Available online www.jocpr.com

Journal of Chemical and Pharmaceutical Research, 2014, 6(3):516-521

Research Article

ISSN : 0975-7384
CODEN(USA) : JCPRC5

Analysis of fault tree importance of turret carrier system of CNC machine tools based on BDD

Jie Yu[1], Wu-sheng Tang[1]* Shuang Yu[2], Hai-long Zhang[3] and Ning Ding[1]

[1]Mechanical Engineering College of Changchun University, China
[2]Foreign Trade Department of Changchun Vocational and Technical College, China
[3]Information Center of Sino-Japanese Friendship Hospital of Jilin University, China

---

ABSTRACT

BDD technique is applied to analyze the parts importance of the turret carrier system of the CNC machine tools. Through calculating, parts importance is listed according to the values. The structural importance and probability importance of the turret carrier system are calculated in the paper. From the results we can see that the values of the two methods are perfectly close. But BDD methods are more effective than the FTA methods and can be calculated with the computer.

Keywords: BDD, CNC machine tools, Fault Tree, Importance, Turret Carrier System

---

INTRODUCTION

Turret carrier system is a unit with frequent faults of a series of CNC machine tools. The operating principle of the turret carrier system is given as below: as the turret carrier system gets the tool selection commands, the motor makes the worms gears and screws turn, the movable teeth plate rises up, knife sets release and transmission plates drive the tool sets translocation. On the selection station, hall switches send out signals to reverse the motor, the locating pins enter the positioning grooves with the force of the springs, the tool sets cannot turn, the movable teeth plates move down and realize fine positioning and locking. When the locking is placed, hall switches send out signals with the motor off and the knife selection is finished.

The main fault modes of the turret carrier system are units damaged, motor damaged, turn and shift not in place, parts loosed and no turn of the tool sets. The reasons are because of the stuck and misplace of the mechanic parts and parts damaged, loosed, burned and so on.

Transmission deputy of the worm gears of the turret carrier system has a lot of faults mainly in ground, engaging disengaged, worms sprang, worm gears breakage, worm nuts fracture and so on.

The proximity switches, micro switches, encoders and relays of the turret carrier system also have many faults mainly in the loose of the proximity switches and encoders and the damages of the parts.

The motor faults of the turret carrier system are mainly in motor burned out. If mechanical overload or electrical overvoltage and overcurrent phenomenon occur, these show that the motor power is too low or the working voltage is unstable.

The loose of the bottom of the tool sets will lead to the inaccurate workpiece size.

If the bearing of the turret carrier system is damaged, it should be replaced to resume work.

Table 1 The Codes of the Fault Events

Event code	Event name	Event code	Event name	Event code	Event name
G101	the fault of the turret carrier	G102	the fault of clamping accessories	G103	the fault of the main drive system and spindle assembly
G104	the fault of X-axis feed system	G105	the fault of Z-axis feed system	G106	the fault of chip system
G107	the fault of power system	G108	the fault of CNC system	G109	the fault of electrical system
G110	the fault of hydraulic system	G111	the fault of cooling system	G112	the fault of lubricating system
G113	the fault of protecting system	G201	No-translocation of the toolset	G202	inaccurate positioning of tool set
G203	the tool sets not tight	G204	tool set rotating anomaly	G205	the processing precision exceed the standard
G301	no running of the motor	G302	locating pin cannot pull out	G303	the fault of driving system
G304	the fault of translocation cam	G305	the fault of the middle axis	G401	stator coils burnt
G402	the fault of rotor	G501	overload	G502	overload protection failure
B001	over voltage	B002	overcurrent	B003	overheat

Table 2 The Minimum Cut-sets of The Fault Trees

cut-set number	the bottom event contained	Event name	cut-set number	the bottom event contained	Event name
1	B070	bolt damaged	36	B035	unsuitable design
2	B069	bolt loosed	37	B034	ageing
3	B068	pin-hole worn and torn	38	B033	improper adjustment
4	B067	locating pin damaged	39	B032	mistakes in assembly position
5	B066	others on the surface	40	B031	proximity switch loosed
6	B065	bolt loosed	41	B030	encoders damaged
7	B064	output mistakes of censors	42	B029	encoders loosed
8	B063	tool offset value mistaskes in the program	43	B028	slider shearing
9	B062	improper toolset adjustment	44	B027	Bearing broken
10	B061	relays damaged	45	B026	too tight or block of bearing
11	B060	lubricating insufficiency	46	B025	movement
12	B059	others in the meshing zone	47	B024	improper clearence
13	B058	fastening pieces loosed	48	B023	worn and torn
14	B057	no-fastening of bolts	49	B022	worn and torn
15	B056	arrester damaged	50	B021	ground
16	B055	micro switched loosed	51	B020	ground
17	B054	improper adjustment	52	B019	worn and torn
18	B053	mistakes of assembling situation	53	B018	movement
19	B052	problems of design	54	B017	worn and torn
20	B051	unsuitable assembly adjustment	55	B016	movement
21	B050	uneven teeth plate	56	B015	movement
22	B049	low precision of teeth plate	57	B014	movement
23	B048	others in the meshing zone	58	B013	ground
24	B047	rotating teeth plate damaged	59	B012	unsuitable clearance
25	B046	too big clearance	60	B011	gear impact
26	B045	worn and torn	61	B010	ground
27	B044	positioning teeth plate damaged	62	B009	pin broken
28	B043	fastening bolt loosed	63	B008	bearing stuck
29	B042	bad assembly adjustment	64	B007	rotator damaged
30	B041	non-fastening bolt	65	B006	big adjustment of the thermal relay power
31	B040	too tight or blocked of bearing	66	B005	overhigh rated value of the fuses
32	B039	broken	67	B004	software protection out of order
33	B038	worn and torn	68	B003	overheat
34	B037	too large slide resistance	69	B002	overcurrent
35	B036	pin hole worn and torn	70	B001	overvoltage

The Construction of the Fault Trees of the Turret Carrier System of the CNC Machine Tools

We regard the whole CNC machine tool as a system and divide the system into thirteen subsystems. Those are turret carrier system, clamping accessories, main drive system and spindle assembly, X-axis feed system, Z-axis feed system, chip system, power system, CNC system, electrical system, hydraulic system, cooling system, lubricating system and protecting system.

We construct the fault trees of the turret carrier system of the CNC machine tools[1-5]. Table 1 is the codes of the fault events. Table 2 is the minimum cut-sets of the fault trees.

Fig.1 is the fault tree of the faults caused by the turret carrier system. Fig.2 is the fault tree of the faults caused by the transmission-mechanism of the turret carrier system. Fig.3 is the fault tree of the faults caused by the inaccurate positioning of the turret carrier system. Fig.4 is the fault tree of the faults caused by the unlocked of the turret carrier system. Fig.5 is the fault tree of the faults caused by the excessive work precision of the turret carrier system.

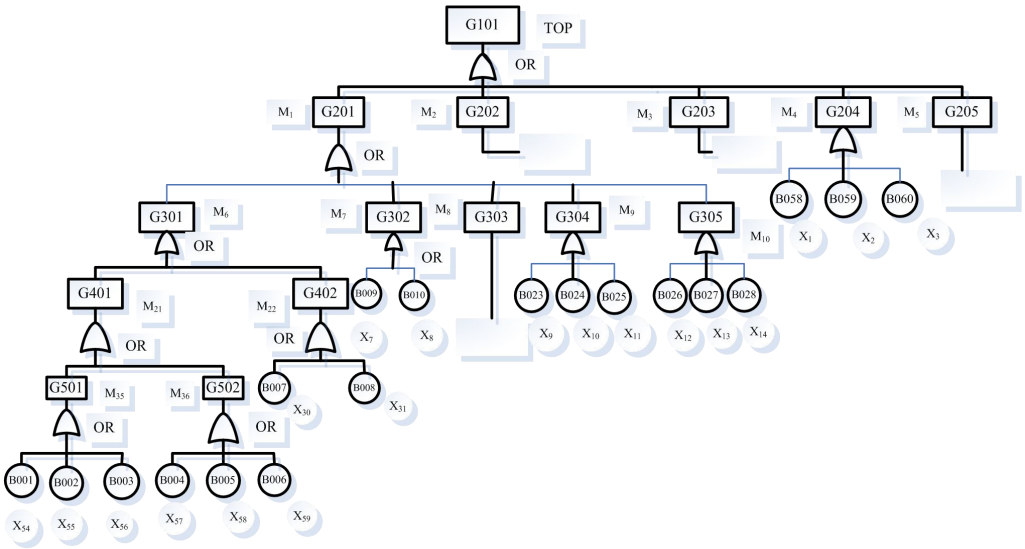

Fig.1 the Fault Tree of the Turret Carrier System

Applying BDD Method to Transform Fault Trees

Transform the complicated fault trees into standard trees containing And, Or, Non-logic gates. From the bottom events, use the basic events to replace the middle events up layers by layers and encode at the same time[6-8]. At last, get BDD of the summit event. The processes are given as the following figures.

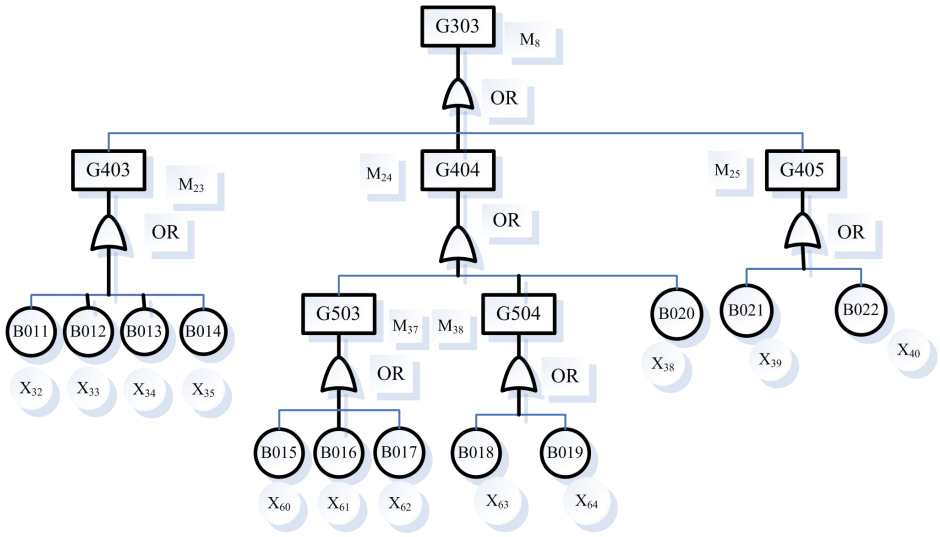

Fig.2 the Fault Tree of the Faults Caused by the Transmission-mechanism of the Turret Carrier System

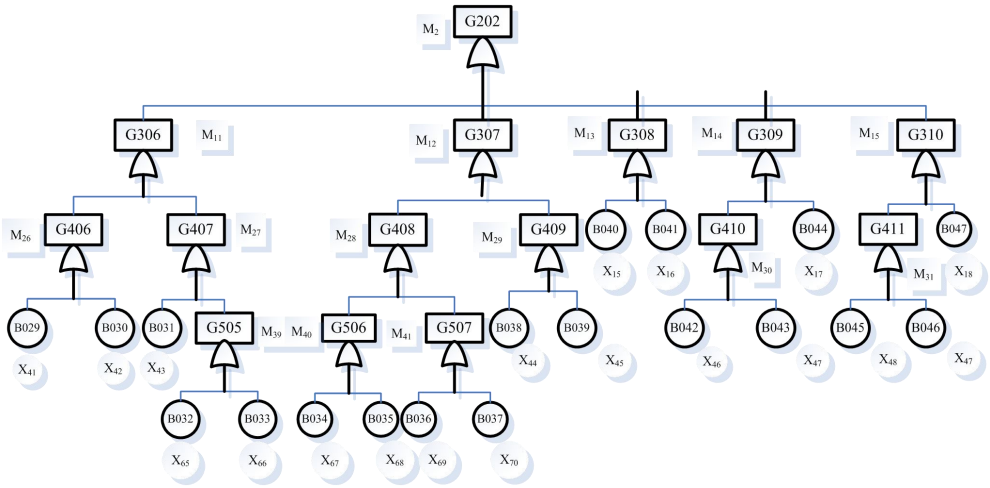

Fig.3 the Fault Tree of the Faults Caused by the Inaccurate Positioning of the Turret Carrier System

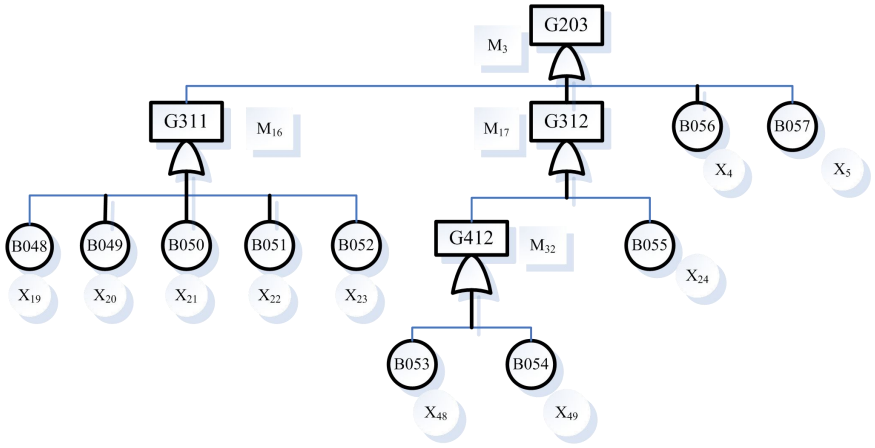

Fig.4 the Fault Tree of the Faults Caused by the Unlocked of the Turret Carrier System

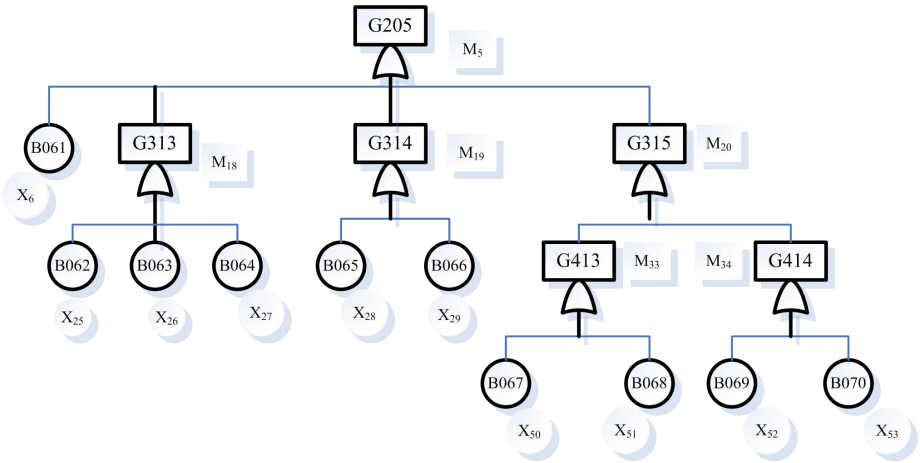

Fig.5 the Fault Tree of the Faults Caused by the Excessive Work Precision of the Turret Carrier System

From the above fault trees, we can know that $X_1 \sim X_6$ are the sibling evens. $X_7 \sim X_{29}$ are the sibling evens. $X_{30} \sim X_{53}$ are the sibling evens. $X_{54} \sim X_{70}$ are the sibling evens.

Applying BDD Method On Importance Analysis

Table3 Importance Results of the Turret Carrier System Based on BDD and FTA

	Construction Importance		Probability Importance	
	BDD method	FTA method	BDD method	FTA method
X_1	0.96278	0.96278	0.5122	0.5122
X_2	0.96278	0.96278	$8.8019*10^{-3}$	0.00880193
X_3	0.96278	0.96278	$8.0913*10^{-3}$	0.00809132
X_4	0.96278	0.96278	$8.4319*10^{-3}$	0.00843197
X_5	0.96278	0.96278	$8.1769*10^{-3}$	0.00817693
X_6	0.96278	0.96278	$8.4327*10^{-3}$	0.00843277
X_7	0.11429	0.11429	0.3297	0.3297
X_8	0.11429	0.11429	$7.0921*10^{-3}$	0.00709211
X_9	0.11429	0.11429	$7.0009*10^{-3}$	0.00700096
X_{10}	0.11429	0.11429	$7.6781*10^{-3}$	0.00767811
	0.11429	0.11429	$7.1365*10^{-3}$	0.00713652
X_{11}	0.11429	0.11429	$7.3276*10^{-3}$	0.00732763
X_{12}	0.11429	0.11429	$7.9221*10^{-3}$	0.00792210
	0.11429	0.11429	$7.8457*10^{-3}$	0.00784571
X_{13}	0.11429	0.11429	$7.5923*10^{-3}$	0.00759233
	0.11429	0.11429	$7.3825*10^{-3}$	0.00738251
X_{14}	0.11429	0.11429	$7.5587*10^{-3}$	0.00755870
	0.11429	0.11429	$7.0143*10^{-3}$	0.00701432
X_{15}	0.11429	0.11429	$7.0001*10^{-3}$	0.00700011
	0.11429	0.11429	$7.4782*10^{-3}$	0.00747826
X_{16}	0.11429	0.11429	$7.3582*10^{-3}$	0.00735827
	0.11429	0.11429	$7.5593*10^{-3}$	0.00755935
X_{17}	0.11429	0.11429	$7.7144*10^{-3}$	0.00771445
	0.11429	0.11429	$7.9129*10^{-3}$	0.00791293
X_{18}	0.11429	0.11429	$7.7659*10^{-3}$	0.00776592
	0.11429	0.11429	$7.3575*10^{-3}$	0.00735751
X_{19}	0.11429	0.11429	7.0314*10-3	0.00703142
	0.11429	0.11429	7.0949*10-3	0.00709491
X_{20}	0.11429	0.11429	$7.7615*10^{-3}$	0.00776154
	0.09231	0.09231	$6.9971*10^{-3}$	0.00699716
X_{21}	0.09231	0.09231	$6.9035*10^{-3}$	0.00690355
	0.09231	0.09231	$6.8625*10^{-3}$	0.00686252
X_{22}	0.09231	0.09231	$6.8549*10^{-3}$	0.00685497
	0.09231	0.09231	$6.0128*10^{-3}$	0.00601282
X_{23}	0.09231	0.09231	$6.7759*10^{-3}$	0.00677593
	0.09231	0.09231	$6.5672*10^{-3}$	0.00656721
X_{24}	0.09231	0.09231	$6.5526*10^{-3}$	0.00655264
	0.09231	0.09231	$6.9138*10^{-3}$	0.00691380
X_{25}	0.09231	0.09231	$6.7745*10^{-3}$	0.00677451
	0.09231	0.09231	$6.8021*10^{-3}$	0.00680213
X_{26}	0.09231	0.09231	$6.2766*10^{-3}$	0.00627663
	0.09231	0.09231	$6.3214*10^{-3}$	0.00632144
X_{27}	0.09231	0.09231	$6.5538*10^{-3}$	0.00655381
	0.09231	0.09231	$6.2165*10^{-3}$	0.00621655
X_{28}	0.09231	0.09231	$6.7727*10^{-3}$	0.00677272
	0.09231	0.09231	$6.2942*10^{-3}$	0.00629421
X_{29}	0.09231	0.09231	$6.5437*10^{-3}$	0.00654371
	0.09231	0.09231	$6.7045*10^{-3}$	0.00670459
X_{30}	0.09231	0.09231	$6.0732*10^{-3}$	0.00607321
	0.09231	0.09231	$6.0943*10^{-3}$	0.00609432
X_{31}	0.09231	0.09231	$6.6577*10^{-3}$	0.00665773
	0.09231	0.09231	$6.0317*10^{-3}$	0.00603179
X_{32}	0.09231	0.09231	$6.0038*10^{-3}$	0.00600385
	0.03315	0.03315	$5.9919*10^{-3}$	0.00599190
X_{33}	0.03315	0.03315	$5.6785*10^{-3}$	0.00567853
	0.03315	0.03315	$5.7793*10^{-3}$	0.00577932
X_{34}	0.03315	0.03315	$5.6675*10^{-3}$	0.00566752
	0.03315	0.03315	$5.6928*10^{-3}$	0.00569281
X_{35}	0.03315	0.03315	$5.6648*10^{-3}$	0.00566481
	0.03315	0.03315	$5.3321*10^{-3}$	0.00533215
X_{36}	0.03315	0.03315	$5.6918*10^{-3}$	0.00569183
	0.03315	0.03315	$5.5549*10^{-3}$	0.00555492
X_{37}	0.03315	0.03315	$5.6648*10^{-3}$	0.00566481
	0.03315	0.03315	$5.0036*10^{-3}$	0.00500362
X_{38}	0.03315	0.03315	$5.0328*10^{-3}$	0.00503281
	0.03315	0.03315	$5.1026*10^{-3}$	0.00510261
X_{39}	0.03315	0.03315	$5.2217*10^{-3}$	0.00522177
	0.03315	0.03315	$5.0095*10^{-3}$	0.00500953
X_{40}	0.03315	0.03315	$5.1127*10^{-3}$	0.00511277
	0.03315	0.03315	$5.2092*10^{-3}$	0.00520921

X_{41}	
X_{42}	
X_{43}	
X_{44}	
X_{45}	
X_{46}	
X_{47}	
X_{48}	
X_{49}	
X_{50}	
X_{51}	
X_{52}	
X_{53}	
X_{54}	
X_{55}	
X_{56}	
X_{57}	
X_{58}	
X_{59}	
X_{60}	
X_{61}	
X_{62}	
X_{63}	
X_{64}	
X_{65}	
X_{66}	
X_{67}	
X_{68}	
X_{69}	
X_{70}	

From table3 we can see that the construction importance and probability importancevalues of the parts are very close with BDD method and FTA method. But it is a complicated process using the traditional FTA analysis to get the construction importance and probability importance. It is an effective and accurate process when using BDD method and it can be realized with the computer.

CONCLUSION

Apply BDD method to get the concrete values of the construction importance and probability importance of the basic events of the turret carrier system of the CNC machine tools. In light of these values, we can adopt some measurements to increase the reliability of the turret carrier system and increase the total reliability step by step.

Acknowledgements

This research work was sponsored by the project of Department of Education of Jilin Province (No.2014282).

REFERENCES

[1]Sinnamon R M, Andrews J D. New Approaches to Evaluating Fault Tree [A], Proceedings of ESrel'95 Conference[C]. June.**1995.** 241-254.
[2]Xiang-rui Dong.Reliability Engineering. Beijing. Tsinghua University Press. **1990**.
[3]Wei-xin Liu. Mechanical Reliability Design.Beijing. Tsinghua University Press.**1996**.
[4]Rui-yuan Liu. *Reliability Engineering* .**2002**. 4.P153-155.
[5]Zhi-qiang Fang. Lian-hua Gao. Reliability Engineering. **2002**.1.P22-24.
[6]Xiang-cheng Xu, Jian-guo Zhang. *Reliability Engineering*. **2003.3.**P103-106**.**
[7]Yan-nian Rui, Ge-yan Fu. Modern Reliability Design.Beijing. Defense Industry Press.**2006**.
[8]Chao Zhang.Optimization of Dynamic Fault Tree AnalysisBased on BDD. Master Thesis.Northwestern Polytechnical University .**2006**.