ISSN : 0974 - 7435 Volume 10 Issue 11

2014

BioTechnology

An Indian Journal

FULL PAPER

BTAIJ, 10(11), 2014 [5394-5401]

Analyze Chinese mechanical engineering research progress and outlook

Yuzhi Zhang

Hebei College of industry and Technology, Hebei 050000, (CHINA)

ABSTRACT

In the world of highly developed science and technology, mechanical engineering advanced levels restrict productivity, and decide a nation comprehensive strength to a certain extent. In order to let public to be clearer about Chinese mechanical engineering current research progress and future outlook, the paper firstly makes simple introduction on Chinese mechanical engineering, analyzes Chinese mechanical engineering current development status in every field. That is Chinese mechanical engineering has been greatly developed in every field, but some fields development is good, while others development is slower. And then according to analytic hierarchy process, in case considering progressiveness, practicability, safety and contribution as well as other influence factors, it gets Chinese mechanical engineering future development key points contents occupied proportions that is to further implement mechanical artificial intelligence, and relative filed professional integration and each field mechanical's integration of mechanical and electrical in every field, and their proportions are respectively 0.344, 0.314 and 0.342. Therefore, it is clear that Chinese mechanical engineering future development trend is relative stable, and moves forward correct directions, is beneficial to Chinese such field modernization construction and development.

KEYWORDS

Mechanical engineering; Future outlook; AHP; Artificial intelligence.

INTRODUCTION

From primitive society to current developed science and technological modernization society, mechanical engineering always plays important roles in promoting social development. The cause is mechanical engineering is a science that analyzes everything with core physical principles. However, in all daily life of human, it cannot do without physical law, human economic life can find shadows of physical law. And how to find physical law and apply it to meet human demands are leading tasks of mechanical engineering. Human design, production, manufacturing, running and maintenance and else, all need mechanism engineering to provide theories and technical foundation for them so that can normal operate.

With human ceaseless exploration and discovery on science, mechanical engineering has also rapidly developed in lots of fields, such as tribology field, robot mechanism theory field, mechanical transmission theory and mechanical dynamics field, biosimulation machine and bio-manufacturing theory field, electronics and digital manufacturing field, metrology field, ultra-precision machining and processing and manufacturing field, surface functional structure field, design science field, prototyping and manufacturing field, high energy beam machining field, micro and nano-manufacturing and nano-manufacturing field and so on. And outlook of mechanism engineering future is developing towards artificial intelligence, professional integration and mechanical and electrical integration. In order to more clearly understand current mechanical engineering research progress and outlook, the paper will analyze and research on the problem.

MODEL ESTABLISHMENTS

Construct hierarchical structure

In order to find out China current mechanical engineering research progress and main research directions, firstly it should find out most influential unit on mechanical engineering development that is to find out main influence factors that affect China mechanical engineering development. Subsequently, the paper then on the basis of analytic hierarchy process, it makes quantization on Chinese mechanism engineering main development directions. And then establish target layer, criterion layer and scheme layer relations.

Target layer: The direction of Chinese mechanical engineering main development.

Criterion layer: scheme influence factors, Y_1 is progressiveness, Y_2 is practicability, Y_3 is safety, Y_4 is contribution.

Scheme layer: V_1 is artificial intelligence, V_2 is professional integration, V_3 is mechanical and electrical integration, it gets hierarchical structure as Figure 1 shows.

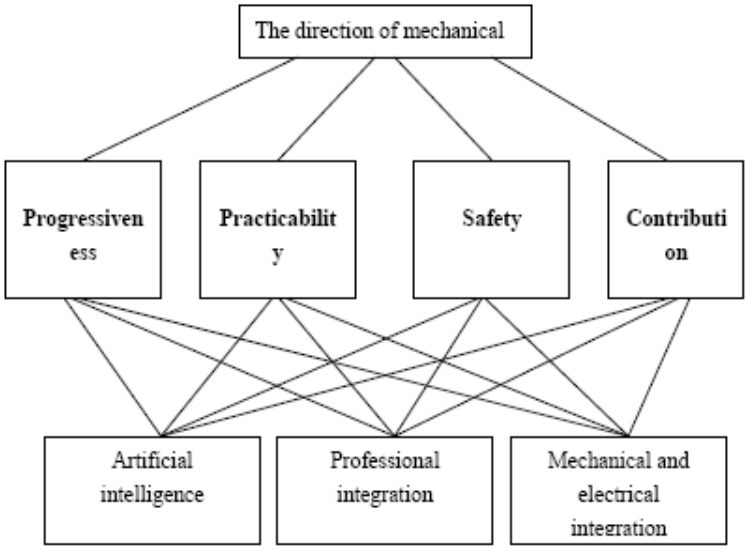

Figure 1 : Hierarchical structure

Construct judgment matrix

In order to get each factor comparison quantified judgment matrix, here set 1~9 scale, as TABLE 1 shows.

TABLE 1 : 1~9 scale table

Scale a_{ij}	Definition
1	factor i and factor j have equal importance
3	factor i is slightly more important than factor j
5	factor i is relative more important than factor j
7	factor i is extremely more important than factor j
9	factor i is absolute more important than factor j
2, 4, 6, 8	Indicates middle state corresponding scale value of above judgments
Reciprocal	If i factor compares to j factor, it gets judgment values is, a_{ji} =1/ a_{ij} , a_{ii} =1

Now set a_{ij} to represent ratio of β_i and β_j to G influence, and get judgment matrix A, in the paper set judgment matrix between layer two and layer one is A_1, element a_{ij}, divisor α_i, α_j, factor is A_1, then it has following formula showed judgment matrix A_1

$$A_1 = \begin{bmatrix} A_1 & \alpha_1 & \alpha_2 & \alpha_3 & \alpha_4 \\ \alpha_1 & a_{11} & a_{12} & a_{13} & a_{14} \\ \alpha_2 & a_{21} & a_{22} & a_{23} & a_{24} \\ \alpha_3 & a_{31} & a_{32} & a_{33} & a_{34} \\ \alpha_4 & a_{41} & a_{42} & a_{43} & a_{44} \end{bmatrix}$$

And in above formula, for a_{ij} values defining, we generally adopt 1~9 proportion scale to assign value on influence extent, as Figure 2 shows.

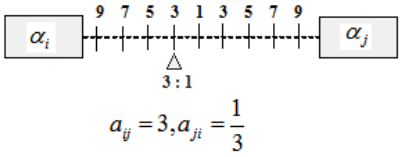

Figure 2 : Nine scale assignment schematic diagram

According to lots of experts experiences and refer to lots of documents as well as 1~9 scale setting, it gets paired comparison matrix that are respective as TABLE 2-6.

TABLE 2 : Comparison matrix

G	Y_1	Y_2	Y_3	Y_4
Y_1	1	1/4	4	4
Y_2	4	1	4	4

Y_3	1/4	1/4	1	1
Y_4	1/4	1/4	1	1

TABLE 3 : Comparison matrix

Y_1	V_1	V_2	V_3
V_1	1	1	1/3
V_2	1	1	1/3
V_3	3	3	1

TABLE 4 : Comparison matrix

Y_2	V_1	V_2	V_3
V_1	1	3	4
V_2	1/3	1	2
V_3	1/4	1/2	1

TABLE 5 : Comparison matrix

Y_3	V_1	V_2	V_3
V_1	1	4	5
V_2	1/4	1	4
V_3	1/5	1/4	1

TABLE 6 : Comparison matrix

Y_4	V_1	V_2	V_3
V_1	1	5	6
V_2	1/5	1	5
V_3	1/6	1/5	1

Consistency test

Use consistency indicator test formula as: $CI = \frac{\lambda_{\max} - n}{n-1}$. From which $\lambda_{\max}$ is comparison matrix maximum feature root, n is comparison matrix order. It is clear that judgment matrix is inversely proportional to CI value.

$$C=\begin{Bmatrix}1 & 1/4 & 4 & 4\\ 4 & 1 & 4 & 4\\ 1/4 & 1/4 & 1 & 1\\ 1/4 & 1/4 & 1 & 1\end{Bmatrix}$$

$$\xrightarrow{\text{Column vector normalization}}\begin{Bmatrix}0.182 & 0.143 & 0.4 & 0.4\\ 0.727 & 0.571 & 0.4 & 0.4\\ 0.045 & 0.143 & 0.1 & 0.1\\ 0.045 & 0.143 & 0.1 & 0.1\end{Bmatrix}$$

$$\xrightarrow{\text{Solve sum by line}}\begin{Bmatrix}1.125\\ 2.098\\ 0.388\\ 0.388\end{Bmatrix}$$

$$\xrightarrow{\text{Normalization}}\begin{Bmatrix}0.281\\ 0.525\\ 0.097\\ 0.097\end{Bmatrix}=W^{(0)}$$

$$CW^{(0)}=\begin{Bmatrix}1 & 1/4 & 4 & 4\\ 4 & 1 & 4 & 4\\ 1/4 & 1/4 & 1 & 1\\ 1/4 & 1/4 & 1 & 1\end{Bmatrix}\begin{Bmatrix}0.281\\ 0.525\\ 0.097\\ 0.097\end{Bmatrix}=\begin{Bmatrix}2.731\\ 5.475\\ 1.185\\ 1.185\end{Bmatrix}$$

$$\lambda_{\max}^{(0)}=\frac{1}{4}\left(\frac{2.731}{0.281}+\frac{5.475}{0.525}+\frac{1.185}{0.097}+\frac{1.185}{0.097}\right)=4.23$$

$$w^{(0)}=\begin{pmatrix}0.258\\ 0.518\\ 0.112\\ 0.112\end{pmatrix}$$

Judgment matrix is:

$$C_1=\begin{Bmatrix}1 & 1 & 1/3\\ 1 & 1 & 1/3\\ 3 & 3 & 1\end{Bmatrix},C_2=\begin{Bmatrix}1 & 3 & 4\\ 1/3 & 1 & 2\\ 1/4 & 1/2 & 1\end{Bmatrix},C_3=\begin{Bmatrix}1 & 4 & 5\\ 1/4 & 1 & 4\\ 1/5 & 1/4 & 1\end{Bmatrix},C_4=\begin{Bmatrix}1 & 5 & 6\\ 1/5 & 1 & 5\\ 1/6 & 1/5 & 1\end{Bmatrix}$$

Corresponding maximum feature value and feature vector in successive are:

$$\lambda^{(1)}{}_{\max}=3.33, w^{(1)}{}_1=\begin{Bmatrix}0.244\\ 0.244\\ 0.415\end{Bmatrix}$$

$$\lambda^{(2)}{}_{\max}=4.25, w^{(1)}{}_2=\begin{Bmatrix}0.562\\ 0.296\\ 0.085\end{Bmatrix}$$

$$\lambda^{(3)}{}_{\max}=3.20, w^{(1)}{}_3=\begin{Bmatrix}0.625\\0.203\\0.130\end{Bmatrix}\ \lambda^{(4)}{}_{\max}=3.16, w^{(1)}{}_4=\begin{Bmatrix}0.641\\0.204\\0.184\end{Bmatrix}$$

According to $CI=\frac{\lambda_{\max}-n}{n-1}$ it gets RI value that can refer to TABLE 7.

TABLE 7 : RI value

n	1	2	3	4	5	6	7	8	9	10	11
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51

For judgment matrix C, $\lambda^{(0)}{}_{\max}=4.25, RI=0.96$

$$RI=\frac{4.25-4}{4-1}=0.083$$
$$CR=\frac{CI}{RI}=\frac{0.083}{0.96}=0.087<0.1$$

It shows C inconsistency degree within permissible range, at this time it can use C feature vector to replace weight vector. Similarly, to judgment matrix C_1, C_2, C_3, C_4, all passed consistency test by using above principle. Therefore, calculation results from object layer to scheme layer can refer to Figure 3.

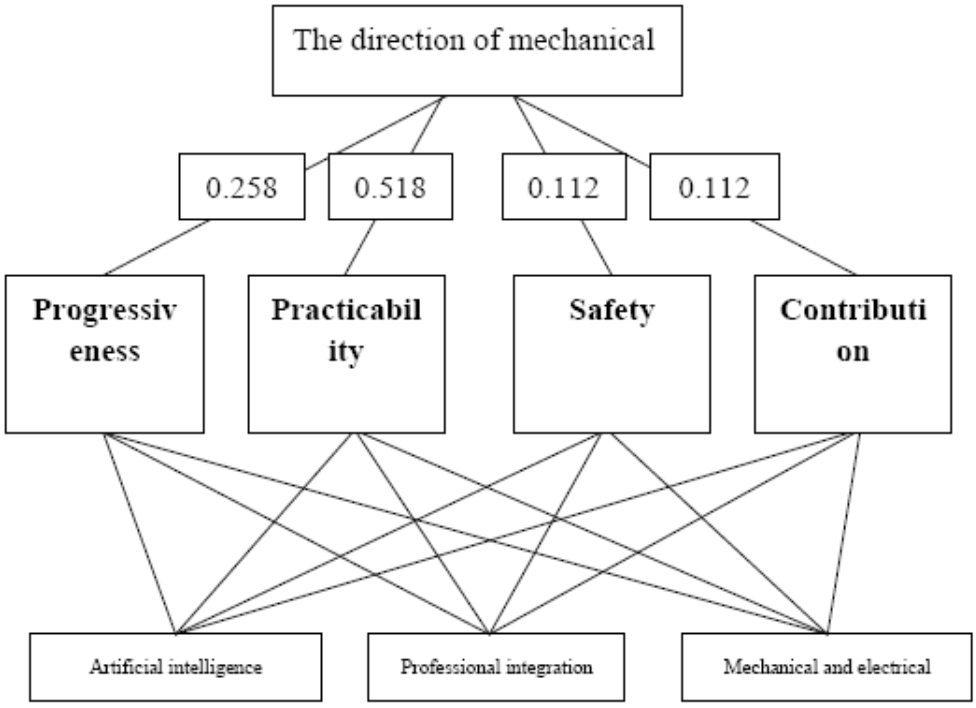

Figure 3 : Target layer to scheme layer calculation result

$$\begin{Bmatrix}0.244\\0.244\\0.415\end{Bmatrix},\begin{Bmatrix}0.562\\0.296\\0.085\end{Bmatrix},\begin{Bmatrix}0.625\\0.203\\0.130\end{Bmatrix},\begin{Bmatrix}0.641\\0.204\\0.184\end{Bmatrix}$$

Calculation structure is as following:

$$w^{(1)} = (w_1^{(1)}, w_2^{(1)}, w_3^{(1)}, w_3^{(1)})$$
$$= \begin{Bmatrix}0.244 & 0.562 & 0.625 & 0.641\\0.244 & 0.296 & 0.203 & 0.204\\0.415 & 0.085 & 0.130 & 0.184\end{Bmatrix}$$

$$w = w^{(1)}w^{(0)}$$
$$= \begin{Bmatrix}0.244 & 0.562 & 0.625 & 0.641\\0.244 & 0.296 & 0.203 & 0.204\\0.415 & 0.085 & 0.130 & 0.184\end{Bmatrix}\begin{Bmatrix}0.258\\0.518\\0.112\\0.112\end{Bmatrix}$$
$$= \begin{Bmatrix}0.344\\0.314\\0.342\end{Bmatrix}$$

By above analysis, it is clear that Chinese mechanical engineering has been greatly developed in every field, but some fields development is good, while others development is slower. And then according to analytic hierarchy process, in case considering progressiveness, practicability, safety and contribution as well as other influence factors, it gets Chinese mechanical engineering future development key points contents occupied proportions that is to further implement mechanical artificial intelligence, and relative filed professional integration and each field mechanical's integration of mechanical and electrical in every field, and their proportions are respectively 0.344, 0.314 and 0.342. Therefore, it is clear that Chinese mechanical engineering future development trend is relative stable, and moves forward correct directions, is beneficial to Chinese such field modernization construction and development.

CONCLUSION

The paper firstly makes simple introduction on Chinese mechanical engineering, analyzes Chinese mechanical engineering current development status in every field. That is Chinese mechanical engineering has been greatly developed in every field, but some fields development is good, while others development is slower. And then according to analytic hierarchy process, in case considering progressiveness, practicability, safety and contribution as well as other influence factors, it gets Chinese mechanical engineering future development key points contents occupied proportions that is to further implement mechanical artificial intelligence, and relative filed professional integration and each field mechanical's integration of mechanical and electrical in every field, and their proportions are respectively 0.344, 0.314 and 0.342. Therefore, it is clear that Chinese mechanical engineering future development trend is relative stable, and moves forward correct directions, is beneficial to Chinese such field modernization construction and development.

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