PRINCIPLE OF THE MINIMUM RATE OF ENERGY DISSIPATION IN RIVER DYNAMICS

XU GUOBIN[1] and LIAN JIJIAN[2]

[1]Professor, School of Civil Engineering, Tianjin University, Tianjin 300072,China
(Tel: +86-022-27401284, Fax: +86-022-27401284, e-mail: xuguob@sina.com.cn)
[2]Professor, School of Civil Engineering, Tianjin University, Tianjin 300072,China
(Tel: +86-022-27401284, Fax: +86-022-27401284, e-mail: jjlian@tju.edu.cn)

A number of researchers extend the principle of maximum entropy only applied to isolation systems to the field of river dynamics, considering that self-adjustments in an alluvial river were subject to the principle maximum entropy (1962' 1964, 1965, and 1987). However, a river is a typical open system. There is no the principle of maximum entropy in open systems (1998, 1977, and2004). The subject of the theories of non-equilibrium thermodynamics is open systems. It is shown that the adjustments of an open system follow the principle of minimum entropy production in the linear region of non-equilibrium (1977).

Helmholtz first proposed the concept of minimum rate of energy dissipation of flow in 1868. Vickerstaff (Великанов M.A.) applied this concept to the field of river dynamics in the 1950s. Yang C.T., Chang H.H. etc. have further developed the minimum rate of energy dissipation since the 1970s (1979, 1994, and 1979). However, the principle of minimum rate of energy dissipation has not been proved theoretically. Usually this principle is also called the hypothesis of minimum rate of energy dissipation.

In this paper, based on the principle of minimum entropy production of the theories of non-equilibrium thermodynamics, the mathematical calculations between the entropy production and the entropy current are performed starting from the Gibbs function in thermodynamics, and by use of the equations of continuity, motion and energy in flow mechanics. An expression of the minimum rate of energy dissipation is obtained. Final, the major conclusions of this study may be summarized as:

(1) The minimum entropy production is equivalent to the minimum rate of energy dissipation. The principle of minimum entropy production is one of the theories of non-equilibrium thermodynamics. It was strictly proved in theory that this principle can be applied to all open systems.

(2) Based on the minimum entropy production, the expression of minimum rate of energy dissipation of flow can be applied to steady uniform flow or non- uniform flow.

(3) The principle of minimum rate of energy dissipation is also one of the theories of optimization approach. On given constraints, a set of decision variables can be acquired by minimizing the rate of energy dissipation of flow.

(4) The self-adjustments of an alluvial river are possessed of the equilibrium tendentiousness, and the self-adjustments are subject to the principle of minimum entropy production or the minimum rate of energy dissipation.

REFERENCES

Leopold L.B.,Langbein W.B.(1962). *The Concept of Entropy in Landscape Evolution.*

U.S.Geological Survey,Profesional Paper 500-A,p.20.

Langbein W. B. (1964).*Geometry of River Channels*. American Society of Civil Engineers Proceedings. Vol.90, pp.301-312.

Langbein W. B. (1965).*Closure on "Geometry of River Channels"*. Journal of the Hydraulics Division.Vol.91 (HY3), pp.297-313.

Qian Nin, Zhang Ren, Zhou Zhide. (1987).*Evolution of River Bed*. Beijing: Science Press, pp.314-316(in Chinese).

Gong Maozzhi. (1998) *Thermodynamics*. Wuhan: Wuhan University Press (in Chinese).

Nicolis G., Prigogine I. (1977).*Self-Organization in Non-Equilibrium Systems*. New York: Wiley- Interscience.

Xguo Guobin, Lian Jijian.(2004).*Changes of the entropy, the entropy production and the rate of energy dissipation in river adjustment* .Advnces in Water Science,Vol.15(No.1),pp.1-5(in Chinese).

Yang C.T., Song C.C.S. (1979). *Theory of Minimum Rate of Energy Dissipation*. Journal of the Hydraulics Division.Vol.105 (HY7),pp.769-784.

Yang C.T. Variational (1994).*Theories in Hydrodynamics and Hydraulics*. Journal of the Hydraulic Engineering.Vol.120 (No.6), pp737-756.

Chang H.H. (1979).*Minimum Stream Power and River Channel Patterns*. Journal of Hydrology.Vol.41, pp.303-327.

Katchalsky A., Curran P. F. (1965).*No-equilibrium Thermodynamic in Biophysics*. Cambridge: Harvard University Press.