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SWOT-AHP hybrid model for vehicle lubricants from CNPCLC, China

Jiang Qingzhe[1], XuYanming[1], Xin Wenju[2], Song Zhaozheng[1]*, Song Qianqian[1] and Ke Ming[1]

[1] State Key Laboratory of Heavy Oil Processing, China University of Petroleum, Beijing 102249, China
[2] Tuba Oilfield Petrochemical Plant, Xinjiang Uygur Autonomous Region, Turpan 838202, China

Abstract: In recent years, owing to the strong increase in demand for lubricants, China is ranked second in the global lubricant market. With the rapid development of China's automobile industry, there is an increasing demand for vehicle lubricants and an increasing requirement for higher quality lubricants. While the demands for vehicle lubricants are increasing year by year in China, the quality grade of vehicle lubricant will be improved by leaps and bounds, and the high standard lubricant for automobile will be directly brought in line with international practice. At present, the market share of most high-end vehicle lubricant has been occupied by foreign lubricant brands. So for China National Petroleum Corporation Lubricant Company (CNPCLC), the urgent issue is that strategies must be made to respond to the stern challenges and to occupy more market share. In this paper, by using the analytic hierarchy process (AHP) technique that has the advantage of combining quantitative with qualitative analysis, a SWOT-AHP model for CNPCLC vehicle lubricants is developed, presenting a good tool for studying the competitive factors domestic and overseas for vehicle lubricants. Finally a strategic plan for CNPCLC vehicle lubricants is suggested.

Key words: SWOT, AHP, CNPCLC, vehicle lubricant, strategic planning

1 Introduction

During the last decade, the global lubricant market has undergone dramatic changes due to industry consolidation with flat industrial demand, sharp changes in consumption structure and increasing competitive pressure on profits. Since 1991, despite the drop in demand for lubricants at some regions, the worldwide market demand has remained around 36-38 million tonnes per year, in which vehicle lubricants account for nearly 55%. The demand for lubricants has grown by 28.2% in Asia over the last decade, but the lubricant markets in central and eastern Europe (including Russia) shrank by 50% in 1980s, while Western Europe has shrunk by nearly 10%. Exceeding Europe and North America, the Asia-Pacific region now makes up close to 36% of the global lubricant market (Nagendramma and Kaul, 2012; Gao and Ma, 2011). Worldwide demand for lubricants will rise 2.6 percent annually till 2015, due to increasing demand in emerging markets, e.g. Brazil, Russia, India and China (BRIC). The rapidly growing markets in Asia-Pacific region, led by China, will continue to be the primary driver of growth in the lubricant market, because many companies worldwide come to invest in Asia-Pacific region due to relatively low labor costs and political stability. Latin America and the Africa-Middle East region will also achieve favorable growth in manufacturing as significant countries in both regions continue their industrial development. During the decade from 2011 the demand for lubricant in Asia-pacific regions will be 15.5 million tonnes, and China will account for 40% of the demand in this region. By 2020, the demand for lubricating oil in China will have doubled, and consumption will surpass America (Report on China Lubricating Oil Market, 2011-2015).

In China, due to ongoing rapid industrialization as well as rapid expansion of the motor vehicle fleet, the demand for vehicle lubricants is high. In 2010, 0.66 million tonnes of lubricant were consumed in China, a growth of 9.4 percent year-on-year, and the proportion of vehicle lubricants is 58.8% (Gao and Ma, 2011). With environment protection regulation becoming more and more strict and technological innovations in engines, the demand for high performance vehicle lubricants will increase. At present, about 60% of China's market share of high-end automotive lubricants is occupied by foreign companies, e.g. Shell (including Shell Unified) 33%, Exxon Mobil 16% (Qu and Zhang, 2009). Besides, lubricant enterprises, either foreign or domestic companies, all have to face such challenges as step-by-step improvement of the domestic legal system, increasing market supervision, further standardization of China's lubricant

*Corresponding author. email: song@cup.edu.cn
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market, decreasing automobile and oil product tariffs and accelerating upgrade of fuel oils. These challenges require all lubricant enterprises to employ forward-looking strategies to take advantage of the market.

Achieving long-term development and enhancing competitive power is a problem for CNPCLC. In the study, a SWOT-AHP model was developed based on the literature (Kurttila et al, 2000; Kajanus et al, 2004; Lee and Walsh, 2011) for CNPCLC vehicle lubricant, and its internal and external environments were analyzed, finally a development strategy is developed.

2 Methods

2.1 SWOT analysis

The SWOT (Strengths, Weaknesses, Opportunities and Threats) approach is systematic and comprehensive diagnosis of factors related to a new product, technology, management, or planning (Weihrich, 1982). It is used extensively in strategic planning, where all the factors influencing the operational environment are diagnosed (Weihrich, 1982; Kotler, 1994; Smith, 1999; Hill and Westbrook, 1997). Specifically, it allows decision-makers to categorize factors into internal (strengths, weaknesses), which examine the assets within the organization which could impact on success or failure, and external (opportunities, threats), which investigates factors in the environment that are typically outside of the organization's control that may affect the performance of the organization, as they relate to a decision and thus enables them to compare opportunities and threats with strengths and weaknesses (Lee and Walsh, 2011).

With clear, simple and concrete characteristics , SWOT is a commonly used strategic planning technique in competition and management, especially in business circles (Jin, 1999). With the SWOT analysis of enterprises, four scenarios (Table 1) are developed by matching external environment with internal resource and capacity of enterprises (Pesonen et al, 2000). By utilizing strengths and opportunities, avoiding weaknesses and threats, different scenarios require different strategies, as shown in Table 1. However the main weaknesses of this approach are that the importance of each factor in decision-making cannot be measured quantitatively. In addition, it is difficult to determine the factors which most influence the strategic planning.

Table 1 Strategic choices

	Strengths	Weaknesses
Opportunities	SO: Development Using strengths and taking opportunities	OW: Reverse Taking opportunities, avoiding weaknesses
Threats	ST: Diversification Avoiding weaknesses and threats	TW: Defense Taking opportunities, resisting threats

2.2 Analytic hierarchy process (AHP)

AHP, originally developed by Saaty (1977; 1980; 1982; 2008), is a mathematical method for analyzing complex decision-making problems with multiple criteria. Basically, AHP is a general theory of measurement based on some mathematical and psychological foundations (Kangas, 1993). Dealing with problems qualitatively and quantitatively, AHP has been proved to be a useful decision-analysis approach (Kurttila et al, 2000; Kajanus et al, 2004; Shrestha et al, 2004). One of the advantages of AHP is that the method can convert intangible factors into numerical values, and systematically assess the weights of the selected factors in pairs through a series of comparisons (Saaty, 1977; 1980; 1982; 2008).

The fundamental theory of the AHP process (Ananda and Herath, 2003; Pohekar and Ramachandran, 2004) is decomposition of a complex problem into a hierarchical system, with goal (objective) at the top of the hierarchy, criterions and sub-criterions at levels and sublevels of the hierarchy, and decision alternatives at the bottom of the hierarchy (see Fig. 1). Elements at given hierarchy level are compared in pairs to assess their relative preference with respect to each of the elements at the next higher level.

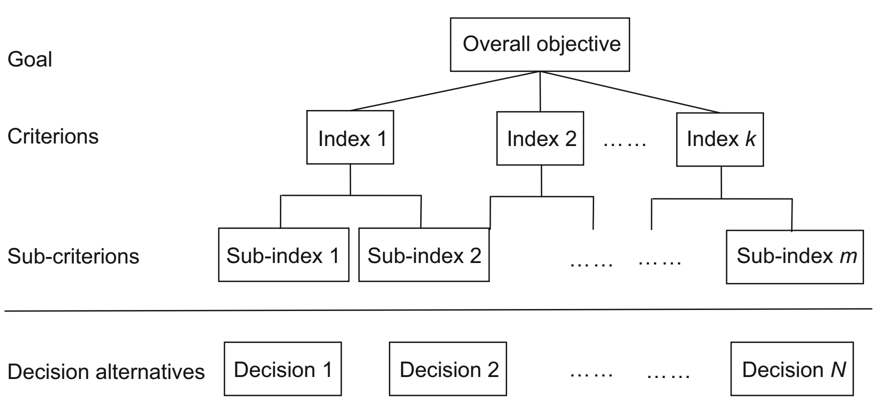

Fig. 1 Hierarchical structure of AHP

The specific steps involved in AHP are as follows:

Step 1, establishment of a pairwise comparison matrix A:

In the hierarchy structure, factors of each level are denoted as: A_1, A_2, ···, A_n. Based on the index of the upper level, the weights of the factors, w_1, w_2, …, w_n are determined. The relative importance of a_i and a_j is shown as a_{ij}, and the pairwise comparison matrix of factors A_1, A_2, ···, A_n denoted as $A = [a_{ij}]$. In the matrix, the element $a_{ij} = 1/a_{ji}$ and thus, when $i = j$, $a_{ij} = 1$. According to the Saaty's fundamental scale, number 1–9 is used to assess the intensity of preference between two factors, elaborated in Table 2 (Saaty, 1977;

1980; 1982; 2008). Namely, the value of w_i may vary from 1 to 9. The algebraic matrix is expressed in Eqs. (1)-(2):

Table 2 Measurement scale of AHP

Intensity of relative importance	Definition
1	Equal importance
3	A little more importance of one over the other
5	Obvious importance
7	Significant importance
9	Absolute importance
2, 4, 6 and 8	Intermediate values between two adjacent judgments

$$A=\begin{bmatrix} 1 & a_{12} & \cdots & a_{1n} \\ 1/a_{12} & 1 & \cdots & a_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ 1/a_{1n} & 1/a_{2n} & \cdots & 1 \end{bmatrix} \quad (1)$$

$$A=\begin{bmatrix} w_1/w_1 & w_1/w_2 & \cdots & w_1/w_n \\ w_2/w_1 & w_2/w_2 & \cdots & w_2/w_n \\ \vdots & \vdots & \ddots & \vdots \\ w_n/w_1 & w_n/w_2 & \cdots & w_n/w_n \end{bmatrix} \quad (2)$$

Step 2, calculating weights

In the pairwise comparisons, some inconsistencies may be obtained. When A contains inconsistency, the weight can be estimated by using the eigenvalue technique Eq. (3).

$$(A-\lambda_{\max} I)W=0 \quad (3)$$

where $\lambda_{\max}$ is the largest eigenvalue of matrix A; W is the eigenfactor of matrix A; I is the identity matrix. If the matrix does not include any inconsistency, W is the exact estimation of the weight vector. In calculation of the weight, the sum of each eigenfactor is equal to one.

Step 3, consistency test

Saaty (1977) has reported that the largest eigenvalue, $\lambda_{\max}$, of a reciprocal matrix A is always greater than or equal to n (number of rows or columns). If the pairwise comparisons do not include any inconsistency, $\lambda_{\max} = n$. The more consistent the pairwise comparisons, the more close to n the value of computed $\lambda_{\max}$. A consistency index (CI), which estimates the level of consistency with respect to a comparison matrix is given in Eq. (4). A consistency ratio (CR) that measures the coherence of the pairwise comparisons is calculated in Eq. (5). To estimate CR, the average consistency index of randomly generated comparisons, RI, has to be obtained (see Table 3). RI varies functionally, according to the size of the matrix (Saaty, 1980).

$$CI=\frac{\lambda_{\max}-n}{n-1} \quad (4)$$

$$CR=\frac{CI}{RI} \quad (5)$$

Table 3 Average random consistency index

N	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

As a rule of thumb, a CR value of 10% or less is considered as acceptable. Otherwise, all or some of the comparisons must be repeated in order to resolve the inconsistency of the pairwise comparisons (Kangas, 1994).

3 SWOT-AHP model for CNPCLC vehicle lubricant

To investigate the decision making factors using a SWOT-AHP model, decision makers, who have some decision making power in regard to technology and marketing of vehicle lubricant need to be identified first. For the purpose of this study, the decision makers were all from CNPCLC.

3.1 Qualitative analysis

Strengths, Weaknesses, Opportunities and Threats of CNPCLC vehicle lubricant are listed in Table 4, which indicates the advantages and disadvantages, and the opportunities for development and the threats faced for CNPCLC, due to the influence from internal resources and external environments.

Table 4 Qualitative SWOT analysis of CNPCLC vehicle lubricants

Strengths (S)	Opportunities (O)
Unique strength of CNPC affiliated Kunlun Lubricant (S_1) Rapid development of brand and high recognition (S_2) Affordable price, cost-effective performance, courteous service (S_3) Excellent Hardware Facilities, emphasis on personal training (S_4) Widespread gas stations to promote Kunlun Lubricant (S_5)	Huge consumption potential of vehicle lubricant (O_1) More rational lubricant users (O_2) Continually upgraded performance of vehicle lubricant (O_3) Continual change in sales mode (O_4) Increasing proportion of China Auto in favor of enforcing OEM (Original Equipment Manufacturer) marketing (O_5)
Weaknesses (W)	**Threats (T)**
Brand core value unpopular with people, high-grade association not strong (W_1) Insufficiently distinct product positioning, lack of subdivision, unreasonable product system (W_2) Relative backwardness of research and development of vehicle lubricant (W_3) Relative backwardness of constructing late-model marketing channel (W_4) Less obvious effect of OEM linkage (W_5)	Impeding domestic market development of CNPCLC due to dominant position of foreign lubricant brands (T_1) Higher recognition of foreign brands over domestic lubricant brands for China's consumers (T_2) Great difficulty in autonomous development of lubricant additives due to monopolizing technology (T_3) Impact of counterfeit and shoddy products (T_4)

3.2 Quantitative analysis

For S category case, the quantitative calculation includes the following steps:

Step 1, establishment of a pairwise comparison matrix of S category, *A*

$$A=\begin{bmatrix}1 & 2 & 3 & 4 & 5\\ 1/2 & 1 & 3 & 4 & 6\\ 1/3 & 1/3 & 1 & 2 & 3\\ 1/4 & 1/4 & 1/2 & 1 & 2\\ 1/5 & 1/6 & 1/3 & 1/2 & 1\end{bmatrix}$$

Step 2, calculating the weights (*W*) and the largest eigenvalue (λ_{max}) of the S category

To obtain a normalized matrix *A'*, each column of the judgment matrix should be treated (taking the first column for example):

$$\sum_{k=1}^{5} a_{k1} = 1+1/2+1/3+1/4+1/5 = 2.286$$

$$\bar{a}_{11} = \frac{a_{11}}{\sum_{k=1}^{5} a_{k1}} = \frac{1}{2.286} = 0.438$$

$$\bar{a}_{21} = \frac{a_{21}}{\sum_{k=1}^{5} a_{k1}} = \frac{1/2}{2.286} = 0.219$$

$$A'=\begin{bmatrix}0.438 & 0.533 & 0.383 & 0.348 & 0.294\\ 0.219 & 0.267 & 0.383 & 0.348 & 0.353\\ 0.146 & 0.089 & 0.128 & 0.174 & 0.176\\ 0.109 & 0.067 & 0.064 & 0.087 & 0.118\\ 0.088 & 0.044 & 0.043 & 0.043 & 0.059\end{bmatrix}$$

Each row of the normalized matrix (A') is added up. Taking the first row for example, we gain the average vector of S matrix, $\bar{W}$.

$$\bar{W}_1 = \sum_{j=1}^{5} \bar{a}_j = 0.438+0.533+0.383+0.348+0.294 = 1.996$$

$$\bar{W} = [1.996, 1.569, 0.713, 0.445, 0.277]^T$$

The sum of elements of the average vector is:

$$\sum_{i=1}^{5} \bar{W}_i = 1.996+1.569+0.713+0.445+0.277 = 5$$

Components of the vector are calculated, namely the weights of indexes,

$$W = [0.399, 0.314, 0.143, 0.089, 0.055]^T$$

Computing the largest eigenvalue (λ_{max}) of the S matrix:

$$(AW)=\begin{bmatrix}1 & 2 & 3 & 4 & 5\\ 1/2 & 1 & 3 & 4 & 6\\ 1/3 & 1/3 & 1 & 2 & 3\\ 1/4 & 1/4 & 1/2 & 1 & 2\\ 1/5 & 1/6 & 1/3 & 1/2 & 1\end{bmatrix}\begin{bmatrix}0.399\\0.314\\0.143\\0.089\\0.055\end{bmatrix}=\begin{bmatrix}2.087\\1.629\\0.724\\0.499\\0.280\end{bmatrix}$$

$$\begin{aligned}\lambda_{max} &= \sum_{i=1}^{5}\frac{(AW)_i}{nW_i}\\ &= \frac{(AW)_1}{5W_1}+\frac{(AW)_2}{5W_2}+\frac{(AW)_3}{5W_3}+\frac{(AW)_4}{5W_4}+\frac{(AW)_5}{5W_5}\\ &= 5.120\end{aligned}$$

Step 3, testing the consistency of the S category

$$CI = \frac{\lambda_{max}-n}{n-1} = (5.120-5)/4 = 0.030$$

According to Table 3, as *N* is 5, *RI*=1.12,

$$CR = \frac{CI}{RI} = \frac{0.030}{1.12} = 0.027$$

So, a *CR* value of 0.027 is acceptable (<0.1).

Step 4, calculation of priority scores of each strategic factor (Wang and Gan, 1995; Wang and Chen, 2010)

The role of each factor depends on its importance and actual level. If the role is defined as the priority score, and its actual level is called as estimated scale parameter, we can gain a formula below:

Priority score of each factor
=estimated scale parameter × weight

Where the estimated scale parameter of each factor in turn increases from 1 to 4, the positive value indicates Strengths and Opportunities, while the negative shows Weaknesses and Threats. Moreover, the larger the absolute value, the greater the scale parameter. The weights and priority scores of each SWOT category are shown in Tables 5-8.

Table 5 Each factors of the Strengths category

S	S_1	S_2	S_3	S_4	S_5	Weight	Scale parameter	Priority score
S_1	1	2	3	4	5	0.399	2	0.798
S_2	1/2	1	3	4	6	0.314	3	0.942
S_3	1/3	1/3	1	2	3	0.143	2	0.285
S_4	1/4	1/4	1/2	1	2	0.089	1	0.089
S_5	1/5	1/6	1/3	1/2	1	0.055	1	0.055

Note: *CR*= 0.027

Table 6 Each factors of the Weaknesses category

W	W_1	W_2	W_3	W_4	W_5	Weight	Scale parameter	Priority score
W_1	1	3	2	4	5	0.402	–3	–1.207
W_2	1/3	1	3	6	3	0.287	–2	–0.575
W_3	1/2	1/3	1	3	2	0.159	–2	–0.318
W_4	1/4	1/6	1/3	1	2	0.083	–3	–0.249
W_5	1/5	1/3	1/2	1/2	1	0.068	–2	–0.136

Note: *CR*=0.085

Table 7 Each factors of the Opportunities category

O	O_1	O_2	O_3	O_4	O_5	Weight	Scale parameter	Priority score
O_1	1	2	4	3	5	0.398	3	1.194
O_2	1/2	1	3	2	6	0.266	2	0.532
O_3	1/4	1/3	1	2	4	0.147	4	0.587
O_4	1/3	1/2	1/2	1	6	0.145	2	0.289
O_5	1/5	1/6	1/4	1/6	1	0.045	1	0.045

Note: *CR*=0.079

Table 8 Each factors of the Threats category

T	T_1	T_2	T_3	T_4	Weight	Scale parameter	Priority score
T_1	1	2	2	5	0.4369	3	–1.311
T_2	1/2	1	2	4	0.2942	2	–0.588
T_3	1/2	1/2	1	3	0.1947	2	–0.389
T_4	1/5	1/4	1/3	1	0.0742	2	–0.148

Note: *CR*=0.0210

Step 5, computing the global priority score of each factors (Wang and Chen, 2010)

The global priority score of Strengths, Weaknesses, Opportunities and Threats is calculated,

$$S=\sum S_i=2.170 \qquad W=\sum W_j=-2.485$$

$$O=\sum O_k=2.647 \qquad T=\sum T_l=-2.437$$

4 Results and discussion

4.1 Quadrilateral of SWOT strategy

A four half-dimension coordinate system is used with four variables, namely the overall priority score of S, W, O and T as a semi-axis, respectively, (Wang and Gan, 1995; Sun et al, 2007; Huang and Lee, 2008; Wang and Chen, 2010). The overall priority score of each factor is marked on the relevant semi-axis of the coordinate system, (e.g., S′, W′, O′ and T′), and the strategic quadrilateral is made by connecting the four points in sequence, which represents the strategic position of CNPCLC vehicle lubricants (Fig. 2).

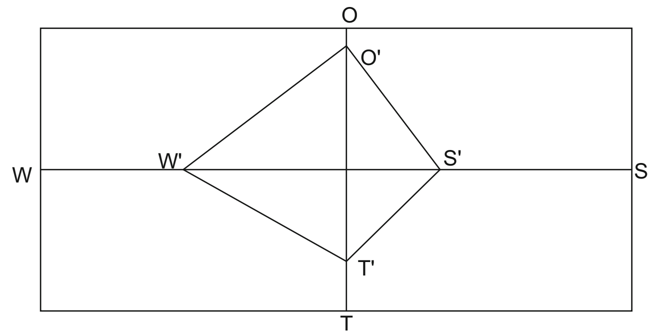

Fig. 2 Strategic quadrilaterals of CNPCLC vehicle lubricants

4.2 Strategic vector (θ, ρ)

In a quantified SWOT analysis, the strategic type and intensity of an enterprise is expressed by a strategic azimuth angle θ and a strategic intensity coefficient ρ, respectively. In a strategic style and intensity coordinate of SWOT, a polar coordinate (θ, ρ) with an azimuth angle θ and a polar radius ρ means the strategic vector (Wang and Gan, 1995; Sun et al, 2007; Huang and Lee, 2008; Wang and Chen, 2010).

(1) Computing the strategic azimuth angle θ

According to the quadrant that barycentric coordinates of the strategic quadrilateral lie in, $P(X,Y)$, the strategic style is determined as follows.

$$P(X,Y)=P(\sum x_i/4,\sum y_i/4)=(-0.079,0.052)$$

where x_i and y_i indicate separately the horizontal and vertical axis of S′, W′, O′ and T′ in the strategic quadrilateral.

Mathematically, the azimuth angle θ is $\tan\theta=Y/X\,(0\le\theta\le2\pi)$, therefore, $\theta=\arctan Y/X$ $=\arctan(0.052/(-0.079))\approx146.4^\circ$.

(2) Calculation of the strategic intensity coefficient ρ

Even in the same strategic type, the type of strategic intensity should be determined. So, some definitions are given below:

The positive intensity of strategies: $U=O'\times S'$
where O' is opportunities and S' is strengths. The positive intensity of strategies means that opportunities or strengths of enterprises are dominant.

The negative strategic intensity: $V=T'\times W'$
where T' and W' represent threats and weaknesses, respectively. The negative strategic intensity means that weaknesses or threats of enterprises are dominant.

The strategic intensity coefficient ρ is defined as: $\rho=U/(U+V)$

Values of ρ reflect the implemented intensity of strategic styles, $\rho\in[0,1]$.

Based on the data mentioned above, the results can be obtained as follows:

U=5.742, V=6.057, ρ=0.49

To sum up, in the SWOT-AHP hybrid model, the strategic vector is expressed with an azimuth angle θ and a polar radius ρ. That is, the vector of strategies (θ, ρ) = (146.4°, 0.49). Strategic styles and strategic intensity of CNPCLC vehicle lubricants are shown in Fig. 3.

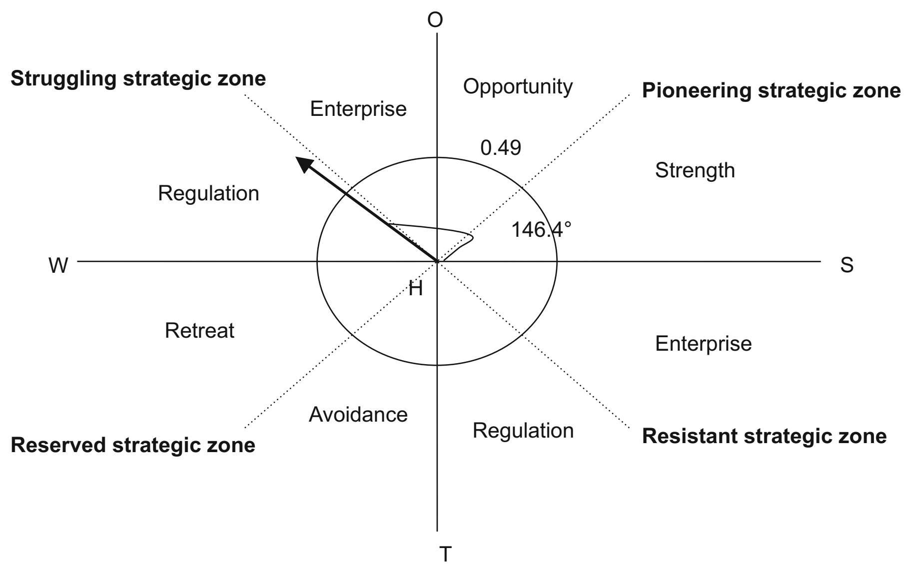

Fig. 3 Coordinate of strategic styles and strategic intensity of CNPCLC vehicle lubricant

5 Conclusions

By analysis of a quantified SWOT of CNPCLC vehicle lubricants, the Kunlun brand possesses more external opportunities, and as well a great many deficiencies. As seen in Fig. 3, the kind of regulation in the struggle is adopted, and WO strategy combined external opportunities with internal weaknesses should be mainly brought into force.

(1) To seize external opportunities:

The rapid development of China's automobile industry is the precondition of CNPCLC vehicle lubricant business development. Consumers become more and more rational so that they tend to select cost-effective lubricants in which the Kunlun brand has an advantage. The upgrade of vehicle lubricant requirements pushes enterprises' technology innovation. With the national automobile industry continuing to rise and the increase of automobile localization, Kunlun Lubricant must actively seek to communicate and collaborate with related industries. Because Chinese car owners are paying more attention to the maintenance of their vehicles, more and more diversified demands on lubricant products should be met.

(2) Improving Kunlun Lubricant own limitations as soon as possible:

In the first place, the Kunlun vehicle lubricants find the location of a clear positioning and enhances the technology associability of its brand. Increasing technological accumulation and creating its own key technology are called as "Hard Skills" in the next place. Again, it not only accelerates channel innovations of Kunlun Lubricant, but also strengthens and enhances its marketing network. Finally, it is urgent and admits of no delay to restructure of its products and increase the sales proportion of high standard automobile lubricants.

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