handle each solved model by an experienced operator. However the post-processing by the proposed method is extremely convenient and rapid, and only needs 1 to 2 seconds.

Table 3 Comparison of time consumption

	Modeling （min）	Solve (h)	Post-process (min)	Total (h)
By manual operation	31.17	28.0	300	33.5
By script program	1.33	22.4	0.17	22.4

The proposed method can greatly improve the efficiency in FE modeling and post-processing, it also can slightly reduce the solving time in batch, as shown in Table 3. Manual operation costs about 33.5 hours and the proposed method costs about 22.4 hours when comes to the total time consumption. The programming method can save at least 33.1% time in contrast with the manual operation.

It is more time-saving and efficient when comes to different tool angles or feed rates because manual operation needs to re-sketch the part and re-define the contact interaction to generate new models.

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An orthogonal cutting FE model is proposed by considering the plough effect of cutting edge as the initial model. A series of FE models with different tool angles, feed rates and workpiece initial temperatures can be immediately established and automatically submitted in batch to ABAQUS solver by running a script programmed with Python language.

The proposed method can generate the saw-tooth chip morphology and accurately predict the average cutting forces. It can also precisely predict the residual stresses profile of the machined surface.

Beside the usual capacity of the traditional FE models, the new approach has evident advantage in term of solving efficiency and time consumption. It saves time to set up models, submit INP files and conduct post-processing compared to manual operation. Moreover, the method can automatically process the output database and extract the important desired data when comes to the post-processing.

The proposed method can effectively avoid human mistakes. Usually, much more data of the constitutive equation needs to be inputted and improved, the geometry parameters also need to be redesigned when the machining process changes. The revision process can easily produce any mistakes for human negligence. Hence, the manual operation takes any serious risks whereas the proposed method will avoid such worriness. Further, the script is easy to program, debug, revise and improve. Python language is quite concise and convenient to modify the script program, which will save much more energy and resource of computer. The script can make good use of computer and stop it at proper time with its shutdown program.

In conclusion, the proposed method is sincerely recommended because of its great convenience especially when it is applied to the parametric FE models with simple geometry. Compared with the traditional FE modelling process, the new approach will save much more time consumption.

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