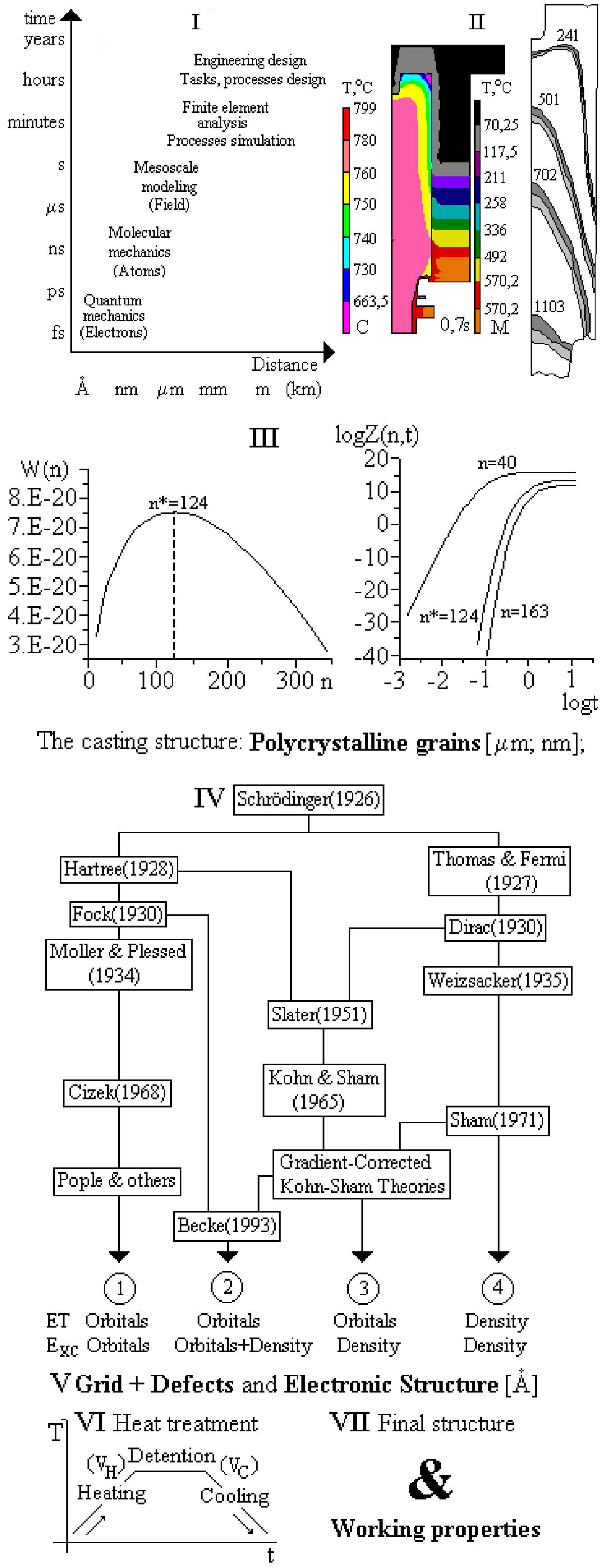

Fig.3 *Knowledge Transfer for micro-foundry – Design of structure & Working properties*

I – Multiscales modeling and structure design; II technological move (regime) of solidification zone – ▰, where develop phase transition of first order; III – crystallization, nucleation work W of nuclei with n particles(atoms), number of nuclei of n particles (n^* – critical nucleus) and the end Polycrystalline grains with size [µm; nm]; IV – quantum chemistry methods, E_T – the kinetic energy of electrons; E_{EX} – exchange functional [5];

V – meso-level structure of grains, Grid+Defects and electronic structure [Å]; VI –heat treatment, phase transition of second order; Heating and Cooling with velocities V_H and V_C; VII – Final structure with Working Properties.

2.3 Economy – little market, micro-foundry and sustainable future

World economy creates ample opportunity for the development of small (local) geography markets. For small domestic market – the main reason as a source of development is the preservation and development of the standard of living. Sustainable future of our economy is transfer Sustainable future of our economy is the inclusion in the fourth revolution Industry 4. For example in the US historically taken [2]: The 1st industrial revolution was driven by the advent of steam engines being used to power production facilities; The 2nd industrial revolution was driven by the assembly line, exemplified by Henry Ford a century ago; The 3rd industrial revolution, which occurred in the 1970s, was driven by the use of computers in production.

2.4 Base principles – smart factories

Interoperability: the ability of cyber-physical systems (delivery of parts, assembly plants and products), people and "smart" factories to connect and communicate with each other through the "Internet of Things" and "Internet Services"; **Virtualization:** virtual copies of the smart factory created by connecting the sensor data to monitor the physical production process with the virtual model of the factory and models for simulation of production; **Decentralization:** the possibility of cyber-physical systems in a smart factory to make decisions for yourself; **Ability to work in real time:** the ability to collect and analyze data in real time for immediate decision-making; **Orientation services:** supply of services (cyber-physical systems, people or smart factories) by "Internet Services"; **Modularity:** flexible adaptation to smart factories to changing requirements through replacement or extension of individual modules; 3D Printer **Security:** the biggest challenge is limiting risks related to security.

2.5 Market "Smart Factory" – micro-foundry.

On Fig. 4 is shown "Smart Micro-foundry" for Industry 4

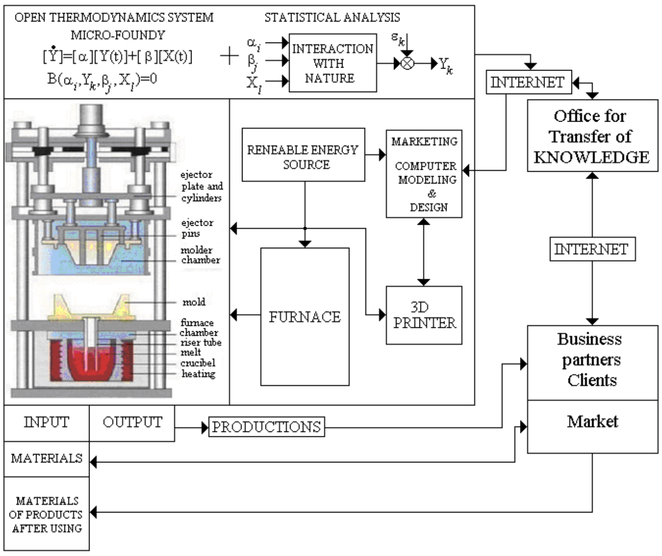

***Fig.4** Ecology–economics complex of "Smart Micro-foundry" on the base of Gas counter pressure casting method – Industry 4*

Micro-foundry is Open Thermodynamics System (OTS) is describe by stochastic differential equation in the subject of Ito – Stratonovich, which introduce transformation input materials and energies flows, where matrixes α_i, β_j – physical and constructive parameters, and i, j =1,…, m; matrixes column X(t), Y(t) – input, output parameters, and k, l = 1,…n; equation B is operator of controllability of OTS, which is support in zero by change of some parameters of control [10]; Statistical analysis ε_k – ecological complexity interaction micro-foundry with nature [6], 3D Printer [11].

For preservation and development of our standard of living is necessary in our opinion to buy and patents to quantum mechanics and economic reforms. The revolution Industry 4 is need of many scientists – mathematicians, physicists, IT specialists, engineering of electronics and computer hardware. Many work places will close. For that reason the workers need of skills of "sustainable job" or "sustainable future" on the base of education of all life.

Scientific Research Fund intensifies through mathematics but complete theory cannot do according to Gödel's theorem. Development of knowledge is through research on its borders, which requires estimates with the greatest likelihood to prove theorems necessary. Development of knowledge is through research on its borders, which requires estimates with the greatest likelihood to prove theorems necessary. Person-year is a measure of infiltration of mathematics and mathematical physics in scientific experiments and micro-companies (family) needed job creation - for example is needed 3600 (person-years per year); BAS total of 35 000 (person-years per year); for the economy to about 100 000. This perspective we believe is aimed at the future with decades ahead, but a mass influx of scientists in the economy should start from many years ago.

X. Conclusions

Knowledge transfer to economy is by Computational Mathematics and Mathematical Physics and patents of quantum mechanics.

Our economy will need for the next years from many mathematicians and mathematical physicians

X1. References

1. http://www.ec.europa.eu/horizon2020/KI-02-13-413-BG-N

2. M. Lorenz, M. Rüßmann, R. Strack, K. L. Lueth, M. Bolle, Man and Machine in Industry 4.0 September 2015, BCG, US.

3. *www.insurancegateway.co.za/.../Irn=13212&URL=**Industry+4**...*

4. *www.spacecad.bg/siemens* Plattform INDUSTRIE 4.0.

5. *https://rsc.anu.edu.au/~pgill/papers/066ECC.pdf*

6. E. C. Bojanov, I. N. Vuchkov, Statisticheski metodi za modelirane I optimizirane na mnogofaktorni obekti, Tehnika, Sofia, 1973. (In Bulgarian)

7. S. Bushev, Theoretical model of structureformation in die casting, Proced. XXII Int. Sci. Tech. Conf. "FOUNDRY 2015",16.-17. April, 2015, Pleven, Bulgaria, p.60-63, ISSN: 1310-3946

8. A. Maneva, S. Bushev, The structure-formation process at casting – methodology for foundries, XXIII Int. Sci. Tech. Conf. "FOUNDRY 2016",13.-15. April, 2016, Pleven, Bulgaria, p.40-43, ISSN: 1310-3946

9. St. Bushev, Mathematics industry economy – micro-foundry, Int. Scientific Journal, Science.Business.Society, Y. 1, 6/2016, p.15-18 ISSN PRINT 2367-8380

10. S. M. Bushev, Thesis of PhD: Controllability problems of crystallization process in casting, TU – Sofia, 1993.

11. www.sffsymposium.engr.utexas.edu/.../2013-66-Snelling.**pdf**

12. www.bg.wikipedia.org/wiki/**История_на_математиката** www.bg.wikipedia.org/wiki/**Философия**; www.bg.wikipedia.org/wiki/**История_на_физиката**; www.bg.wikipedia.org/wiki/**История**; www.eoearth.org/article/Ecosystem.