International Journal of Mechanical and Production Engineering Research and Development (IJMPERD)
ISSN (P): 2249–6890; ISSN (E): 2249–8001
Vol. 9, Issue 6, Dec 2019, 595–608

TRANS STELLAR •Journal Publications •Research Consultancy

SPLITTING TOTAL GEAR RATIO OF TWO-STAGE HELICAL REDUCER WITH FIRST-STAGE DOUBLE GEARSETS FOR MINIMAL REDUCER LENGTH

NGUYEN VAN CUONG[1], LE HONG KY[2], TRAN THI HONG[3], NGUYEN THANH TU[4] & VU NGOC PI[5]

[1]*University of Transport and Communications, Ha Noi City, Vietnam*

[2]*Vinh Long University of Technology Education, Vinh Long City, Vietnam*

[3]*Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam*

[4,5]*Thai Nguyen University of Technology, Thai Nguyen City, Vietnam*

ABSTRACT

This article introduces a study on splitting the total gear ratio of a two-step helical reducer with the first step double gear sets. In order to do that, an optimization problem with the objective is the minimal length of the reducer was carried out. Moreover, the effects of several parameters containing the total gear ratio, the allowable contact stress, the output torque and the face width coefficient were investigated. For examining the relation between the partial gear ratios and the input parameters, a simulation experimental work was performed. Besides, the models for splitting the total reducer gear ratio were found.

KEYWORDS: Gear Ratio, Optimal Gear Ratio, Optimal Reducer Design & Two-Step Helical Reducer

Received: Aug 09, 2019; **Accepted:** Aug 29, 2019; **Published:** Nov 12, 2019; **Paper Id.:** IJMPERDDEC201951

Original Article

INTRODUCTION

So far, several researches have been concentrated in finding optimal gear ratios of a gearbox or a mechanical transmission system. The reason is that the volume, the size of a gearbox or a mechanical transmission system is strongly affected by the gear ratios of each stage. In addition, there are three common methods for splitting the total ratio. These methods include the graph method, the practice method and the modelling method.

The Graph Method

This is the earliest method for finding the partial gear ratio. According to this method, the partial gear ratio is determined, graphically. For instance, the optimal partial ratios of the first and the second stages (u_1 and u_2, respectively) of a three step helical gearbox are determined, based on the total gear ratio u_h by using the graph on Figure 1 for getting minimal reducer mass. The transmission ratio of the third step u_3 is then determined from the total ratio and the ratios of step 1 and 2 by the following equation

$$u_3 = \frac{u_h}{u_1 \cdot u_2} \tag{1}$$

The mentioned method was applied in several works [1–3].

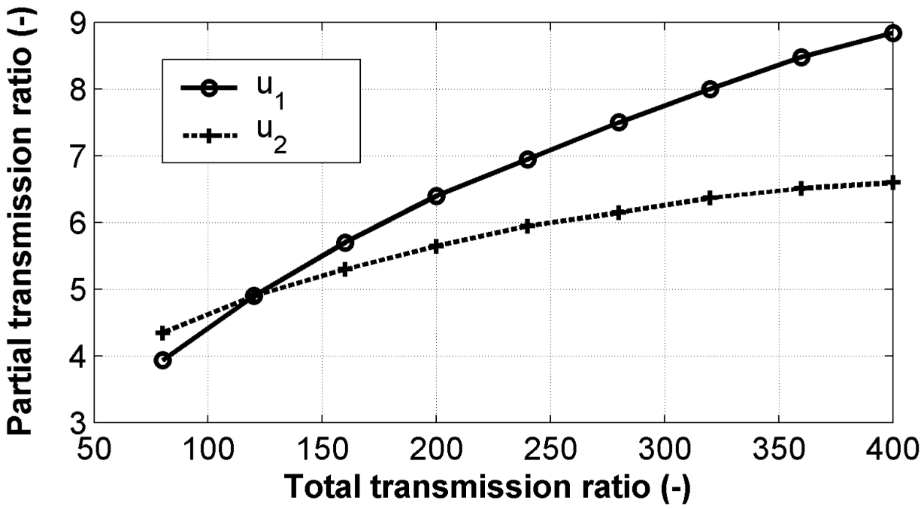

Figure 1: Gear-Ratios of Steps 1 and 2 Versus Total Gear Ratio [1].

The Practice Method

The reason it can be named like that because, in this method, the optimal partial gear ratios of a gearbox are found based on the results of analyzing practice data. Milou and his co-authors were first used this method in [3]. Based on collected data from gearbox companies, they reported that the mass of a two step helical gearbox is minimal when the ratio a_{w2} / a_{w1} is from 1.4 to 1.6 (a_{w1}, a_{w2} are the centre distances of the first and the second step, respectively). From this note, the optimal partial gear ratios of this gearbox were proposed.

By Models

Using this method, the optimal partial ratios of all stages will be determined by formulas, which were found by solving optimal problems with different objective functions. For example, with a two stage helical reducer, for getting minimal length of gearbox, the optimal partial gear ratio of the stage 2is calculated by the following equation [4]:

$$u_2 \approx 1.1966 \cdot \left(\frac{k_c \cdot \psi_{ba2}}{\psi_{ba1}} \right)^{0.35} \cdot u_h^{0.2939} \tag{2}$$

where, ψ_{ba1} and ψ_{ba2} are the coefficients of wheel face width of the stages 1 and 2; $k_C = 1 \ldots 1.3$ is a coefficient; u_h is the total gearbox ratio. Using the model method, many studies [4-16] have been done for determination of the optimal partial gear ratios. In these studies, formulas to calculate the optimal partial gear ratios were found with dissimilar objectives, such as to get minimal gearbox mass of two and three stage reducers [5], to get minimal mass of gears of three-step gearboxes [6], or minimal gearbox length of three stage helical reducers [7].

In addition, the optimal partial gear ratios have been calculated for not the same types of gearboxes such as helical gearboxes, bevel gearboxes or worm gearboxes.

Regarding helical gearboxes, the optimal gear ratios have been found for two-step gearboxes [3–8], three step gearboxes [9–16] and four step gearboxes [13–20]. Concerning bevel gearboxes, the optimal partial ratios were calculated for two step[1, 3, 21] and for three step bevel helical gearboxes [22]. Also, several studies have been conducted to get the optimal partial ratios of worm-gearboxes, for instance two step worm-gearboxes [3, 23, 24] and worm helical gearboxes [24–26].

In addition to studies on determining the optimal gear ratios for gearboxes, many researchers have tried to find the optimal gear ratios of a mechanical transmission system including a gearbox and a V-belt drive [27-30] or a chain drive [31–33].

This article presents a study on splitting the total ratio of a two-stage helical reducer with the first-stage double gear sets, which has been used widely in mechanical transmission systems. In the study, the minimal reducer length was selected for the target of the optimisation problem. Also, the influence of input parameters containing output-torque, the total gear ratio, the coefficients of the wheel face width of the first and second stages, and the allow able stress have explored. Furthermore, for evaluating the influences of the mentioned parameters on the optimal partial gear ratios, a simulation experiment was performed. Additionally, proposed models to calculate the optimal partial gear ratios were presented.

METHODS

Determination of Optimization Problem

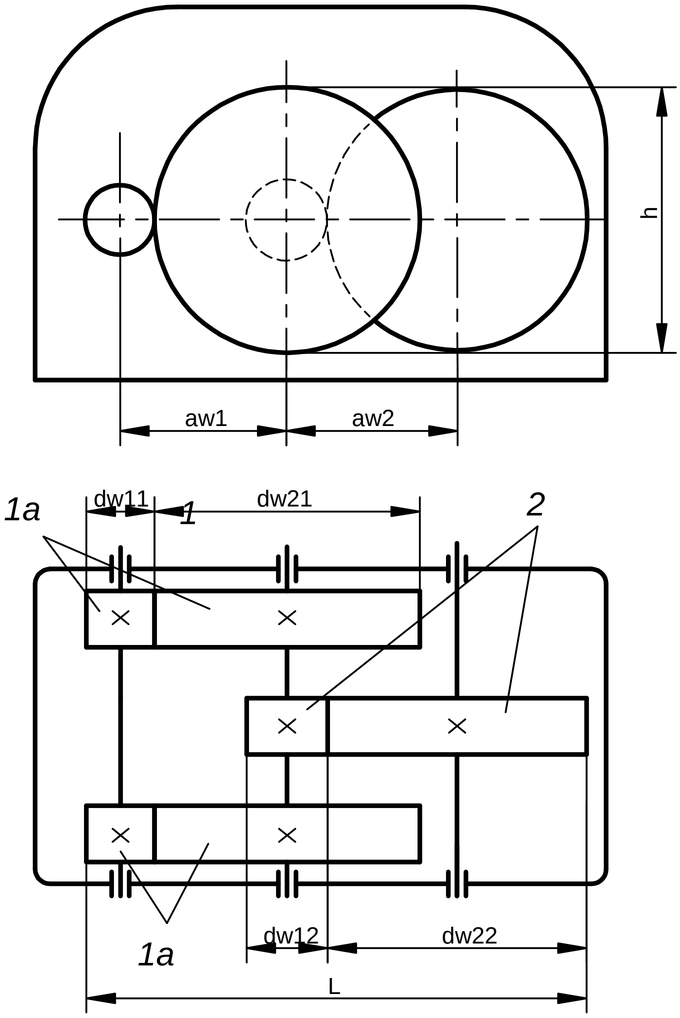

Figure 1: Calculation Schema.

The length of a two-stage helical reducer with the first-step double gear sets is determined as (see Figure 1)

$$L = \frac{d_{w11}}{2} + a_{w1} + a_{w2} + \frac{d_{w22}}{2} \tag{3}$$

Where, a_{w1} and a_{w2} are the centre distances of two steps; d_{w11} and d_{w22} are the pitch diameters (mm) of two steps. d_{w11} and d_{w22} can be calculated as in [34]

$$d_{w11} = \frac{2 \cdot a_{w1}}{u_1 + 1} \tag{4}$$

$$d_{w22} = \frac{2 \cdot a_{w2} \cdot u_2}{u_2 + 1} \tag{5}$$

In which, u_1, u_2 are the gear ratios of stages 1 and 2; $u_1 \cdot u_2 = u_g$ in which u_g is the total reducer ratio

Therefore, the optimization problem is described by

$$minimize\ L \tag{6}$$

With constraints

$$1 \le u_1 \le 9 \tag{7}$$

$$1 \le u_2 \le 9$$

From the above equations, for solving the optimization problem we need to calculate a_{w1}, a_{w2}, d_{w11} and d_{w22}.

Calculating Centre Distance a_{w1}

The centre distance a_{w1} is calculated by[34]

$$a_{w1} = K_a \cdot (u_1 + 1) \cdot \left(\frac{T_{11} \cdot k_{H\beta}}{[\sigma_H]^2 \cdot u_1 \cdot \psi_{ba1}} \right)^{1/3} \tag{8}$$

In which, K_a =43 is the coefficient of the material [34]; $k_{H\beta}$ is a load ratio; $k_{H\beta} = 1.02 \ldots 1.28$ [34]and it can be selected as $k_{H\beta} = 1.1$; $[\sigma_H]$ is the allowable stress (MPa); $[\sigma_H] = 350 \ldots 420$ (MPa) for steel gear; ψ_{ba} is the coefficient of wheel face width of the stage 1: $\psi_{ba1} = 0.3 \ldots 0.35$ [34].

In addition, the relation between the output torque and the torque on the pinion can be found by

$$T_{out} = 2 \cdot T_{11} \cdot \eta_{hg}^2 \cdot \eta_{be}^3 \cdot u_g \tag{9}$$

Where, η_{hg} is gear efficiency ($\eta_{hg} = 0.96 \ldots 0.98$ [34]); η_{be} is bearing efficiency ($\eta_{be} = 0.99 \ldots 0.995$ [34]). Selecting $\eta_{hg} = 0.97$ and $\eta_{be} = 0.992$ and replacing them into equation (9) we have

$$T_{11} = \frac{0.5444 \cdot T_{out}}{u_g} \tag{10}$$

Substituting (10) and $k_{H\beta} = 1.1$ into (8) gets

$$a_{w1} = 36.2442 \cdot (u_1 + 1) \cdot \left(\frac{T_{out}}{[\sigma_{H1}]^2 \cdot u_1 \cdot u_g \cdot \psi_{ba1}} \right)^{1/3} \tag{11}$$

After having a_{w1}, the pinion pitch diameter is found by[34]

$$d_{w11} = \frac{2 \cdot a_{w1}}{u_1 + 1} \tag{12}$$

Calculating Centre Distance a_{w2}

The centre distance of stage 2 a_{w2} can be determined by [34]

$$a_{w2} = K_a \cdot (u_2 + 1) \cdot \left(\frac{T_{12} \cdot k_{H\beta}}{[\sigma_H]^2 \cdot u_2 \cdot \psi_{ba2}} \right)^{1/3} \tag{13}$$

Also, the output torque of the reducer is calculated as

$$T_{out} = T_{12} \cdot \eta_{hg} \cdot \eta_{be}^2 \cdot u_2 \tag{14}$$

Choosing $\eta_{hg} = 0.97$ and $\eta_{be} = 0.992$ as in section 2.1 and substituting them into (14) we have

$$T_{12} = \frac{1.0476 \cdot T_{out}}{u_2} \tag{15}$$

Substituting (15), K_a =43 and $k_{H\beta} = 1.1$ into (13) gets

$$a_{w2} = 45.0814 \cdot (u_2 + 1) \cdot \left(\frac{T_{out}}{[\sigma_H]^2 \cdot u_2^2 \cdot \psi_{ba2}} \right)^{1/3} \tag{16}$$

Experimental Work

To explore the relation between the input parameters and the optimal gear ratio of each step, a simulation experiment was done. The experiment was planned with a 2-level full factorial design and5 input parameters (Table 1). Subsequently, there are $2^5 = 32$ numbers of tests for the experiment. From Equations (4) and (5), a computational program was built to conduct the experiment. Table 2 reports various input factor levels and the output results (the optimal partial ratio of second step u_2).

RESULTS AND DISCUSSIONS

Figure 2 presents the effects of the involvement factors on the optimal partial gear ratio of the second step u_2. It is reported that u_2 is greatly affected by the total reducer ratio u_g. When u_g grows, it increases considerably. Also, u_2 is affected by the coefficients of the wheel face width of both steps ψ_{ba1} and ψ_{ba2}. Additionally, it is noted that u_2 does not depend on the allowable stress as well as the output torque T_{out}.

Figure 3 describes the Pareto diagram of the standardized effects of u_2.Based on this chart, it can be seen that u_g (factor A), ψ_{ba1} (factor B), ψ_{ba2} (factor C) and their interactions AB and AC are statistically significant at the 0.05 level with the output results (the optimal gear ratio u_2) as these factors cross the reference line. Also, u_2 is not affected by AS (factor D) and T_{out} (factor E) because they do not appear to the right of the reference line.

Table 1: Input Factors

Factors	Code	Unit	Low	High
Total Gear Box Ratio	u_g	-	5	30
Wheel Face Width Coefficient of Step 1	x_{ba1}	-	0.3	0.35
Wheel Face Width Coefficient of Step 2	x_{ba2}	-	0.35	0.4
Allowable Contact Stress	AS	MPa	350	420
Output Torque	T_{out}	Nmm	10^5	10^7

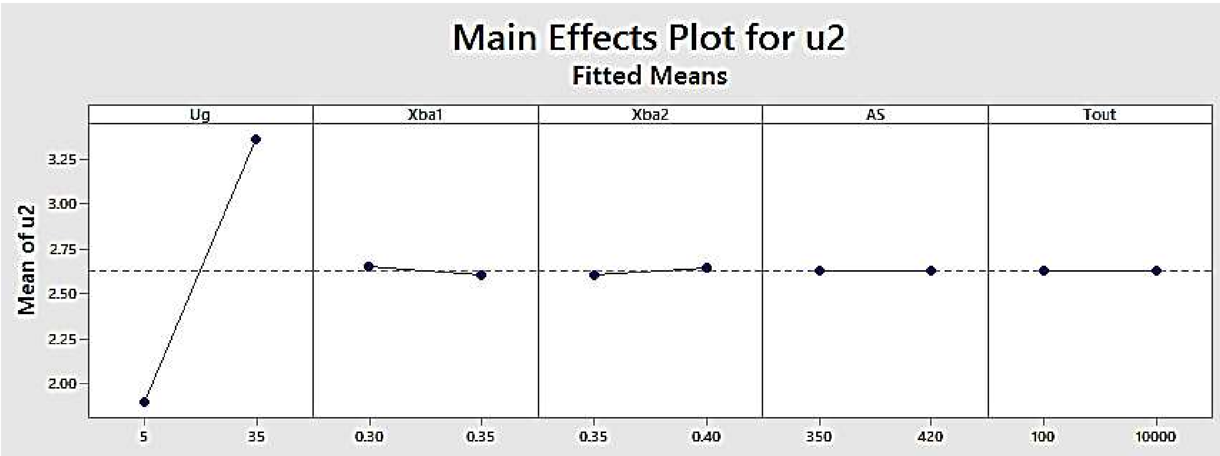

Figure 2: Main Effects Plot for u_2.

The Normal Graph of the standardized effects is presented on figure 4. It can be seen from the chart that the biggest factor affecting u_2 is u_g (factor A). Besides, u_g (factor A) and ψ_{ba2} (factor C) have a positive influence. The optimal partial ratio u_2 rises with the growth of these factors. Furthermore, ψ_{ba1} (factor B) and the interaction BC have a negative influence. If these factors increase, u_2 decreases.

Table 2: Plan of Experiment and Results

Std Order	Run Order	Centre Pt	Blocks	u_g	Xba1	Xba2	AS (MPa)	Tout (Nm)	u_2
25	1	1	1	5	0.3	0.35	420	10000	1.90
17	2	1	1	5	0.3	0.35	350	10000	1.90
29	3	1	1	5	0.3	0.4	420	10000	1.93
6	4	1	1	30	0.3	0.4	350	100	3.44
15	5	1	1	5	0.35	0.4	420	100	1.89
19	6	1	1	5	0.35	0.35	350	10000	1.87
31	7	1	1	5	0.35	0.4	420	10000	1.89
2	31	1	1	30	0.3	0.35	350	100	3.34
28	32	1	1	30	0.35	0.35	420	10000	3.33

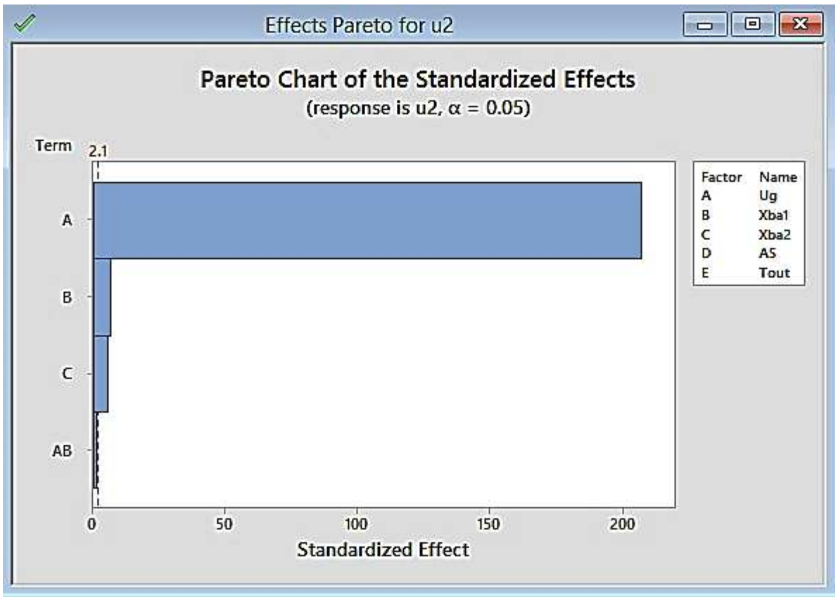

Figure 3: Pareto Effects for u_2.

Figure 5 demonstrates the predicted influences and the coefficients for u_2. It is revealed that all the P-values of u_g, ψ_{ba1}, ψ_{ba2} and the interaction $\psi_{ba1}\cdot\psi_{ba2}$ are zero. Hence, these factors are significant to u_2. Therefore, u_2 can be found by the following equation

$$u_2 = -0.799 + 0.048741\cdot u_g + 6.64\cdot\psi_{ba1} + 7.32\cdot\psi_{ba2} - 20.1\cdot\psi_{ba1}\cdot\psi_{ba2} \tag{17}$$

Equation (17) fits the data quite well because the R^2 is nearly 100% (Figure 5). Hence, the equation can be used for calculation of the optimal partial ratio u_2. Once having u_2, the optimal partial ratio of the first step u_1 can be found as $u_1 = u_g / u_2$.

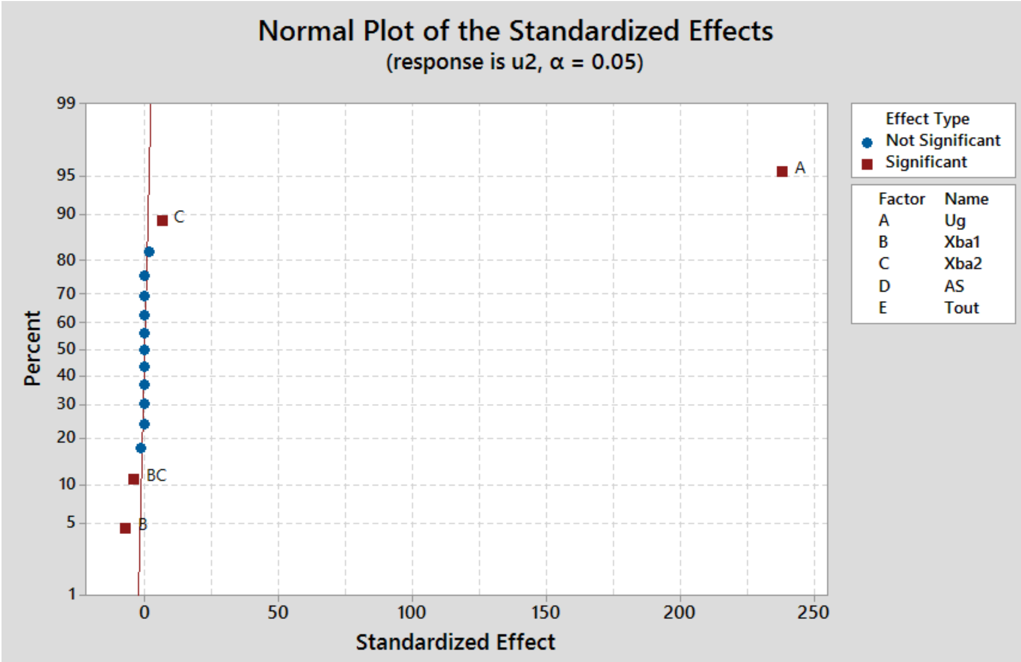

Figure 4: Normal Plot for u_2.

Coded Coefficients

Term	Effect	Coef	SE Coef	T-Value	P-Value	VIF
Constant		2.62892	0.00270	972.93	0.000	
Ug	1.46222	0.73111	0.00270	270.57	0.000	1.00
Xba1	-0.04471	-0.02236	0.00270	-8.27	0.000	1.00
Xba2	0.03926	0.01963	0.00270	7.26	0.000	1.00
Xba1*Xba2	-0.02512	-0.01256	0.00270	-4.65	0.000	1.00

Model Summary

S	R-sq	R-sq(adj)	R-sq(pred)
0.0152852	99.96%	99.96%	99.95%

Figure 5: Predicted Effects and Coefficients for u_2.

CONCLUSIONS

In the present work, optimization aspects splitting the total ratio of a two-step helical gearbox with the first step double gear sets were conducted. For doing that, an optimization problem was performed. The minimal reducer length was selected as the problem target. Also, the effect of the input factors containing the entire reducer ratio, the coefficients of the wheel face width of two steps, the output torque as well as the allowable stress was investigated. In addition, the equations to calculate the optimal partial gear ratios were suggested.

ACKNOWLEDGEMENTS

We would like to give special thanks to Thai Nguyen University of Technology for financially supporting this work.

REFERENCES

1. *V. N. Kudreavtev; I. A. Gierzaves; E.G. Glukharev, Design and calculus of gearboxes (in Russian), Mashinostroenie Publishing, Sankt Petersburg (1971).*
2. *Trinh Chat, Some problems of kinematics calculation of transmission mechanics system (in Vietnamese), Proc. of the National Conference on Engineering Mechanics Vol. 2 (Hanoi) pp. 7–12 (1993).*
3. *Milou, G. Dobre, F. Visa, H. Vitila, Optimal Design of Two Step Gear Units, regarding the Main Parameters. VDI Berichte No 1230, p. 227 (1996).*
4. *Vu Ngoc Pi, A new study on optimal calculation of partial transmission ratios of two-step helical gearboxes, 2nd WSEAS Int. Conf on Computer Engineering and Applications (CEA'08), Acapulco, Mexico, January 25–27, pp. 162–165 (2008).*
5. *Nguyen Thi Hong Cam, Vu Ngoc Pi, Nguyen Khac Tuan, Le Xuan Hung, Tran Thi Phuong Thao, Determining optimal partial transmission ratios of mechanical driven systems using a V-belt drive and a helical reducer with second-step double gear-sets. H. Fujita et al. (Eds.): ICERA 2018, LNNS 63, pp. 261–269, https://doi.org/10.1007/978-3-030-04792-4_35 (2019).*
6. *A.N. Petrovski, B.A. Sapiro, N.K. Saphonova, About optimal problem for multi-step gearboxes (in Russian). Vestnik Mashinostroenie, No. 10, p. 13 (1987).*
7. *Vu Ngoc Pi, A method for optimal calculation of total transmission ratio of two step helical gearboxes. Proceedings of the National conference on Engineering Mechanics, Ha Noi, p. 12 (2001).*
8. *Vu Ngoc Pi, Nguyen Khac Tuan, Le Xuan Hung, Luu Anh Tung, A New Study on Determination of Optimum Gear Ratios of a Two-Stage Helical Gearbox. In: Awang M., Emamian S., Yusof F. (eds) Advances in Material Sciences and Engineering. Lecture Notes in Mechanical Engineering. Springer, Singapore, 2019, pp. 107–115.*
9. *Vu Ngoc Pi, Nguyen Khac Tuan, Optimum determination of partial transmission ratios of Three-step helical gearboxes for getting minimum cross section. Journal of Environmental Science and Engineering A 5, pp. 570–573 (2016).*
10. *Sarmah, C. K. (2016). Gender GAP in Assam: a Socio-Demographic Analysis. International Journal of Applied Mathematic & Statistical Sciences, 5(5), 47–52.*
11. *Vu Ngoc Pi, Nguyen Dang Binh, Vu Quy Dac, Phan Quang The, Optimal Calculation of Total Transmission Ratio of Three-Step Helical Gearboxes for Minimum Mass of Gears. (In Vietnamese) Journal of Science and Technology of 6 Engineering Universities, p. 91 (2006).*
12. *Vu Ngoc Pi, A new study on optimal calculation of partial transmission ratio of three-step helical reducers.*
13. *The 3rd IASME / WSEAS International Conference on Continuum Mechanics, Cambridge, UK, p. 23(2008).*
14. *Vu Ngoc Pi, A new study on optimal calculation of partial transmission ratios of three-step helical reducers for getting minimal cross section dimension. The 2nd WSEAS International Conference on Computer Engineering and Applications (CEA'08), Acapulco, Mexico January 25–27, pp. 290–293 (2008).*
15. *Vu Ngoc Pi, Optimal determination of partial transmission ratios of three-step helical gearboxes with first and third-step double gear-sets for minimal mass of gear. American Conference on Applied Mathematics (MATH'08), Harvard, Massachusetts, USA March 24-26, pp. 385–388 (2008).*
16. *Romhild I, Linke H, Gezielte Auslegung Von Zahnradgetrieben mit minimaler Masse auf der Basis neuer Berechnungsverfahren. Konstruktion 44, pp. 229–236 (1992).*

17. *Vu Ngoc Pi, A new study on the optimal prediction of partial transmission ratios of three-step helical gearboxes with second-step double gear-sets, WSEAS TRANSACTIONS on APPLIED and THEORETICAL MECHANIC, Issue 11, Volume 2, November 2007.*

18. *Ovidiu Buiga, 3 stage helical speed reducer partial gear ratios optimal determination using genetic algorithms, Proceedings of Romanian Academy, Series A, Volume 20, Number 2/2019, pp. 156–163 (2019).*

19. *Vu Ngoc Pi, 2008. Optimal determination of partial transmission ratios for four-step helical gearboxes with first and third step double gear-sets for minimal mass of gears. Applied Computing Conference (ACC' 08), Istanbul, Turkey, May 27–30.*

20. *Vu Ngoc Pi,Optimal calculation of partial transmission ratios for four-step helical gearboxes with first and third-step double gear-sets for minimal gearbox length. American Conference on Applied Mathematics (MATH'08), Harvard, Massachusetts, USA March 24-26, pp. 29–32 (2008).*

21. *Le Xuan Hung, Vu Ngoc Pi, Nguyen Van Du. Optimal calculation of partial transmission ratios of four-stephelical gearboxes with second and fourth-step double gear-sets for minimal mass of gears. The international symposium on Mechanical Engineering (ISME Ho Chi Minh city, Vietnam, pp. 21–23, (2009).*

22. *Vu Ngoc Pi, Optimal determination of partial transmission ratios for four-step helical gearboxes with first and third step double gear-sets for minimal mass of gears, Applied Computing Conference (ACC '08), Istanbul, Turkey, May 27-30, pp. 53–57, (2008)*

23. *Vu Ngoc Pi, A new and effective method for optimal calculation of total transmission ratio of two step bevel - helical gearboxes, International colloquium on Mechanics of Solids, Fluids, Structures & Interaction Nha Trang, Vietnam, 716-719 (2000).*

24. *Karthik, K., Manimaran, A., Rayudu, J. V., & Sharma, D. (2017). Optimization of the Process Parameter in Drilling of GFRP using HSS Drill.*

25. *Vu Ngoc Pi, A study on optimal calculation of partial transmission ratios of three-step bevel helical gearboxes, International Workshop on Advanced Computing and Applications (ACOMP 2008), March 12-14, pp. 277–286, (2008).*

26. *Chernavsky S A et al, Design of mechanical transmissions: Manual for high technical schools (Moscow: Mashinostroenie) p.560, (1984).*

27. *Vu Ngoc Pi and Vu Quy Dac, Calculation of total transmission ratio of two step worm reducers for the best reasonable gearbox housing structure (in Vietnamese), J. of Science and Technology - Thai Nguyen University Vol. 1 (41) pp 65-69 (2007).*

28. *Vu Ngoc Pi and Vu Quy Dac, Optimal calculation of partial transmission ratios of worm-helical gear reducers for minimal gearbox length J. of Science & Technology - Technical Universities, No. 61, pp. 73–77 (2007).*

29. *Vu Ngoc Pi, Nguyen Khac Tuan, Le Xuan Hung, Nguyen Thi Quoc Dung, Bui Thanh Hien, Determining Optimum Gear Ratios of a Worm—Helical Gearbox for Minimum Acreage of the Cross Section. In: Awang M., Emamian S., Yusof F. (eds) Advances in Material Sciences and Engineering. Lecture Notes in Mechanical Engineering. Springer, Singapore, 2019, pp. 89-96.*

30. *Vu Ngoc Pi, Nguyen Thi Hong Cam, Nguyen Khac Tuan, Optimum calculation of partial transmission ratios of mechanical driven systems using a V-belt and two-step bevel helical gearbox, Journal of Environmental Science and Engineering A 5, p. 566, (2016).*

31. *Vu Ngoc Pi, Tran Thi Phuong Thao, Le Thi Phuong Thao, A new study on optimum determination of partial transmission ratios of mechanical driven systems using a V-belt and two-step helical gearbox. Vietnam Mechanical Engineering Journal,*

No. 10, p. 123, (2015).

32. *Vu Ngoc Pi, Nguyen Thi Hong Cam, Nguyen Khac Tuan, Optimum calculation of partial transmission ratios of mechanical driven systems using a V-belt and two-step bevel helical gearbox. Journal of Environmental Science and Engineering A 5, p. 566, (2016).*
33. *Vu Ngoc Pi, Nguyen Khac Tuan, Le Xuan Hung, Nguyen Thi Hong Cam, Tran Thi Phuong Thao, Determining Optimum Partial Transmission Ratios of Mechanical Driven Systems using a V-Belt Drive and a Three-Stage Helical Reducer, In: Awang M., Emamian S., Yusof F. (eds) Advances in Material Sciences and Engineering. Lecture Notes in Mechanical Engineering. Springer, Singapore. 2019, pp 81–88.*
34. *Matarneh, R. A. M. I., Sotnik, S. V. I. T. L. A. N. A., & Lyashenko, V. Y. A. C. H. E. S. L. A. V. (2018). Search of the Molding Form Connector Plane on the Approximation Basis by the Many-Sided Surface with Use of the Convex Sets Theory. International Journal of Mechanical and Production Engineering Research and Development, 8(1), 977–98.*
35. *Vu Ngoc Pi, Tran Thi Phuong Thao, Dang Anh Tuan, Optimum determination of partial transmission ratios of mechanical driven systems using a chain drive and two-step helical gearbox. Journal of Environmental Science and Engineering B 6, p. 80 (2017).*
36. *Nguyen Thi Hong Cam, Vu Ngoc Pi, Nguyen Khac Tuan, Le Xuan Hung, Tran Thi Phuong Thao, A study on determination of optimum partial transmis-sion ratios of mechanical driven systems using a chain drive and a three-step helical reducer, H. Fujita et al. (Eds.): ICERA 2018, LNNS 63, pp. 91–99, 2019,*
37. *https://doi.org/10.1007/978-3-030-04792-4_14*
38. *Vu Ngoc Pi, Nguyen Khac Tuan, Le Xuan Hung, A New Study on Calculation of Optimum Partial Transmission Ratios of Mechanical Driven Systems Using a Chain Drive and a Two-Stage Helical Reducer. In: Awang M., Emamian S., Yusof F. (eds) Advances in Material Sciences and Engineering. Lecture Notes in Mechanical Engineering. Springer, Singapore, 2019, pp. 97–105.*
39. *Trinh Chat, Le Van Uyen, Design and calculus of Mechanical Transmissions (in Vietnamese), Educational Republishing House, Hanoi, (1998).*

AUTHORS PROFILE

Nguyen Van Cuong received the B.Sc. degree from University of Transport and Communications in 2007 in Vietnam. He received his Ph.D. degree from Tula State University in Russia in 2013. Currently, he is a lecturer at the Faculty of Mechanical Engineering, University of Transport and Communications, Hanoi, Vietnam. His research interests include CAD/CAM/CAE, manufacturing technology etc. and optimum design of gearboxes.

Le Hong Ky was born in Vietnam in 1963. He obtained a Engineer in Mechanical Engineering in 1987 from Ho Chi Minh University of Technology and Education, Vietnam. In 1996, he received Master of Mechanical Engineering from Ho Chi Minh University of Technology and Education, Vietnam. In 2016 he got Doctor in Mechanical Engineering at National Research Institute of Mechanical Engineering

(NARIME), Vietnam. Now He is a Lecturer and works as an Vice Rector at Vinh Long University of Technology Education, Vietnam. His current research focuses on optimization in machining processes such as grinding, EDM machining etc. and optimum design of gearboxes.

Tran Thi Hong was born in Quang Tri province, Vietnam in 1956. She obtained a B.Eng in Mechanical Engineering in 1980 from Institute of Construction Bucharest, Romania, and she received Mater of Eng. from Asian Institute of Technology (AIT), Bangkok, Thailand in 1992. In 2000she got her PhD in Mechanical Engineering field at Vietnam National University – Ho Chi Minh City, Vietnam. Now she works as an Assoc. Prof. at Nguyen Tat Thanh University. Her current research focuses on optimization in machining processes, EDM machining etc., optimum design of gearboxes and automation.

Nguyen Thanh Tu was born in Thai Nguyen province, Vietnam in 1981. He received the degree Mechanical Engineering in 2004 from Thai Nguyen University of Technology, Vietnam. In 2010, he received his Mater of Engineering from Thai Nguyen University of Technology, Vietnam. In 2017 he got his PhD in Mechanical Engineering field at Hanoi University of Technology, Vietnam. Now he works at Thai Nguyen University of Technology. His current research focuses on optimization in machining processes such as grinding, EDM machining etc. and optimum design of gearboxes.

Vu Ngoc Pi was born in Thai binh province, Vietnam in 1964. He obtained a BSc in Mechanical Engineering in 1985 from Thainguyen University of Technology, Vietnam. In 1997, he received his Mater of Engineering from Hanoi University of Technology, Vietnam. In 2008 he got his PhD in Mechanical Engineering field at Delft University of Technology, The Netherlands. Now he works as an Ass. Prof. at Thai Nguyen University of Technology. His current research focuses on optimization in machining processes such as grinding, EDM machining etc. and optimum design of gearboxes.