Analysis of commercial vehicle ride dynamics

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Keywords: Vehicle ride dynamic; commercial; vehicle vibration

ABSTRACT–Modelling and simulation are tools for studying and analyzing the dynamics behaviors of vehicle. These kind of methods can easily show the dynamic performances of vehicle without any constraint of cost, time and safety compared to other approaches. In this study, a 7 degrees of freedom (DOF) of commercial vehicle is employed in the vehicle ride performance analysisincluding body displacement, body roll and body pitch. The model parameters are obtained from CarSim software by selecting Utility Truck as a benchmark. Such simulation model was developed in MATLAB/Simulink software. Road disturbance from step input is applied to the wheel. The location of input is varied to each tire and somehow at both tires for analysis purposes. Based on this road disturbances, the performances of passive suspension system were investigated. Simulation results consist of roll angle, pitch angle and vehicle body displacement are analyzed.

1. INTRODUCTION

Commercial vehicle frequently used for a commercial carrier vehicle with gross vehicle weight not more than 3.5 tonnes. Due to frequent this type of vehicle on the road contributed to the more risk of accident. Literature review showed that many accident cases recorded because of rollover problem [1].According to fatal crashes rate stated in [2] most rollover accidents are fatal and the rate is quite high.

Many factors can drives to the vehicle rollover problem such as turning radius too small or the turning speed too fast [3]. This kind of vehicle rollover can be classified into tripped vehicle rollover [4].In order to prevent rollover is by providing vehicle an ability to resists overturning moments generated during cornering [5].

2. METHODOLOGY

The scopes that need to be done on this paperare the mathematical derivation, development of mathematical modelling and detailed analyzing with correspondence to the step input at 0.1 m high at 1 second applied for representing a bump on the road.

The study concerns only the vertical dynamics of the vehicle, neglecting the small motions in the horizontal plane such as longitudinal and transversal oscillations. The vehicle aerodynamic effect is also neglected and the road is assumed to be level except for road disturbance. The vehicle is also assumed to be rigid where the load transfer from one point to another is hundred percent effective. All parameters of the vehicle also assumed to be constant throughout the simulation process.

Figure 1 shows the 7 DOF full car ride model used to study the vertical interaction between vehicle and road, considering both the roll and pitch motion of the car. The case of integrated suspension for all part of the vehicle is considered.

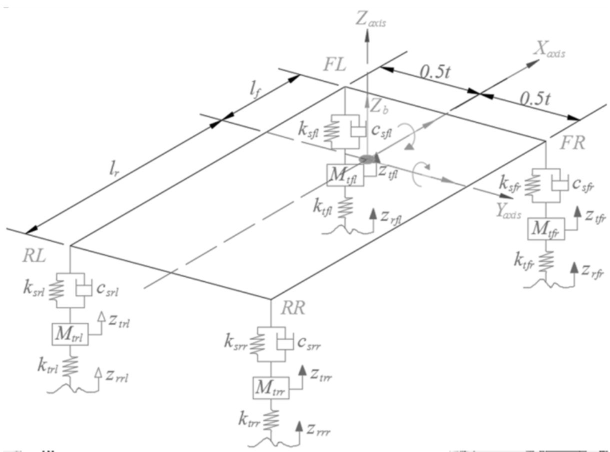

Figure 1 7DOF full car ride model

The equation of motion of the vehicle vertical body & wheel, pitching and rolling motion respectively are expressed as:

$$F_{sfl}+F_{tfl}+F_{sfr}+F_{tfr}+F_{srl}+F_{trl}+F_{srr}+F_{trr} = M_b\ddot{Z}_b \quad (1)$$

$$F_{tfl}-F_{sfl}-F_{tfl}=M_{tfl}\ddot{Z}_{tfl} \quad (2)$$

$$F_{tfr}-F_{sfr}-F_{tfr}=M_{tfr}\ddot{Z}_{tfr} \quad (3)$$

$$F_{trl}-F_{srl}-F_{trl}=M_{trl}\ddot{Z}_{trl} \quad (4)$$

$$F_{trr}-F_{srr}-F_{trr}=M_{trr}\ddot{Z}_{trr} \quad (5)$$

$$-l_f(F_{sfl}+F_{tfl}+F_{sfr}+F_{tfr})+l_r(F_{srl}+F_{trl} +F_{srr}+F_{trr})=I_\theta\ddot{\theta} \quad (6)$$

$$-0.5t(F_{sfl}+F_{tfl}+F_{sfr}+F_{tfr})+0.5t(F_{srl}+F_{trl} +F_{srr}+F_{trr})=I_\alpha\ddot{\alpha} \quad (7)$$

The 7 DOFparameters of the considered vertical model are summarized in Table 1 below:

Table 1 Utility truck parameters from CarSim software

Descriptions	Symbols	Values
Front distance from CG	l_f	0.55 m
Rear distance from CG	l_r	1.373 m
Width of sprung mass	t	1.26 m
Vehicle body sprung mass	M_b	600 kg
Front unsprung mass	$M_{tfl\&r}$	80 kg
Rear unsprung mass	$M_{trl\&r}$	88 kg
Body roll of inertia	α	384 kgm^2
Body pitch of inertia	θ	624 kgm^2
Suspension spring stiffness	k_s	35 kN/m
Tire spring stiffness	k_t	22 kN/m
Suspension damping	c_s	30 kN/m

3. RESULTAND DISCUSSION

Figure2 shows response of vehicle roll when a step input applied at one tire. The result give the same magnitude of roll angle but different direction due to earlier assumption as in Figure 1 which is for the roll angle that follow clock wise direction will give positive value. Magnitude of roll tend to interchangeable direction between left and right tire at the same value of $\pm 0.08^\circ$.

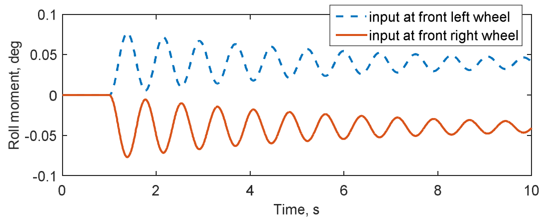

Figure 2 Analysis of body roll angle

Figure3 shows response of vehicle pitch angle when a step input applied at one tire. The same result gained for pitching moment and the value interchange the direction between front and rear tire at $\pm 0.05^\circ$ .Figure4 shows response of vehicle vertical displacement when a step input applied at a correspondence tire. Result gained higher for body displacement when disturb at front left and right tire with value of 0.07m compared to when applied at rear tire with only 0.03m due to different distance of l.

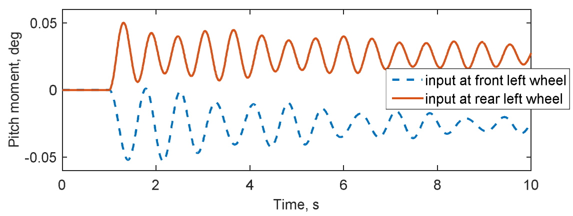

Figure 3 Analysis of body pitch angle

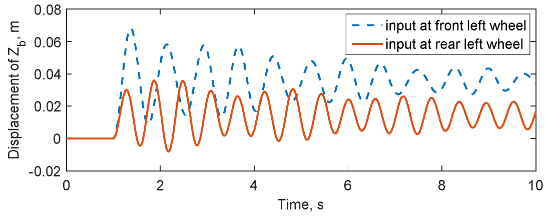

Figure 4 Analysis vertical body displacement

4. CONCLUSION

In this study, the mathematical equations were derived as the sequential of Newton Law to estimatethe dynamic system evolving according to a 7 DOF full commercial vehicle ride model. The model was introduced as a tool for suspension behavior estimation in the context of simulation study with implementation of step input from Matlab/Simulink.

REFERENCES

[1] Cerezo, V., and Conche, F.: 'Risk assessment in ramps for heavy vehicles—A French study', Accident Analysis & Prevention, 2016, 91, pp. 183-189

[2] Yim, S.: 'Design of a Preview Controller for Vehicle Rollover Prevention', IEEE Transactions on Vehicular Technology, 2011, 60, (9), pp. 4217-4226

[3] Yan, Z., and Jun, W.: 'Analysis of properties on cargo constrained system of truck rollover based on MATLAB/simulink', in Editor (Ed.)^(Eds.): 'Book Analysis of properties on cargo constrained system of truck rollover based on MATLAB/simulink' (2011, edn.), pp. 395-397

[4] M.A. Abdullah, M.A. Salim, M.Z. Mohammad Nasir, M.N. Sudin, and F.R. Ramli, "Dynamics performances of Malaysian passenger vehicle,"*ARPN Journal of Engineering and Applied Sciences*, ISSN 1819-6608,vol. 10, no. 17, pp. 7759-7763, 2015.

[5] M.A. Abdullah, J.F. Jamil and A.E. Mohan, *Vehicle dynamics modeling & simulation*, Malacca: Centre for Advanced Research on Energy (CARe), Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka; ISBN: 978-967-0257-78-5; 2016.

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Effect of nitriding temperature and time on the surface hardness and grain size of MgAZ91D alloy

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Keywords: Nitriding; alloy; hardness

ABSTRACT – Magnesium AZ91D is widely applied in the telecommunication sectordue to its low density and excellent strength to the weight ratio. However, it possess a low surface hardness that will weaken the adhesion properties especially when hard coating is to be applied. The need of hard coating is crucial to enhance its corrosion resistance. In this work, nitriding process was carried out to improve the surface properties of MgAZ91D in order to enhance its corrosion properties. The nitriding process was performed at various temperatures, i.e., 300°C, 400°C, and 500°C,for 1 and 2 hours using high temperature furnace with the nitrogen gas flow at a constant rate of 5 scfh.. Its surface hardness wasanalyzed using Vickers microhardness. Result showed that the surface hardness of the nitrided MgAZ91D increased with the increase in the process temperature and time. Thus, the nitriding temperature and time are crucial in obtaining good surface propertiesof MgAZ91D.

1. INTRODUCTION

Magnesium and its alloys, especially AZ91D receivea lot of consideration because of their light weight and superior specific strength. It has a high strength to weight ratio with a density only 2/3 of aluminium and 1/4 of iron [1]. It also has good properties in thermal conductivity, dimensional stability, and good machinability [2] for automotive and telecommunication industries. The most common magnesium alloy used is AZ91D. The chemical composition of MgAZ91D alloy, based on ASTM standard is shown in Table 1. The reason for the success of this particular type of alloy is its beneficial properties (e.g. high strength to weight ratio) making it remarkable for automotive application where weight reduction is of significant concern.

Table 1 Composition of AZ91D magnesium alloy

Mg	Al	Zn	Mn	Si	Cu	Fe	Ni
90	9	0.35	0.13	0.1	0.03	0.005	0.002

However, the MgAZ91Dis also known for its weakness in corrosion resistance as well as low surface hardness [3]. Recent works have proven that nitriding can improve the corrosion properties of MgAZ91D [4].
Nitriding process is a technique that able to modify the surface of the substrates and increase their surface hardness [5]. In this study, thenitriding process was conducted using conventional method, in which the process was carried out at a low melting temperature using nitrogen gas. The process parameters that need to be controlled are gas flow rate, temperature, and time [6-7].

2. METHODOLOGY

Cast AZ91D magnesium alloy samples were cut into 20 mm×10 mm×3 mm and used as substrate. Prior to nitriding process, the surface of each sample was ground with abrasive paper of 800 and 1200 grits, then followed by polishing with fine alumina paste. The gas nitriding process was conducted using the gas furnace, with allowing the nitrogen gas flow. Table 2 shows the nitriding parameters used in this study.

Table 2 Nitriding process parameters

Time, (Hour)	Temperature, (°C)	Nitrogen Gas	
		Pressure (Pa)	Flow rate, (SCFH)
1	300	300	5
	400		
	500		
2	300		
	400		
	500		

3. RESULTS AND DISCUSSION

The surface hardness of the nitrided MgAZ91D compared to the untreated sample as shown in Figure 1. All of the surface hardness values for the nitrided MgAZ91D are higher compared to the untreated sample. The surface hardness increases as the temperatures and the nitridingtime increase, which indicatesdevelopment of compound layer at the surface.

Figure 2 shows the cross sectionalimage of the untreated and nitrided MgAZ91Dwith respect to the temperatures and nitriding time. It can be clearly seen that the size of MgAZ91D grain grows as the temperature is increased. However, the effect of nitriding time on the size of MgAZ91D grain isnegligible and insignificant. The nitrided compound layerdeveloped on the MgAZ91D surface, however, is very thin as revealed by the optical microscope image in Figure 2.

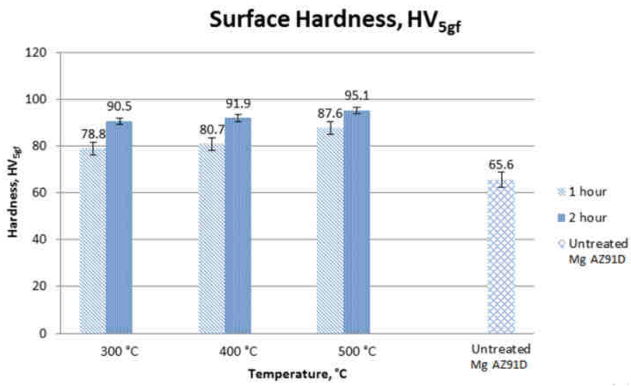

Figure 1 Surface hardness of the untreated MgAZ91D and nitrided MgAZ91D with different temperatures and nitriding time.

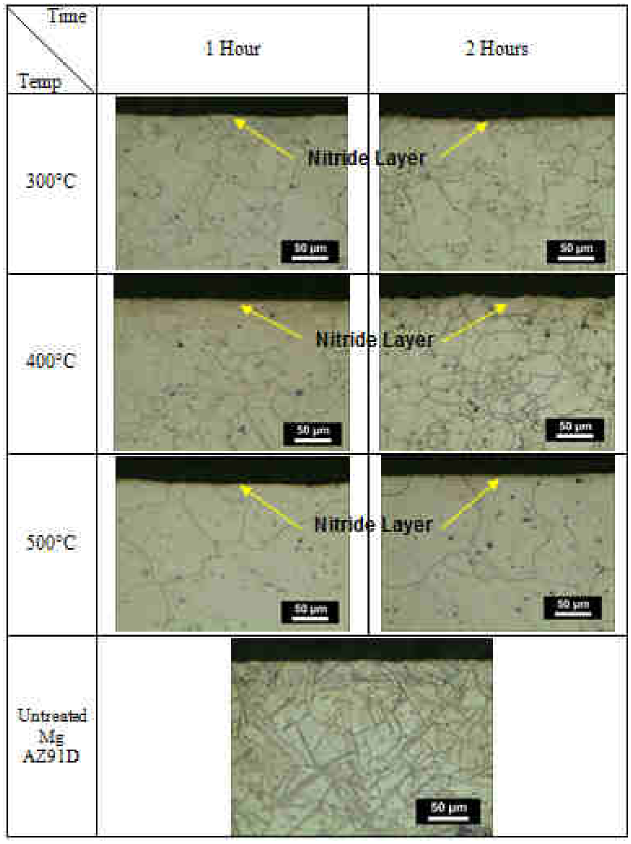

Figure 2 Optical microscopic images of cross section of the untreated and the nitrided MgAZ91D with regard to temperatures and nitriding time.

4. CONCLUSIONS

The MgAZ91D has been successfully nitrided within the selected process parameters using modified gas furnace. For the grain growth effect, the increase in temperature and nitriding time increased the grain size. Contrariwise, the effect of grain size growth toward the surface hardness of the nitrided MgAZ91D has been inverted due to the nitride hard phases. Results of surface hardness strengthen the evidence of compound layer establishment at the surface of the nitride MgAZ91D. All of the nitrided MgAZ91D possess higher surface hardness values than the untreated MgAZ91D.

ACKNOWLEDGEMENTS

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REFERENCES

[1] J.E. Gray and B. Luan. “Protective coatings on magnesium and its alloys, a critical review”, *J. Alloys Compound.*, vol. 336, pp. 88–113,2002.

[2] S. Fujisawa, A. Yonezu, T. Okamura, and K. Yoneda, “Estimation of microstructural plastic property of die-cast Mg alloy (AZ91D) with an elevated temperature indentation”, *Mater. Sci. Eng.,A,* vol. 616, pp. 63–70, 2014

[3] H.Xu, Z. Ji, M. Hu, Z. Wang. “Microstructure evolution of hot pressed AZ91D alloy chips reheated to semi-solid state”,*Trans. Nonferrous Met. Soc. China,* 22(12), 2906–2912,2012.

[4] Z.M. Rosli, M. Zaimi, J.M. Juoi, Z. Mahamud. ‘Corrosion Performance of Nitrided Based Coating On AZ9I Mg Alloy In Hank’s Solution,”*Mater. Sci. Forum,* 819, 303–308,2015.

[5] Z.Xie, Q.Chen, T.Chen,X.Gao, X.Yu, H. Song, Y. Feng. “Microstructure and properties of nitrogen ion implantation/AlN/CrAlN/MoS2-phenolic resin duplex coatings on magnesium alloys.”*Mater. Chem. Phys.,* 160, 212–220, 2015.

[6] S. R. Hosseini andA. Ahmadi.“Evaluation of the effects of plasma nitriding temperature and time on the characterisation of Ti 6Al 4V alloy,”*Vacuum*, 87, 30–39, 2013

[7] Y.Yusuf, J. M. Juoi, Z. M.Rosli, W. L.Kwan, Z. Mahamud.“Effects of Process Temperature and Time on the Properties of Microwave Plasma Nitrided Ti-6Al-4V Alloy”, *Pertanika J. Sci. Technol.,*21(1), 45–58,2013.

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Verification of commercial vehicle ride dynamics

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Keywords: Dynamics modelling; model verification; ride dynamics

ABSTRACT–This paper presents a 7 degrees of freedom (DOF) model of commercial vehicle ride dynamics modelling verification. The development of thisvehicle ride model is for studying the dynamics of vehicle which concerned with movement of vehicles including vertical vibration, roll and pitch moments. This model is used by considering all the important parameters in the vehicle dynamic for describing the motions and verified using CarSim software. The results indicatedthat the performance of the model in Simulink were similar as in CarSim simulation.

1. INTRODUCTION

A vehicle vertical dynamic model is a very suitable model used by many researchers for vibration controlling of vehicle for avoiding sensation of discomfort does not exceed a certain level[1]. This simulation model was verified with vehicle simulation software to represent the vehicle dynamics behavior [2].

Modelling commercial vehicle plays an important role in automotive industry in prevention of rollover problem. This is in line with the progress of the performance of vehicle suspension systems where it is speeded in recent year through introduction of semi-active and active suspension components [3].

Verification step is needed in modeling and simulation study for ensuring the development model is correct or not. One way for certifying it by comparing the results between the real vehicle simulation software such as CarSim Mechanical Simulation [4].

2. METHODOLOGY

The commercial vehicle ride model in this study is based on a four wheels vehicle. The ride model consists of 7 DOF which involves vehicle body acceleration, pitch, roll and four wheels vertical motions. All the mathematical derivations and assumption as stated in [5].

The 7 DOFs vehicle model was first verified by comparing its response against the real vehicle response simulated in CarSim.Vehicle configuration used in this study is the Utility Truck with Ride Tests Chassis Twist road procedure. Systems used is the Rear drive- torque with ration 1.0 and the maximum power is 40 kW. The modelling of vehicle dynamics developed from Matlab Simulink is shown in Figure 1.

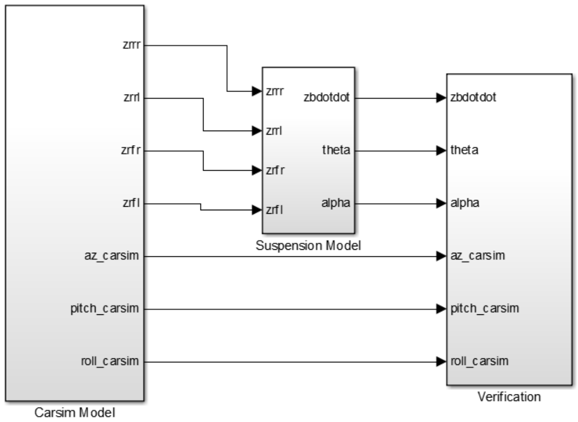

Figure 1 Verification for 7 DOF vehicle ride model

The road profile disturbance acts on the CarSim Model system. The signal from the suspension model system are transmitted to the verification model to compute the output variables. The output variables namely roll, pitch and body acceleration are recorded and compared with Utility Truck simulation results.

A vehicle vertical model is developed in Matlab/Simulink using the mathematical derivation. The parameter specifications of the vertical vehicle model are listed in Table 1 as reference from [1]:

Table 1 List of parameters used in vehicle vertical model simulation.

Descriptions	Symbols	Values
Front distance from CG	l_f	0.55 m
Rear distance from CG	l_r	1.373 m
Width of sprung mass	t	1.26 m
Vehicle body sprung mass	M_b	600 kg
Front unsprung mass	$M_{tfl\&r}$	80 kg
Rear unsprung mass	$M_{trl\&r}$	88 kg
Body roll of inertia	α	384 kgm^2
Body pitch of inertia	θ	624 kgm^2
Suspension spring stiffness	k_s	35 kN/m
Tire spring stiffness	k_t	22 kN/m

Suspension damping	c_s	30 kN/m

3. RESULTAND DISCUSSION

Figure2, 3 and 4show responses of vehicle roll, pitch angle and vertical acceleration of the vehicle when the input applied from the Ride Tests Chassis Twist road procedure for Utility Truck in CarSim software. The performance as seen in the figures shown that the vehicle roll and pitch motion curves and vertical acceleration curve pattern is following the pattern of the CarSim Vehicle respectively.

The roll motion of a vehicle is the moment of the vehicle about its longitudinal axis. The roll motion angle of the vehicle in the Simulink model and CarSim Model as depicted in Figure 2 signifies that the roll having almost same in term of trend and pattern of the curve and also approximately at the same time and value of the roll angle. This is shows that the roll angle gathered from the Simulink model is verified through the CarSim model.

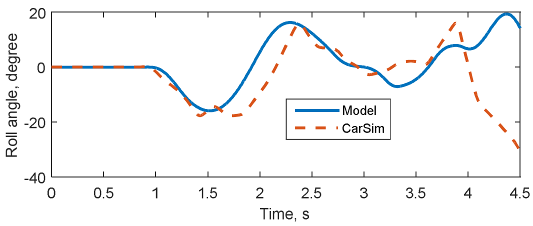

Figure 2 Verification of disturbance for roll angle

The pitch angle of the vehicle in the model as shown in Figure 3 represents that the pitch having almost zero during the early time of the simulation or during the vehicle were start to disturb approximately from 1 – 2.8 s. The maximum pitching angle is almost the same at 6.7 s approximately 12.2 degree produced by the Simulink model while the CarSimmodel have the maximum pitching angle of 11.9 degree which means it has only about 0.3 varies difference of the magnitude.

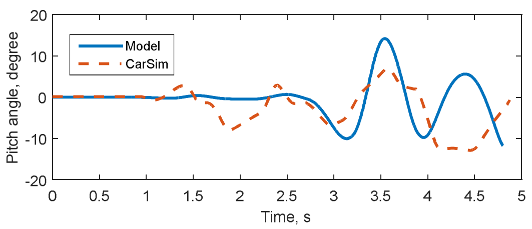

Figure 3 Verification of disturbance for pitch angle

The body acceleration of vehicle as illustrated in Figure 4 below shown that the Simulink model and CarSim simulation have similar trend but slightly different in magnitude. This error may be due to simplified model used in Simulink while the CarSim simulation is of course more precise because it is based on the actual tested vehicle simulation process.

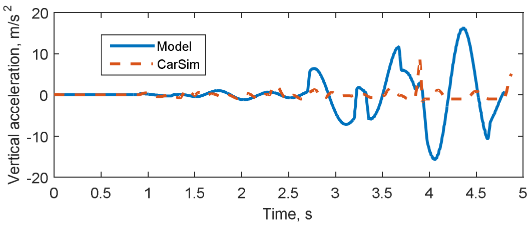

Figure 4 Verification of disturbance for acceleration

4. CONCLUSION

In this study, the commercial vehicle with passive suspension system consists of 7 DOF ride model has been developed and verified. The Verification model was erected by using MATLAB Simulink software and compared with the well-known mechanical simulation software namely Utility Truck CarSim.

These model isverified by simulating the models at a speed with an identical road disturbance. Three graphs were recorded which were the roll angle, pitch angle and body acceleration graph. The results show the similar trend between Simulink model and Utility Truck CarSim model though slightly different in magnitude due to simplifying Simulink model process. This similarity indicate that the Simulink model can be used for further research to study commercial vehicle ride performance.

REFERENCES

[1] M.A. Abdullah, J.F. Jamil, A.E. Mohan: 'Vehicle Dynamics Modeling and Simulation', Centre for Advanced Research on Energy (CARe), Faculty of Mechanical Engineering, Universiti Teknikal Malaysia Melaka, 2016. 2016.

[2] Satar, M.I., Hudha, K., Mat, W.A.W., Othman, R.N.I.R., Murrad, M., Aparow, V.R., and Salleh, M.S.: 'Modelling and verification of 5 degree of freedom vehicle longitudinal model', in Editor (Ed.)^(Eds.): 'Book Modelling and verification of 5 degree of freedom vehicle longitudinal model' (2015, edn.), pp. 1-6.

[3] Çalışkan, K., Henze, R., and Küçükay, F.: 'Potential of Road Preview for Suspension Control under Transient Road Inputs', IFAC-PapersOnLine, 2016, 49, (3), pp. 117-122

[4] Ubaidillah, Pamungkas, K., Nizam, M., and Mazlan, S.A.: 'Simulation and model verification of a vehicle handling dynamics', in Editor (Ed.)^(Eds.): 'Book Simulation and model verification of a vehicle handling dynamics' (2015, edn.), pp. 280-285

[5] Amin, M.H.I.M., Hudha, K., Kadir, Z.A., and Amer, N.H.: 'Skyhook control for 7 DOF ride model of armored vehicle due to road disturbance', in Editor (Ed.)^(Eds.): 'Book Skyhook control for 7 DOF ride model of armored vehicle due to road disturbance' (2015, edn.), pp. 1-5

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Reveal hidden wastes in overall equipment effectiveness by using maynard operation sequence technique

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Keywords: Overall equipment effectiveness; Maynard operation sequence technique, Hidden wastes

ABSTRACT – Overall equipment effectiveness (OEE) indicates effectiveness of the machine by comparing with an machine that runs non-stop at ideal speed and produces zero defect products. However, the unnecessary production was classified as operating time and excessive transport time or set-up process was considered as planned downtime. All these hidden wastes cause the inaccuracy in calculate OEE. Therefore, a new method is proposed to reveal hidden wastes in OEE. Maynard Operation Sequence Technique (MOST) is a work measurement used to evaluate the working mechanism and minimal non-value added activities. The result shows OEE level has increased after the implementation of MOST.

1. INTRODUCTION

Overall equipment effectiveness (OEE) is commonly used in the industry to indicate the efficiency of the machine. In other words, OEE monitor the real performance of the machine and compared it with the ideal machine that always under optimal manufacturing conditions [2]. OEE is consists of three main factors which are availability, performance and quality [1]. Availability determines the ratio of actual run time to planned production time; performance shows the result of ideal cycle time multiple with total runs and divided with actual run time. For quality, it shows about the ratio of total good products to total products produced.

To achieve world class OEE which 85%, industries have use several tools to improve their processes. Mulla and Ramesh [3] enhanced OEE by using 5S technique and the result is satisfied. Anyway, it shows that manpower brings great impact to the OEE of the process. There are lean wastes neglected in the tradition of OEE. It encourages the machine to run all the time but some of the works may start concurrently and reduces the cycle time. Moreover, the excessive transport time and set-up process are classified as planned downtime which can be minimized but it is acceptable in OEE. These lean wastes can be tracked by using Maynard operation sequence technique (MOST). Bon and Daim [4] stated that manpower might do unnecessary works or excessive motion when completing a task. MOST can be focused in this area and improve it by work study and work measurement and study of the work.

2. METHODOLOGY

OEE has three main elements, availability, performance and quality level. It is a simple equation that used to indicate the health of the machine.

$$Availability = \frac{OperatingTime}{PlannedproductionTime} \quad (1)$$

$$Performance = \frac{(IdealCycleTime \times TotalRuns)}{ActualRunTime} \quad (2)$$

$$Quality = \frac{TotalGoodParts}{TotalParts} \quad (3)$$

$$OEE = Availability \times Performance \times Quality \quad (4)$$

MOST is a work measurement and it will use to identify the hidden wastes in OEE. Mini MOST defined a sequence in three actions which are general, control move and tool use. Through these three actions, the action of the worker is studied and non-value added activities will be identify. Time measurement unit (TMU) as the time measurement and it had considered the distance between the operator, workplace, use of tool and the space.

a. General Move
It defines the free movement of object in air. Table 1 shows the parameters used in General Move. Each parameter represents the general action of the worker.

Table 1 Parameters used in General Move

Represent	A	B	C	P
Describe	Action Distance	Body Motion	Gain Control	Placement

b. Control Move
It defines movement of object in contact with a surface or attach to an object during motion. Table 2 shows the parameters in Control Move and all the motion of worker when in contact with other objects are showed.

Table 2 Parameters in Control Move

Represent	A	B	C
Describe	Action Distance	Body Motion	Gain Control

Represent	M	X	I
Describe	Move Controlled	Process Time	Alignment

c. Tool Use
It defines the application of tool during production or assembly. Table 3 shows the parameters in Tool Use. Each motion is represented by alphabet and the action of worker when using the tool is simplified into a set of parameters.

Table 3 Parameters in Tool Use

Represent	A	B	C
Describe	Action Distance	Body Motion	Gain Control

Represent	P	U
Describe	Placement	Tool Action

d. Time Measurement Unit (TMU)

Table 4 Unit Conversion Table

1 Hour	100,00 TMU
1 Minute	1667 TMU
1 Second	27.8 TMU

3. RESULT AND DISCUSSION

There are some lean wastes are tolerated in OEE. The work done by the operator might considered perfect in OEE but it might be improved by the MOST. The excessive movement and transport time is tolerated in OEE but MOST can track out these hidden wastes. Through MOST, the OEE that considered as 'perfect' can be improved again by eliminate those hidden wastes that tolerated in OEE.

Table 5 Current MOST analysis

Work element	Total TMU	Total time(min)
Shift start	30840	18.50
Stacking of molds	35950	21.57
Setup inside equipment	155790	93.45
Fabrication	74150	44.48
Total	594880	356.86
Nonvalue added	213.54mins	59.84%
Value added	143.32 mins	40.16%

Table 6 Secondary MOST analysis

Work element	Total TMU	Total time (min)
Stacking of Molds	35950	21.57
Loading Mold into equipment	15890	9.53
Door Opening	2130	1.28
Unloading Mold	55870	33.52
Setup Inside equipment	68220	40.92
Data Entry	10780	6.47
Leak Check	15990	9.59
Curing	90	0.05
Door Closing	2640	1.58
Total =	498680	299.15
Non-value Added	155.86 mins	52.10%
Value Added	143.29 mins	47.90%

From Table 5 and 6, it has shown the decreases of non-value added percentages from 59.84% to 52.10%. This is done by changes some internal steps to external steps and minimize the excessive steps that available in the process. Through this, the OEE of the process has increased from 84.32% to 88.94% which above the world class OEE, 85%.

4. CONCLUSIONS

OEE is a good indicator to evaluate the health of the machine and MOST is a tool to utilize the work done by the manpower. MOST is useful in reduce the unnecessary motion of the manpower and this may improve the OEE by visible and eliminate hidden wastes. The operating time could be reduced by implementing the MOST to improve the working mechanism of the manpower. Some of the internal steps may converted to external steps by using MOST. Furthermore, the excessive transport time will be visible by using MOST. Therefore, MOST can use to track out the hidden wastes available in OEE and improve OEE. The future study is developed mathematical model to validate the effect of the MOST to OEE.

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REFERENCES

[1] V.Manojkumar, Dr.R.Kesavan, and S.Kalyanakumar, "Analysis and improvement of overall equipment effectiveness in automatic fettling machine," *National Journal on Advances in Building Sciences & Mechanics*, vol. 5, no. 2, pp. 10-14, 2014.

[2] F.Anvari, R.Edwards, and A.Starr, " Evaluation of overall equipment effectiveness based on market," *Journal of Quality in Maintenance Engineering*, vol. 16, no. 3, pp. 256-270, 2010.

[3] M.Mulla and C.G Ramesh, " Enhancing overall equipment effectiveness of HMC machines through TPM and 5S techniques in a manufacturing company," *International Journal on Mechanical Engineering and Robotics*, vol. 2, no. 2, pp. 52-57, 2014.

[4] A.T.Bon and D.Daim, " Time motion study in determination of time standard in manpower process," *3rd Engineering Conference on Advancement in Mechanical and Manufacturing for Sustainable Environment2010*, 2010.

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Influence of hot compression moulding processing method on the mechanical strength of recycled polypropylene/polyethylene blends

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Keywords: Recycle polyethylene polypropylene blends, hot compression moulding, process parameter, tensile properties

ABSTRACT Recycled polypropylene(PP)/polyethylene (PE) blend sources from the diaper industry is reused for wood plastic composites application. In this study, the relationship between process parameters and mechanical properties of PP/PE blend was analysed. The study was conducted by performing the tensile tests accordance to ASTM D638. The method of applying heat during the hot compression moulding also been varied which pressing from T = 30 °C (room temperature) and T = 200 °C. The results reveal that the tensile properties of the sample that was prepared with T = 30 °C has better tensile strength and Young's modulus of 16.61% and 34.68% respectively.

1. INTRODUCTION

1.1 The demand and dependency of plastic has increased since it has been used from decades ago. The substitution of using metal to plastic for children's toys is the example how plastic has plays it vital role on human live. Usually, plastic product is cheaper than metal, thus the manufacturer able to produce the product at competitive price, however, due to increase in demand and production rate cause high rate of waste and landfill problems. It was reported that in 2013, there were 299 million tons of plastic has been produced around the globe [1]. The increasing of "unwanted waste production" also contributes to the opening more landfills which will cause health and environment issues. In order to facing this problems, the enforcement of reuse, reduce and recycle (3R), waste to energy and waste to wealth initiatives should be done by public and government. There are some constraints when dealing with thermoplastic especially the recycled grades, for instance the process temperature, and total time on heat exposure. A thermoplastic that facing heat exposure beyond melting temperature that value may cause high thermal degradation which may leads on dropping of mechanical, physical and electrical properties [2].

1.2 In this study, the effect of hot moulding processingparameters on the tensile properties of recycled PP/PE blends is investigatedin order to optimise their fabrication method.

2. METHODOLOGY

2.1 Sample preparation

The recycled plastic derived from rejected diapers, containing of 70% of polypropylene (PP) and 30% of polyethylene (PE) supplied by ZFH Industries Sdn Bhd, (Klang, Malaysia). The raw material was compounded byusing internal mixer HAAKE™ Rheomix (ThermoFisher Scientific, Germany) for 10 minutes, 45 rpm and 180 °C. Afterward the blends werecrushed usingTW-SC-400F crusher Machine (Taiwan). 200g of blends was hot compressed mouldedin 20cm x 20cm x 0.3cm (thickness) mould using hot press moulding machine (Go Tech, Taiwan) at 200°C. The method of applying heat was varied, heating from T = 30 °C (room temperature) and T = 200 °C. Both sample were preheated for 25 minutes and full compression for 15 minutes under maximum pressure of 95kgf. After that, the sample was cooled by water quenching. The sample were cut into dumbbell shape of 16.5cm x 1.8cm x 0.3 (thickness) for tensile testing.

2.2 Tensile testing

Tensile testing was conducted on Instron® 8872 Universal Testing machine (Instron, UK) according to ASTM D638[3]. The load was measure by 25kN capacity load cell, at 1mm/min test rate and crosshead of 0.1 mm/min. Seven samples weretested for each compression moulding temperature used[4].

3. RESULTS AND DISCUSSION

3.1 Figure 1 represents the tensile strength between two methods of applying heat for hot compression moulding process. Applying heat from room temperature (T = 30 °C), giving the average tensile strength as 8.65 ± 0.41 MPa which is slightly higher compared to applying heat from T = 200 °C which is 8.33 ± 0.36 MPa.

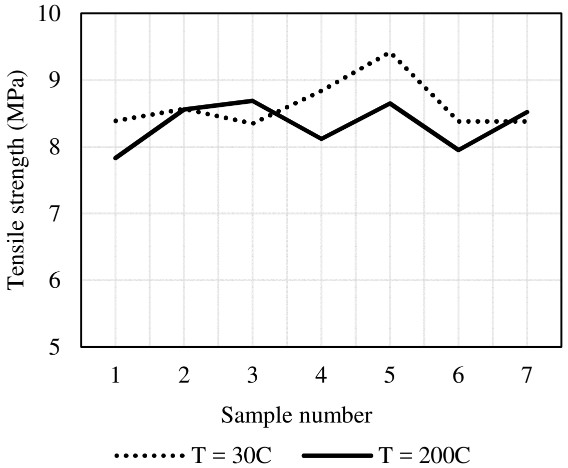

Figure 1 The tensile strength for each sample

Figure 2 illustrates the Young's modulus from the tensile test, of two hot compression moulding methods. The tensile modulus for heat applying technique from T = 30 °C and T = 200 °C have the average tensile modulus as 0.22 ± 0.1GPa and 0.19 ± 0.8 GPa respectively.

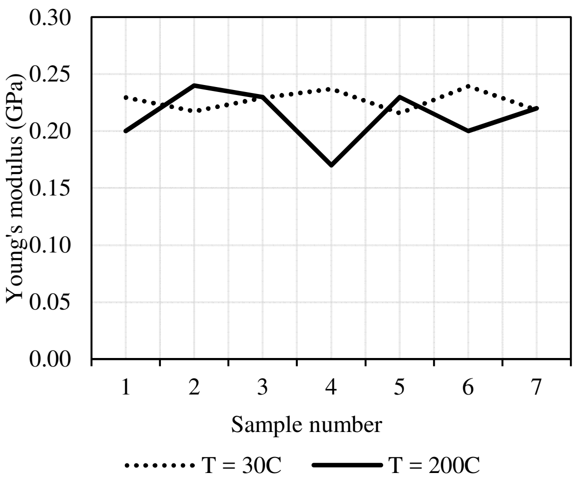

Figure 2 The tensile Young's modulus for each sample

4. CONCLUSIONS

The study of influence of hot compression moulding processing method on the mechanical strength of recycled PP/PE blend was carried out by using an experimental plan with two heat applying techniques, applying heat from T = 30 °C (room temperature) and T = 200 °C.Overall, these studiesillustrate the role of heat applying technique to the tensile properties. It has been observed that applying heat from room temperature will contribute to 16.61% of better tensile strength and 34.68% of better Young's modulus, compared to heat applied at higher temperature.

REFERENCES

[1] S.D.A.Sharuddin, F. Abnisa, W.M.A.Wan Daud, and M. Kheireddine Aroua, "A review on pyrolysis of plastic wastes," *Energy Convers. Manag.*, vol. 115, pp. 308–326, 2016.

[2] C. L. Beyler and M. M. Hirschler, "Thermal Decomposition of Polymers," in *SFPE Handbook of Fire Protection Engineering*, 2nd ed., Morgan Hurley, Ed. Springer, 2002, pp. 110–131.

[3] ASTM International, "Standard Test Method for Tensile Properties of Plastics," *Annu. B. ASTM Stand.*, pp. 1–15, 2004.

[4] N.K. Madi, "Thermal and mechanical properties of injection molded recycled high density polyethylene blends with virgin isotactic polypropylene," *Mater. Des.*, vol. 46, pp. 435–441, 2013.

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Development of a new closed-loop recyclability framework based on extended producer responsibility in mnimizing electronic waste

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Keywords: Extended producer responsibility; cosed-loop recyclability; e-waste

ABSTRACT – As the rapid growth of technology, a lot of electrical and electronic equipment eventually becomes obsolete. Electrical and electronic waste (e-waste) contains a number of unsafe substances which can leak into groundwater if disposed of in conventional landfills, or pollute the air when incinerated. Therefore, a method to reuse and recycling of e-waste is a significant responsibility and solution to reduce environmental impact. The objective of this research is to develop a new framework for closed-loop recyclability based on extended producer responsibility to reduce this environmental impact from e-waste. Extended producer responsibility is the solution in which the manufacturers are encouraged to take back their product at end-of-life and manage the waste. Then, closed-loop recyclability will manage the waste through recycling and reuse the useful waste part. Implementation of a new closed-loop recyclability framework can minimize the volume of waste going to landfill and to achieve the objective of reducing environmental impact. This new closed-loop recyclability framework on extended producer responsibility concept should be applied in industry to reduce their environmental impact.

1. INTRODUCTION

Increasing of economic growth and the development of technology has been the main cause of the increasing of waste. The increasing of e-waste leads to the space problem for landfill and also brings the negative impact to the environment and human health. Kate and Jim [1] discussed that waste elimination by reuse and recycle is one of the best ways to encounter the problem with the increasing volume of electronic waste as shown in Figure 1.

Extended producer responsibility (EPR) encourage manufacturers to collect back their products to reducing end-of-life waste by repairing, reconditioning, remanufacturing or recycling. The end-of-life electrical and electronic appliances such as computer, TV sets, washing machine, refrigerators, water heater and others. According to Hesse et al. [2], tack back system is always benefit both manufacturer and consumer. Closed-loop recyclability concept will be use to manage the take back product. Closed-loop recyclability manage the waste through recycling and reuse the useful waste part. Hence, the manufacturer can increase both profit margins and sales while the consumers always have a better way with the end-of-life electronic products.

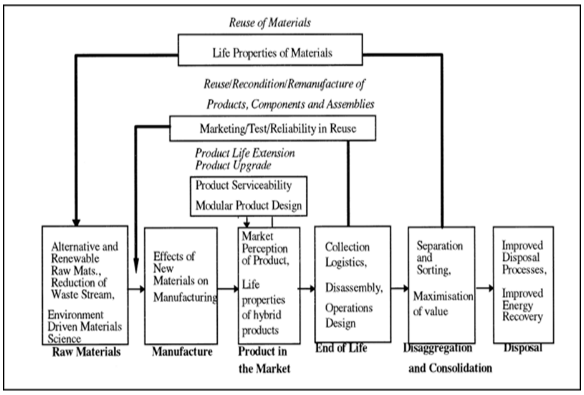

Figure 1 Major technological issues of take back system (Kate and Jim, 1998).

2. LITERATURE REVIEW

2.1 Electronic Waste (e-waste)

Pucket et al. [3], stated that waste of electrical and electronic equipment (WEEE) or e-waste includes a variety of electronic devices ranging from large domestic devices such as refrigerators, air conditioners, cell phones, personal stereos, and consumer electronics to computers which have been rejected by their end-users. The increasing development of this electronic product very fast.

This electronic product contains a lot of harmful material that will cause environmental impact. According to Tanskanen and Butler [4], the electronic product contain a few of toxic metals and chemicals such as lead, mercury, cadmium, chromium, and PCBs and this material will cause great harm to the environment. While Stuart et al. [5] states that electronic products also contain precious metals and plastics as well as ceramic and glass materials that may be reused if proper materials separation and recycling is available.

The dispose of electronic waste or also called as e-waste straight to landfill will result in a lot of valuable material from the electronic waste is lost. Finally, When e-waste is disposed of or recycled without any controls, there are predictable negative impacts on the environment and human health, as describes by Pucket et al. [3].

2.2 Extended Producer Responsibility (EPR)

According to xu [6] noted that Extended Producer Responsibility (EPR) is as the direction for transforming the mode of e-waste take-back. A fundamental element of EPR is the producers are the primary responsible actors for the entire life cycle of their products as stated by Ribeiro and Gomes [7]. Wu and Wang [9] describe that, EPR aims to reach an environmental objective of a decreased total environmental impact from a product, by making the manufacturer of the product responsible for the entire lifecycle of the product and especially for the take-back, recycling and final disposal of the Product. A study by Wu and Wang [9] also stated there are five extended producer responsibility promotional factors, improvement potential of product's environmental performance, feedback to product redesign, closed-loop recyclability, cost-benefit certainty and service substitutability. For this research it will focus more on closed-loop recyclability.

3. CLOSED-LOOP RECYCLABILITY

Closed-loop recyclability means that after remanufacturing or recycling, components or materials obtained from waste products can become the useful input to the same manufacturing process of the same producer. Closed-loop recyclability enable producers to take their wasted products as something reusable, thus encourages them to deal with wasted products in a more scientific way that according to their own manufacturing techniques.

In closed-loop recycling, the properties of the recycled material are not consider different from those of the virgin material. Thus the recycled material can be substitute the virgin material and be used in the identical type of products as before. While in open-loop recycling, the properties of the recycled material is different from those of the virgin material in a way that it is only usable for other product applications, mostly substituting other materials as described by Williams et. Al [8].

The best example of applying closed-loop recyclability in manufacturing industry is Fuji Xerox company. A study by Wu and Wang [9] discover that Fuji Xerox committed to closed-loop recyclability through two steps, first by remanufacturing the usable components and secondly by recycling useless components as materials. The closed-loop recyclability very helpful to recycling process, it have a lot of potential to be develop for each electronic waste. Hence to minimize the waste that happen from electronic product, the closed-loop recyclability for a take back product need to be study to improve their efficient to recycling electronic waste.

4. EXPECTED RESULT

The expected outcome from this research is a new proposed closed loop recyclability framework to manage the e-waste efficiently will be generated. The framework showing the flow of e-waste from landfill until how its part going back to their producer. With this framework, it will help more electronic waste and electronic part to be processed for reuse (repair, upgrade, and resale), recycling, or disposal. The implementation of closed loop recyclability from a take back product will reduce environmental impact since the e-waste will be recycled back and reuse back with a new product in the industry. Since the impact of the e-waste and step to recycle the e-waste was clearly explained in the framework, electronic industry would be more interested in implementing Extended Producer Responsibility (EPR).

REFERENCES

[1] G Kate, and B. Jim, "Electronic Products Recovery-PAWS", a BRITE-EURAM Project. Computer in Industry, 36 (1998), pp. 65-74, 1998.

[2] H. S. Heese, K.Cattani, G. Ferrer, W. Gilland, and A. V. Roth, "Competitive advantage through take-back of used products", European Journal of Operational Research, 164(1), 143-157, 2005.

[3] J. Puckett, T. Smith, "Exporting harm: the high-tech trashing of Asia The Basel Action Network", in Seattle 7 Silicon Valley Toxics Coalition; 2002.

[4] P. Tanskanen, and E. Butler, "Mobile phone take back learning's from various initiatives". In 2007 IEEE International Symposium on Electronics and the Environment, 2007.

[5] J. Stuart, M. K. Low, D. Williams, L. Turbini, and J. Ammons, "Challenges in determining electronics equipment take-back levels". IEEE Trans. Comp., Packag., Manufact. Technol. C IEEE Transactions on Components, Packaging, and Manufacturing Technology: Part C, 21(3), 225-232, 1998.

[6] Z. Xu, "Integrated Information Systems of E-Waste Take-Back Supply Chain", In 4th International Conference on Wireless Communications, Networking and Mobile Computing, 2008.

[7] J. S. Ribeiro, and J. D. Gomes, (2014). "Extending producer responsibility: Framework to incorporate life cycle assessment in aircraft preliminary design based on take-back policies", In International Conference on Innovative Design and Manufacturing (ICIDM), 2014.

[8] T. Williams, O. Heidrich, P.J. Sallis, "A case study of the open-loop recycling of mixed plastic waste for use in a sports-field drainage system", Res Cons. Rec 55 (2), 118–128, 2010.

[9] Y. Wu, and H. Wang, "Study on the Promotional Factors of Extended Producer Responsibility", 2010 International Conference on Management and Service Science, 2010.