Numerical and Three-dimensional Modeling of Flow on Floodplains Covered with Vegetation by Sediment Simulation in Intakes with Multiblock Options (SSIIM) Software

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Abstract : There are hydraulic differences between flow conditions in main section of rivers and floodplains. Under such circumstances flow will be complicated in which they will create interference and width interchange of momentum and also a great mass during flow. Thus, in this study, researchers have performed numerical simulation and three dimensional of flow in rivers with floodplains covered with vegetations. In this study, a series of data have been prepared by using hydraulic Basics related to flow in rivers with floodplains and also other researchers information about vegetation in flood plain, and then modeling by using SSIIM software. The results of modeling will be observed and analyzed by statistical indices of correlation coefficient, sensitivity coefficient, root mean square error and absolute error.

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Key words: vegetation in floodplains, numerical simulation, three dimensional simulation, rivers with floodplains, SSIIM software.

Introduction

During flood in the majority of (Alluvial rivers), water is steepened from main trench and arrived in lateral plains. On these circumstances, the simple and current framework of river section will turn into composed section. It is massively used in designing irrigation and draining systems, channel of transporting water, channels of the flood, River irrigation sections, overflow drains and waste direction . Researchers' investigations in campestral (outdoor) and laboratorial composed sections demonstrated that average Debi of crossing flow from this sections won't be easy. Under these conditions, as soon as arrive flow from main sections to floodplains flood plains, whirlpools will be form between borders of both parts and create rotating flow in width and length. Because of this phenomenon, a part of flow Momentum of main sections will be transferred to floodplains and decrease the rate of flow in main sections and increases it in floodplains. (shiono and knight 1988).

By crossing water flow, because of vegetation Resistance the rate of flow is decreased while its depth is increased during the way. On the view of hydraulics, Vegetation will be able to increase roughness flow direction .while flow rate average will be reduced. Existing roots and vegetation will cause either reduction in wall cut stress or orison stress, in the surface of soil as well as resistance and integration of soil. In the rivers in which are covered with vegetation, coefficient of roughness will be varied by changing of speed, flow depth, the rate of Sedimentation, morphology, way, sort, density and plants' Height.(Fathi Moqadam 1996).

Ayoubzadeh and Zahiri(2004) studied flood management in flood plains by two-dimensional mathematical model. This method is used in non-symmetrical composed sections with wide flooding plans and its results compared with usual method in which there is a egregious difference between them.

Safarzadeh Gandshemin (2009) researched the structure of distressed flow and qualitative consideration of entering Sediment mechanism to lateral lake in the bow of a river by using a three-dimensional numerical model. Proportional conditions of direct lines of underneath and superficial flows in refilling from bow are completely different from direct way and its significance has an important role in secondary flow derived from bow in controlling inner sediment by underneath flows into lake.

Hakimzadeh (2004) is described 3-dimensional numerical modeling in Port River by turbulence 0 and 2- equation. General research of numerical result demonstrated that equivalents of turbulence 0 model will prognosticate lower numerical values for water flow rate into harbor of river; while, 2-equation turbulence model, predicts logical numerical values for these flow components in which these values expressed suitable conformance with laboratory data.

Ismaeeley et al. (2007) described effective factors on sediment transportation in overflowing flood conditions. This research was done with pointing to overview sediments transportation system in seasonal rivers derived from suddenly floods by modeling natural conditions in a laboratory flume with gradient plasticity. results indicated that during study with same hydrographs, on the view of maximum Debi, the median sediment will reduce while basic time of hydrograph is increased but transportation sediments rate will be more than stainable conditions. Hydrograph flooding of median Discharge of transferring bed load in stable conditions will be nearest to transferred bed load when basic time is increased.

Laboratory modeling of breaking hydraulic dam by arriving fast flood to reservoir is analyzed by Abbasi et al. (2009). These results showed that offloading tank period will reduce when rudimentary depth reserving in tank and channel slope are increased. In addition existing sediments in reservoir in which plays a satire role in flow way will increase positive wave movement speed toward down position. Enhancing depth in down position after breaking can be seen because of enhancing basic time and hydrograph Debi maximum.

Keshavarz and his colleague (2008) present 3D numerical simulation of flow pattern around drains drown perpendicular and inclined to coast by observing different border situations. We used 2-equation disturbed model of k-e from all the disturbed models. Rigid-lid and volume of fluid have been used in order to notice free level effect in which volume expressed better accommodations compared with experimental results.

The hydrodynamic of disturbed flow pattern in Bow River was studied by using 3D numerical model (Husseini et al. 2007). Gained results domesticated that the accuracy of k-w model in predicting flow field is high and this model completely predicts secondary flow pattern and changing disturbed testify whole the field long.

In a study by using laboratory data, parameters changing of flow were looked for hydraulic flow rate in a channel of erosion plain covered with vegetation. Its results showed that vegetation will significantly increase alternative effects of flow in main interrupted and flood plain and will reduce Debi in flood plain and whole the channel. (Qolinezhad et al. 2010).

There are many studied in using SSIM model such as numerical simulation of water flow in transition water of channel (Mirmoazen and Pirestani 2008),numerical study of lateral erosion of rivers with sand bed (Tabatabaee et al. 2009),numerical simulation of flow hydraulic in Convergent curved 90 degree (Hosseini, Serqin and colleague 2009), Jertin pattern in 90 degree lake (Seyedan et al. 2007), Jian 3D modeling in river with vegetation (Wilson et al 2006), flow pattern in 55 degree lake (Karami Moqadam and colleagues 2008), 3D modeling of Sediment washing in dam reservoir (Haun and Olsen 2011), crossing flow modeling over board edge overflow (Haunt et al. 2011), flow in gate cover with vegetation (Wilson et al. 2004). Crossing flow in reserved satire (Bihs and Olsen 2009), bed balance changing in channel s (Feurich and Haun 2010).one dimensional mathematical model has been massively used in river engineering plan by hydraulic engineers while 2 dimensional models have used. Both of them have some limitations in which should be observed in gained results analysis. So, using 3D models is necessary.

The total target of this research and investigation is numerical and 3Dflow modeling in flood plain with vegetation.

Method and materials

Mathematical model of study

In this study, SSIIM model is used in order to simulate flow field. In fact, it is a 3D model for simulating flow field and transferring sediments with great ability in using different disturbance models. Evaluation of results will be done by using measured data.

This part will describe 3D equations of flow and sediments transmission in which will solve in 3D numerical model, and numerical solution method. 3D mathematical model is SSIIM in this study.

SSIIM used either structured grid in SSIIM1 either unstructured grid in SSIIM2 model for solving equations in which it consists of 2 sub-structures of numerical and graphical solutions. flow equations in this software is averaged equations of navvir –stotex timing entitled Reynolds equations (RANS). The total form of these equations consist of a cohesion equation and 3 momentum equations in 3 directions.

Hypothesis based model

The most important hypothesis based equations in which use in model consist of (Olsen 2010):

- Uncompressibility
- State equation
- Newtonianyear
- Averaging Reynolds

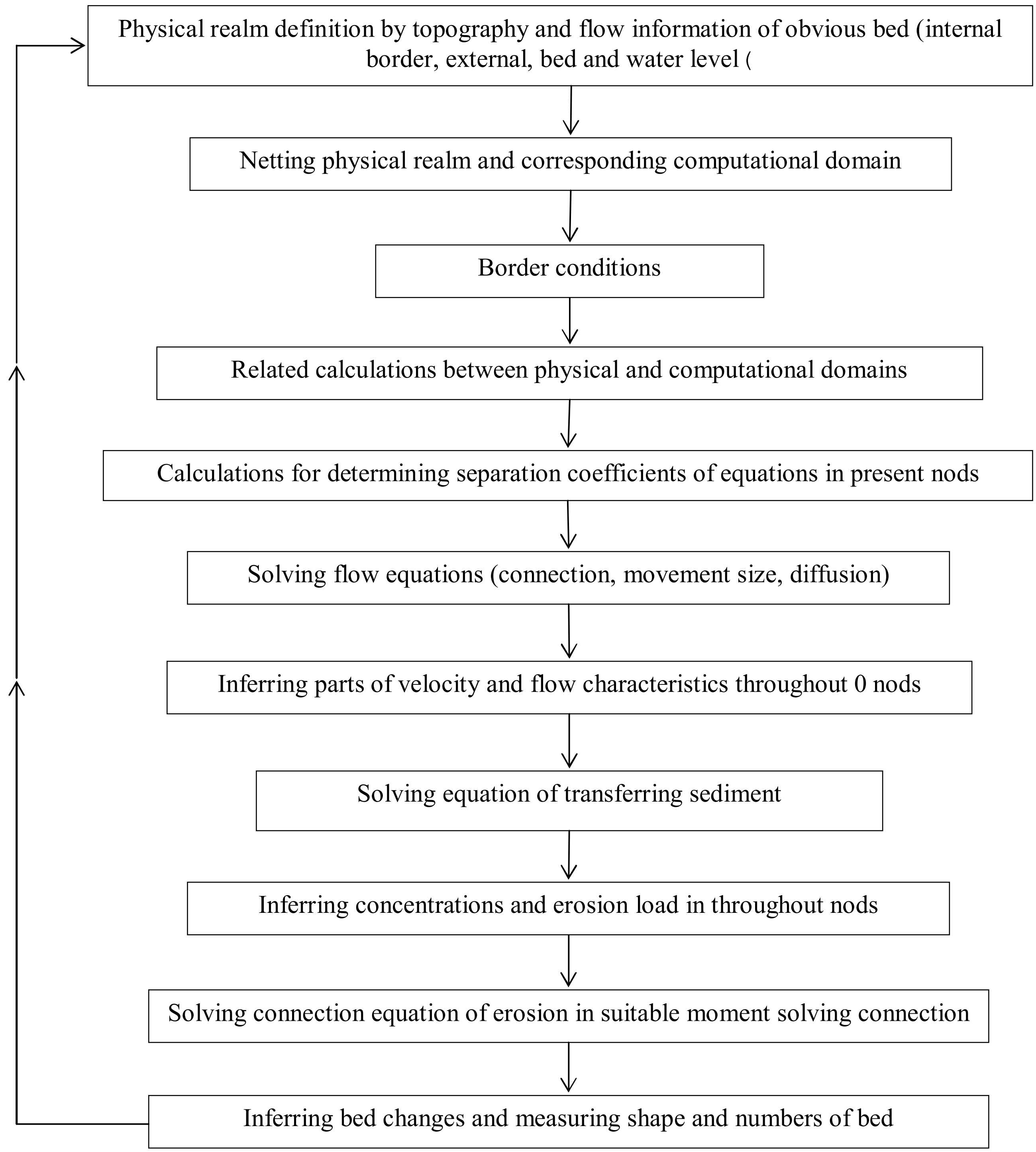
Numerical model SSIM uses wall law for border conditions in both of diffusion models. More details can be seen in Wilcox 1998 and Olsen(2010).

3D model use variation models of eddy viscosity zero equation (isotropic, non-isotropic, and constant) as follow:

$$\nu_t = \lambda_t H u_*$$

Where λ_t is non-dimension eddy viscosity and its assumed as a constant number.

The flow chart of numerical solution procedure in model is:



Laboratory Model Introduction:

Used data of this research come from doctorate thesis of Chatila 1997 in civil engineering of Canadian Ottawa university in which has studied pollution transition and continual flow in channel with composed section and Flood Plain Rivers. The experiment has been done in a flame with 29.26 meters in length, 0.7887 meters in depth, and 1.498 meters in width in 0.00069 meters slope. The wide of main section is 0.787 meters and right direction of flood plain is 0.2098 meters.

Evaluating velocity is done in a section with 12.24 meters distance from upstream. Calculation framework has DX=25cm and DY=7.9 cm with 20 control volume in perpendicular direction. lines network are placed in perpendicular direction in 0,0.05,0.1,0.15,... h toward bed.

Competitive field has 29.26 meters length, 1.498 meters width. Continual flow with relative depth is 0.138 (depth in flood plain ratio to main section). Border condition of upstream in constant Discharge type of cubic meter is 0.068 seconds cubic meters on second and border line of Dirishleh for other alternatives and in downstream from constant depth type and gradient is 0.246 meters and 0, respectively. For solid border, border condition based wall is usable for all the alternatives.

Discussion

Modeling hydrodynamic of flow field in composed sections and rivers of flood plain was performed by 3D numerical model in previous part of meticulous analysis on parameters and also the best composed was determined. In the end, the best performed parameters and their results were presented in which k-e had the best results (fig.1).

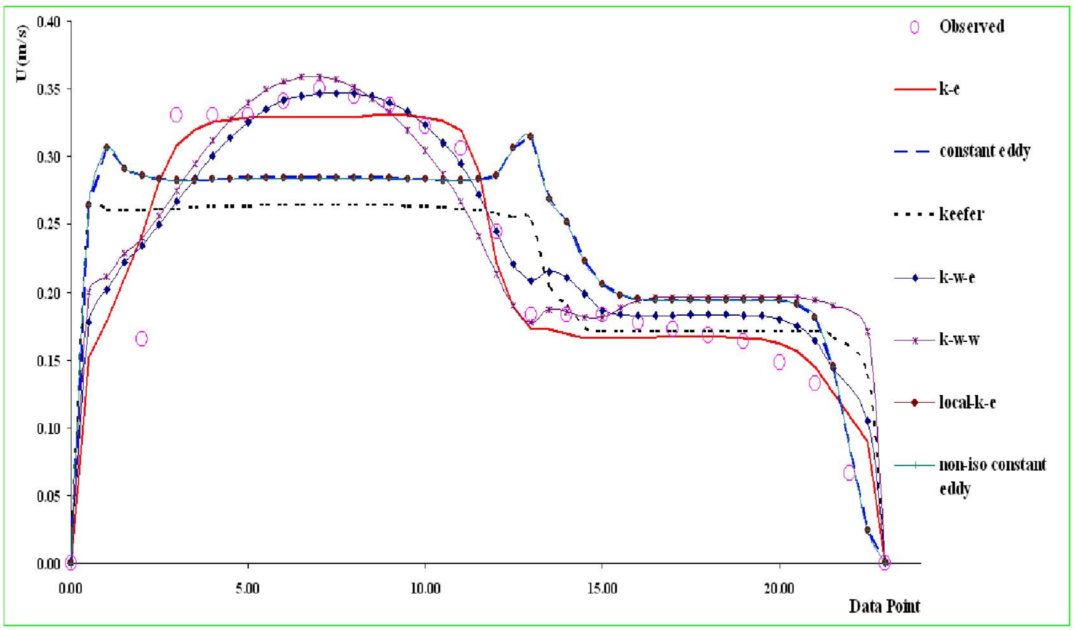


Fig 1. The results of various turbo balance models in grid particle using the best composed parameters.

Evaluating numerical model results in simulation of flow distribution in flow in flooding plain covered with vegetation:

This matter is simulation of flow in uncovered channel with saturated vegetation in which has been modeled by Fisher-Antz- et al (2001) by SSIIM model. This vegetation is to be assumed as like as perpendicular cylinders and their resulted resistance powers have been modeled by drogue power and drogue coefficient. The plethora resistance power resulted from vegetation in the sink form is added to right part of Navir-Stotex momentum equation and simulated by a numerical model. Another method is to be used greater roughness coefficient instead of source term in momentum equation in which resistance power resulted from vegetation only performers in neighborhood of bed and dose not model its effect on the flow depth; for that reason equivalent cylinders and drogue power are performed over flow depth. Gained result from reforming numerical model with laboratory data and also numerical research results is compared by fisher-antz (2001). As mentioned in chapter, momentum equation in numerical model is as follow:

$$\frac{\partial U_i}{\partial t} + U_j \frac{\partial U_i}{\partial x_j} = \frac{1}{\rho}\frac{\partial}{\partial x_j}\left(-P\delta_{ij} - \rho\overline{u_i u_j}\right) - F_i \qquad i,j = 1,2,3$$

The comparison between this equation and equations of previous chapter shows that an extra resistance power is added to right part of equation with a negative sign(-F_i) in which can be interpreted as a external power such as koriolis, drogue power, gravity, etc. the extra resistance power resulted from saturated plant in high plant unit can be modeled as follow:

$$F_{D,i} = \rho \frac{U_i^2}{2} C_D \lambda$$

Where plant population coefficient in control volume unit () is:

$$\lambda = \frac{\Pr ojected\ \ area\ of\ \ plant}{total\ volume} = \frac{D}{l\,s}$$

Where D, cylinder diameter, I,s dimensions of control volume surrounded cylinder in either width or length directions. CD drogue coefficient for diffusion flows with Reynolds numbers greater than 1000 for cylinder is equal to 1. Experiments were performed in a flume with 19.5 meters in length and 0.91 meters width. Diameter, distances, high and depth of elements are 6.4, 7.62, 12 and 33.5 centimeters, respectively and in numerical model X and Y are 0.5 and 0.05 meters, respectively. Flow depth is shared into 20 control volume. Reynolds number is 2.24 *105 and flow number is 0.33. 3D numerical model results with laboratory data and numerical modeling of fisher. Antz et al (2001) in channel with rectangular section are compared in Debi of 0.179 and 0.058 M^3/s. Respectively. the average of relative error percentage in simulated values of normal section in Debi 0.179 and 0.058 are 0.179% and 17.3 % respectively, and in fisher-antz et al (2001) are 6.93 and 16.1 respectively. Qualitatively, simulation accuracy at present time, is confirmed during comparison with similar previous research

Numerical model results in simulation of velocity distribution in flow on flooding plains covered with vegetation:

In this part, the model result compared with measured data in channel with composed section is compared with flooding plain rivers that are available in below chart.

Discharge (m3/s)	0.057	0.041
Relative error in this research(%)	10.7	7.36
Relative error in Fisher-Antz et al.,(2001) research(%)	15.36	5.43

Numerical model accuracy in simulation of velocity distribution in composed section and rivers of flooding plain have been researched in this part. Utilized data in this parties related to doctorate thesis of Chatila (1997) in civil engineering of Canadian Ottawa University in which have studied continual-uniform flow in channel with composed section and rivers of symmetrical flooding plain .experiments were done in a flume with 29.26 meters in length, 0.7887 meters in depth, 1.498 meters (width) in a 0.00069 slope .the width of main section and right direction flooding plain are 0.787 and 0.711meters, respectively. The depth of main section attitude toward flooding plain is 0.02098 meters. Measuring velocity was performed in a section with 12.24 meters from upstream. Calculating network has DX=12.5cm and DY=3.95 cm (level ratio 3.2) and control volume in perpendicular is 40. Network lines is located in perpendicular direction in 0, 0.05, 0.1, 0.15, etc. Highs and h toward bed (h = flow depth). Computational Square has 29.26 meters in length and 1.498 widths Continual and uniform of relative depth in 0.147 (depth in flooding plain ratio to overall depth). Border condition of upstream is 0.068 m^3/s stable Discharge and disrelished border condition for another alternatives in downstream in is 0.246 meters stable depth and gradient for other alternative is zero.

For instance, Olsen (1994) has evaluated model accuracy in internal flow simulation to a sink (300*500 m^2) with 5 meters in depth and 17 m^3/s without any calibration and gained this consequences that hydrodynamic model can simulate flow domain and qualitative pattern. In addition, changed bed between 1 millimeter to 1 centimeter and resulted that calculated velocity distribution by model and its consequences has not significant sensitive toward roughness. Furthermore, manning coefficient (0.015) has been used in which it had been identified in laboratory (Chatila,1997) and it can be seen that mentioned model gives appropriate results by using all the default parameters.

In addition, there is a Comparison between 3D numerical results of SSIIM with SKM results in which was introduced in previous chapter. The size of computation network is as like as before and it can be seen that SSIIM model shows better results compared with SKM because of hypothesis and Simplification. Relative error percentage of SKM model is 12.6%. As we can see 3D modulation compared with SKM model shows suitable results and sever changes of velocity in a region are able to make model main section flow with flooding plain. According to SKM model compared with 3D numerical model and laboratory observations and from practical point of view have appropriate performance and particular status.

In this part, model results have been examined in a large-scale of laboratorial flume in which was used in studies of flooding flow transmission of composed sections and flooding Plains Rivers. Composed section and flooding plain revisers related to FCF symmetrical laboratory flume is consisted of 60 meters in length, 1.5 meters as the width of main section, slope bed (1.0270*10-3), wall slope of main section and flooding plains 1:1,width of floor flood (2.15 meters) and its high (0.15). Measurements are performed in a section with 36 meters distances toward upstream (Knight and Shiono 1990), flow Discharge (1.1142 m^3/s), high (0.28 meters) and meaning roughness coefficient (0.01 meters). The results of 3D numerical simulation were compared with laboratory results in flume with large-scale.

Computing network consists of DX=100cm and DY=10cm level ratio 10) and control volume in perpendicular direction is 20.according to results, it can be seen that 3D numerical model can simulate average velocity distribution based on depth and cutting stress of bed by using default parameters. Relative error of model in average velocity distribution based on depth and cutting stress of bed are 7.42% and 10.1%, respectively, it can be said that, numerical model accuracy in simulation of velocity width distribution and cutting stress of bed in a large-scale flume will be acceptable on the view of quality and quantity.

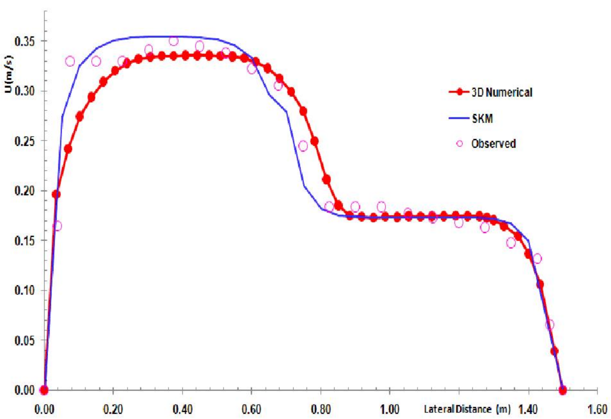


Fig. 2 Results comparisons of SSIIM numerical model with SKM results and laboratory data

Conclusion

In this study, flow transmission in composed sections with vegetation have been researched by using 3D numerical simulation in which evaluating SSIIM model accuracy was the main goal of study. During study procedure, at first 3D numerical model accuracy was confirmed comparing some data, then more modeling were performed by numerical simulations.

The comparison of 3D numerical model results with distribution data of depth velocity at laboratory flume (Chatila) showed that relative error is 9.5 while SKM model in this state is 12.6 and also the results of 3D numerical model in flow simulation in large-scale composed section showed that average relative error in width distribution of depth average velocity and bed cutting stress are 7.42 % and 10.1%, respectively. Thus, this model during simulation shows appropriate values of average bed cutting stress and velocity and extracting relation based on average values of section will show suitable and appropriate accuracy.

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