Current research of unsteady flow effect on ship navigation

Dahuai Zhao

Chongqing JiaoTong University, institute of hehai, Chongqing 400047, china

Abstract

Summarizing the research status at home and abroad of the basic characteristics of the unsteady flow ,various one-dimensional, two-dimensional unsteady flow numerical calculation method and application in the river network ,unsteady flow effects on ship navigation; pointing out that now most of the scholars on the unsteady flow of research is almost the numerical calculation of unsteady flow, however, the research on how the unsteady flow affect the ship is relatively small; The influence of unsteady flow on ship navigation is studied in the future.

Keywords

unsteady flow； numerical calculation； ship navigation.

1. Introduction

If any space point in the flow field of any element is a movement changes over time, such as the water in the water conservancy project scope is called unsteady flow. And Telionis [1] points out that the problem of unsteady flow can be divided into two categories, is the first kind of boundary conditions and initial conditions change caused by the unsteady flow, such as the flood process, vibration flow around wing, wave flow, etc.;The second category for their formation of the unsteady flow phenomena, namely boundary conditions are the same, because the fluid and formation of the unsteady flow phenomena, such as free shear layer, the instability of jet flow, boundary layer, etc. Channel of the unsteady flow is mainly divided into the first category, implies the second case will happen in the first category, namely, two things will happen at the same time, not a single problem of unsteady flow. Channel flow in channel of the upstream hub drain comes mainly from the influence of peak shaving, hydraulic daily regulation, etc., makes the downstream channel of various hydraulic parameters don't meet the requirements of river shipping.

For channel unsteady flow research at present, most is the one dimension, the basic characteristic of the two-dimensional unsteady flow, did not fully analyze the effect of unsteady flow is how waterway shipping, puts forward the basic are some of the more common solution take temporary solution not effect a permanent cure solution. This article mainly the predecessors' studies on channel unsteady flow at home and abroad were reviewed and summarized, induction, and provided a basis for further work.

2. unsteady flow research status

According to the research on unsteady flow path, unsteady flow on navigation are studied for waterway design water level, velocity of channel and channel scour evolution, navigation of the ship.In terms of research on unsteady flow method, from the classical to the saint venant equations is a set of complex partial differential equations of evolution in today's all kinds of differential equation, the various solutions to differential equation method.

2.1 the influence of unsteady flow in channel water level

Unsteady flow produced mainly upstream hub building drainage channel, peak shaving, and daily regulation process and so on, eventually produce is the result of the passage of water level change in a day, very frequently, especially daily regulation process of power plant, waterway traffic may not satisfy the basic requirement of ship navigation, navigation obstruction. Adenocarcinoma [2] wujiangdu channel two-dimensional mathematical model is established, and verified the downstream channel of water level and velocity distribution, points out that under different conditions, the channel

change rate, liquid flow rate, the level of the slope rate of change along the river along the lower, steep steep fall in the flow change had the greatest influence on channel and under various hydraulic parameters in the same circumstances, channel cross section area, the greater the unsteady flow smaller influence on channel. Zhi-li wang [3] in the process of research xiangjiaba or diarrhea, analyzed the dam downstream unsteady flow propagation law, it is concluded that the dam downstream channel water produce certain additional gradient, bind the relation with the water level and flow rate, and the unsteady flow of the lateral deformation of wave will happen that rose water, water wave extrusion caused water steepening; Water, water waves stretch led to the steep fall in the water.Min-xiong cao [4] points out that the hub in the process of drainage, water can satisfy the lowest navigable water level downstream channel, and channel will be in the water wave deformation, make water steep steep fall, affect the navigation. Chong-ming li [5] that will make the plant daily regulation process of downstream water level amplitude is bigger, so that the downstream river water level as steep falls, the surface of the slope increases, the flow regime deteriorated, can not meet the requirement of the ship. High runners-up [6] based on the research of the daily regulation of three gorges power station, found that day water level change more frequently, water level more low, duration, and low water level greatly affect the three gorges shipping irrigation and so on.Argument based on the above literature, can know in peak shaving hub buildings, flood drainage process such as the middle and lower reaches of channel depth is basically meet the requirements of navigation water level, but Tang Yinan [7] pointed out that in the process of water hub buildings caused by the unsteady flow in the downstream channel of water wave trough in the depth of the water does not meet the navigation water depth, individual beaches may have certain restrictions on navigation. Therefore, water level in the channel depth requirement is not a simple and should pay attention to the channel depth of required to draft also to meet the requirements.

2.2 the influence of unsteady flow in channel flow velocity

For waterway in the navigation channel flow has certain requirements, if excessive velocity in the channel, the upside of ship by resistance is larger, or more energy, and cause the waste of resources; Downward ship due to the large flow rate, the ship in the river bend space measures required will be higher, otherwise it will lead to bump the wall of the ship.If low in the channel, downward ships cannot use water flow velocity, makes the resources are wasted and not make full use of. LePei nine [8] of xiangjiaba power station daily regulation under different working conditions, study the change of flow in the downstream channel, points out that the downstream channel flow along the Cheng Tan, the maximum flow frictional reducing transformer along the lower and flow rate, flow velocity increases with the flow in the downstream channel. Min-xiong cao [4] according to the corresponding data, xiangjiaba hydropower station, the downstream channel is given, namely, relation between unsteady flow and channel flow velocity along the flow rate is proportional to the flow rate, and higher stage water velocity generally greater than the water with the traffic flow, but the flow velocity and flow rate, cross section shape. Min-xiong cao [9] pointed out the reasons of power station daily regulation velocity increases, the water discharge increase, with the increase of moments before drainage wave slope at the same time, the channel flow rate increased; Analyzed under, along the water surface slope and velocity decreases with the bottom of a water wave back Mother DE wei [10] considering power station daily regulation, the deterioration of the unsteady flow of the downstream channel navigation condition, put forward to adapt to the navigation condition of hydraulic parameters of the channel, which considering the main factors of the water level amplitude, velocity, water surface slope.Chong-ming li [5] points out that channel under unsteady flow influence, in the small and micro foundation, found that the velocity, water depth and slope will change anytime and anywhere, not follow certain regular changes.

2.3 the influence of unsteady flow in channel evolution

After the construction of water conservancy hub in the upstream, the upstream water will form a reservoir before hub building, originally with sediment precipitation gradually formed water, hub is leaking water drainage, water carrying capacity is very strong, however, and drain water ratio,

scouring riverbed is more significant, as the downstream river slows down, the sand will gradually sink into the channel, the more and long time will cause the channel siltation, lead to navigation and waterway regulation efforts will also increase. ShenXia [11] by establishing make physical model research after the lock drainage channel water features, water surface slope, velocity distribution in flow intensity, when the flow velocity and water level over a certain range, will affect internal channel and various water conservancy facilities, and put forward to extend the hub drainage time, on-line bank protection structure. Rong-yao ji [12] points out that the hub for the drainage of unsteady flow, water level, flow characteristic, the frequent large fluctuations in the downstream river channel, the channel and navigable conditions have a significant impact.

2.4 the influence of unsteady flow of the ship sailing

Hub building drainage of unsteady flow, for the downstream channel, channel of large variation range of water level, the uneven distribution of flow velocity, water surface slope variability, such as the channel deposition occurs, makes in the passage, ship speed, hull drift Angle is affected, so that the staff in the process of ship operation is very difficult and ship time is relatively long. Min-xiong cao [4] are also pointed out the ship sailed under the condition of unsteady flow, the ship up and down the steering range and drift Angle, speed on the extreme value is a constant flow increases, and the rise of water during the steering range is greater than the water. MinYuXiang [13] points out that the power station, adjusting process can make the downstream channel flow velocity and slope changing, increase the ship sailing in the downstream channel of weathering.Long Qijian [14], zhi-li wang [3] is also pointed out the unsteady flow in the downstream channel is very big to ship. Anyhow, unsteady flow in channel channel depth change, swell, uneven flow velocity, water surface slope that resulted in the ship navigation is very difficult in the channel.

3. unsteady flow numerical calculation

3.1 the basic introduction

In 1870, saint venant estuary tidal wave velocity is studied, and the French academy of sciences in 1871 on the association of published two articles, estuarine tidal wave velocity formula is given and the theory and the general equation of unsteady flow in open channel flow the saint venant equations, laid a theoretical basis for study of unsteady flow in open channel flow.The calculation method of one-dimensional unsteady flow of thought is mainly based on flow continuity equation and energy equation for the corresponding correction. Saint venant equations is a set of complex partial differential equation, the solution to roughly show difference method, implicit difference method, three kinds of characteristic line method.Application at present most is showed difference method [15-19] and Preissmann implicit difference method [20] at four o 'clock, and its use in river network, solving practical problems.

3.2 numerical calculation

For unsteady flow numerical calculation can be traced back to the 19th century French flume experiment, established a series of the saint venant equations known as the saint venant equations. Saint venant equations to solve, you may need to certain solving condition (initial conditions, boundary conditions and convergence conditions) to get its solution, and its analytical solution, needs simple terrain conditions and simple or demodulation, for river terrain is relatively complex, generally can not its solution can be got directly, only through a large amount of computing trial out to results.In the popularization of the computer is not age, numerical calculation of unsteady flow generally calculate by hand, calculated on a smaller scale, for general equations for the corresponding simplified, instead of the unsteady flow in steady flow conditions or assume linear equations to deal with, so that the equations of calculation result is not accurate. Computer popularization, the saint venant equations solution obtained fast development, improve the accuracy of the calculation results, more in line with people's needs. Forsythe [26] with finite difference method is proposed to solve the partial differential equations. Zhou Xueyi [27] pointed out that the solution to the saint venant equations according to the basic principle can be divided into discrete characteristic line Method

(Mehtod Of Charaeterisites), Finite Difference Method, Finite Difference Method), the Finite Element Method (Finite Element Mehtod), Finite Volume Method (Finite Volume Mehtod) and limited analysis Method. Abbot [28] put forward using the numerical method of characteristic line, calculation of unsteady flow in open channel flow.Liggett [29] proposed the unsteady flow in open channel flow equation by finite difference method.Lax, conviction yourself [30] replace partial differential equation with finite difference equation to solve the unsteady flow in open channel flow. Davis, [31] Cooley [32] by finite element method is proposed to solve the unsteady flow equations.Wei Lin [33] straight to continuous equation and motion equation using column in the rivers' four point implicit scheme for discrete difference equation, three-stage method to solve.Kai-lin Yang [34] based on the unsteady flow in open channel flow's column to the implicit difference method, matrix transformation is adopted to establish the channel inlet flow and water depth of linear equation. Dronkers JJ [35], Zhang Erjun [36], Wu Shougong [37, yi-tian li [38], kai-lin Yang [39] for already china-africa constant flow, using iterative implicit difference method is used to solve large linear equations, and points out that the method can be divided into two types: direct method and classification method. Xiao-xiang feng [40] using complex boundary, VF sigma coordinate transformation method to track the free surface change to establish vertical two-dimensional unsteady flow and suspended solids distribution mathematical model and use Simple algorithm to solve the control equations. Yu-chuan bai [41] river problem of unsteady flow in river network ultimately comes down to one dimensional saint venant equations to solve the problem, and the river cross flow in the place of the join condition is continuous flow of conservation of energy and water. Xin wu [42] will be one dimensional unsteady flow numerical method (difference calculation of finite element is employed to solve the saint venant equations) is applied to the Cao E river water level prediction, and comparing with the mas Beijing root method in hydrology and its forecast effect is more accurate, at the same time of the unsteady flow equation is derived, related unsteady flow model is established. WuNing [43], FuDianLong [44] is pointed out that the solution of one-dimensional unsteady flow mathematical model is mainly the saint venant equations to solve the problem, and touchdown is introduced on the basis of solving the saint venant equations of one dimensional unsteady flow model method.

4. The prospect

Above all, the generation of unsteady flow is mainly due to the river upstream hub buildings on the upstream water gathered themselves together, and makes the hub buildings out of the water level rise, when the flood comes or hub daily regulation process makes the hub buildings need to drain the water and lead to the downstream channel of water level, flow rate, water surface slope, flow intensity moment and so on various factors change, the channel of ship sailing in drift Angle increases, the steering frequency increases, the navigation becomes more difficult.In addition, the upstream hub leakage is leaking water, water sand carrying ability is stronger, however, the erosion of downstream river bed is very serious, follow down along the river, flow velocity decreases, sand will sink and lead to downstream channel sedimentation, navigation obstruction. Most scholars study of one-dimensional unsteady flow in river network model of the solution, not the effects on the unsteady flow for the navigation of ships have those doing the specific introduction. Open research questions as follows:

(1) curves frequently in mountainous rivers, rivers flow state can form unsteady flow state, lead to ship in the waterway navigation within the affected, now most of the scholars are outstanding ship to how safe navigation in mountainous rivers are no unified regulation, ship sailing on the mountainous rivers should be controlled by those factors?

(2) the river water upstream hub set, makes the present state of water drainage of water, to the downstream river channel scour ability is very strong, with the strong ability of sand, and walked along, water flow at a slower pace, sedimentation, lead to channel is blocked, navigation of ships, for channel sedimentation should how to punish?

For analyzing aerotaxis mountain rivers, choose different rivers or for the same river state in the very different location to establish the corresponding physical model, simulate the rivers in the process of sailing, analysis the river flow state is how to affect the navigation of ships, in the process of the census and statistics department ship sailing ship for unsteady flow state is how to deal with, whether relevant processing measures. Aerotaxis by a large number of mountain river model simulation research, we can find out how to control the ship sailing on the unsteady flow of the balance. Now for the channel regulation does not deal with channel deposition of sediment, the measures are mostly built along, reinforce the riverbed, and so on protective measures. But for comparison with the common drain intervals during the flood, the construction of the spur dike is under two conditions can make full use of it?I don't think so, because the building of the spur dike is to speed up the increase of flow velocity, drainage for usual time still can use, but for the flood during the spur dike will speed up the flow, make the river washed, sediment will be more and more, it does good. We can set up a kind of activity at the site where the sediment siltation often spur dike, common drain intervals remain the same, in the flood period, reduce the height and length of spur dike, makes the water flow rate not significantly accelerated, establishing deposition of sediment was taken, riverbed not washed the balance.

References

[1] Telionis D P. Unsteady Viscous Flows [M]. New York:Springer-Verlag,1981.
[2] Adenocarcinoma, Li Bohai xiao-fei liu. Wujiangdu hubs downstream channel 2-d unsteady flow mathematical model research [J]. Port &waterway engineering, 2012 (7) : 161-165.
[3] Zhi-li wang yong-jun lu. Xiangjiaba water conservancy hub or drainage of the unsteady flow numerical simulation [J]. Water conservancy and hydropower science and technology progress, 2008, 28 (3) : 12-15.
[4] Min-xiong cao, Ma Aixing Hu Jinyi. Plant daily regulation effects of unsteady flow of waterway regulation [J]. Journal of waterway transportation, 2011, 3:10 to 17.
[5] . Chong-ming li. The three gorges power station daily regulation effects on gezhouba above the river shipping. Sichuan water. The first issue in 1994. 15 volumes
[6] High runner-up, li kwok pan, yong-jun lu. Daily regulation of three gorges power station's influence on the downstream water level of yichang station [J]. Journal of waterway engineering journal, 2009, 2:50-53.
[7] Tang Yinan Wu Xueliang. Bailong river drainage of bikou hydropower station instability variation along the river and its influence on the downstream channel [J]. Port &waterway engineering, 1983 (2) : 16-22.
[8] LePei nine, wang. Plant daily regulation discharge impact on downstream shipping and its prevention measures [J]. Journal of waterway port, 2004 (suppl) : 52-58.
[9] . Min-xiong cao, PangXueSong hsiu-hung wang, etc. Of xiangjiaba power station downstream unsteady water and sediment characteristics study [J]. Journal of waterway engineering journal, 2011 (1) : 28-34.
[10] Mother DE wei, rencent, xue-ming li de-yu zhong., xiangjiaba, adjust the unsteady flow in the downstream shipping conditions affect study [J]. Journal of sichuan university, 2014, 46-48 (4) : 71-77.
[11] ShenXia, sheree, chang-hui ji, wang yongping. Lock the unsteady flow characteristic of the drain and navigation safety measures [J]. Journal of China harbor construction, 2016, 4 (4) : 34-38.
[12] Rong-yao ji, yong-jun lu, left chin. Hydropower junction or unsteady flow under the action of waterway regulation research [J]. Journal of water conservancy, 2007, supplement: 318-323.
[13] MinYuXiang. Daily regulation of three gorges power station's impact on shipping [J]. Port &waterway engineering, 2002, 5:28-31.
[14] Long Qijian Li Kefeng, Wang Qing liao. Joint regulating unsteady flow of cascade hydropower stations on the influence of the shipping safety of the hub [J]. Water conservancy water transportation engineering journal. 2011.3:92-97.

[15] Wang Dingyang, Rudolf, md. One dimensional numerical calculation of unsteady flow in open channel flow [J]. Journal of water conservancy, 1986, (11) : 38 and 43.
[16] Wu to d, an albino. Difference scheme with diffusion solution of one-dimensional unsteady flow in open channel [J]. Journal of chongqing jiaotong institute, 1985, (4) : 56-63.
[17] Huang Jingxiang. Drag items to open channel unsteady flow calculation stability of difference scheme of the study [J]. Journal of wuhan institute of hydraulic and electric engineering, 1986, (3) : 1-7.
[18] Koren,V.I.The Analysis of Stability of some Eplicit Finite Differenc Schemes for the Integrating Saint-VenanEquations, Meterologiyai Gidrologiya no1,1967.
[19] Garrison,J.M,Granju,J.P,Price,J.T.Unstea-dy Flow Simulation in River sand Reservoirs,J.of Hy.Div.ASCE,Hy5,1969.
[20] .Cunge,J.A,Holly,F.M,Verwey, A Practical aspects of computational river hydraulics, Pitman Advanced Publishing Program.1980.
[21] .Mahmoodm,Kand Yevjevich,V. Unsteady Flow in open channels.Water Resoanes Publications,1975.
[22] .Chintu Lai.Numerical of Unsteady Open-Channel Flow. Advances in Hydrohydro science, 1986, Vol14:163-333.
[23] Chen Y,Falconer R A. Modified forms of the third order convection Secondord Erdiffusion scheme for the advection diffusion equation. Advances in Water Resources, 1994, (17):147-170.
[24] Tan Weiyan. One dimension is not a constant flow in open channel flow calculation package MYCB [J]. Journal of water conservancy. 1982, (1) : 1-11.
[25] Heptyl vader, Zhao Xiaoxia, huang. One dimension is not a constant flow in open channel flow implicit finite difference numerical solution [J]. Journal of water conservancy, 1986, (4) : 41-47.
[26] .Forsythe,G.F,Wasow,W.R.,Finite-Difference Methods for Partial Differential Equations, John Wiley and Sons, New York, 1960.
[27] Zhou Xueyi. Computing hydraulics [M]. Tsinghua university press, 1989.
[28] Liggett, J.A.,Woolhiser,D.A.,Difference Solutions of the Shallow-Water Equation,
[29] Jour. Eng. Mech. Div. ASCE., vol. 93, April.1967, 39-71.
[30] Lax,P.D., Weak Solutions of Nonlinear Hyperbolic Partial Differential Equations and Their Numerical Computation Communicatio- ns on Pure and Applied Mathematics. Vol.7,1954, 159-163.
[31] Davis, J.M., The Finite Element Method. An Alterative Subdomain Method for Modelling Unsteady Flow in Coastal Waters and Lakes.
[32] Cooley, R.L., Moin, S.A., Finite Element Solution of Saint-Venant Equations, Jour., Hyd. Div., ASCE., vol.102, Sept.1976, 1299-1313.
[33] Wei Lin, zhan-feng cui. One-dimensional unsteady flow calculation program of preliminary study [J]. The people of the Yangtze river, 2001, 32 (12) : 30-32.
[34] Kai-lin Yang. Already unsteady flow graph theory principle [J]. Journal of water conservancy, 2009, 40 (11) : 1281-1289.
[35] Dronkers JJ. River district in offshore, and off the coast of tidal calculation [J]. Journal of waterway transportation science and technology intelligence, 1976, (8).
[36] Zhang Erjun, etc. The unsteady flow level 3 joint algorithm [J]. Journal of east China institute of water conservancy, 1982, (1) : 12-13.
[37] Wu Shougong. Unsteady flow level 4 solution algorithm [J]. Journal of water conservancy, 1985 (8) : 42-50.
[38]. Yi-tian li. The unsteady flow of implicit equations crunode grouping method [J]. Journal of water conservancy, 1997 (3) : 49-57.
[39] [39]. Kai-lin Yang, Bai Zhengyu. Water transfer already unsteady flow linear transformation algorithm [J]. Journal of water conservancy, 2004 (4) : 35- 41.

[40]. Xiao-xiang feng, Zhang Xiaofeng, zhan-feng cui. Vertical two-dimensional unsteady flow and suspended solids distribution model study [J]. Advances in water science, 2006 (4) : 518-525.
[41] Yu-chuan bai, maxell, spring ben-sheng huang, gu yuan Yan. The research progress of numerical simulation of unsteady flow [J]. Journal of water conservancy, 2000, 12:43-47.
[42] Xin wu. One dimensional unsteady flow numerical model in the application of okxzm [D]. Nanjing: hohai university, 2006:1-57.
[43] Wu Ning. One dimensional saint venant equations in the application of the unsteady flow calculation [J]. The people of the Yangtze river, 2001, 32 (11) : 16-18.
[44] Fu DianLong, one-dimensional saint vacant equations of characteristic line method [J]. Journal of nanchang university, 2006, 28 (4) : 386-389.