Can We Specify the Technical Field of Know-How by Making Patent Portfolio Analysis?

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***Abstract*--It is important for companies to make decisions whether new technology is applied as a patent application or should be hidden as know-how to keep technical competitiveness. Companies are given exclusive right by patent granting. On the other hand, know-how is protected under the trade-secrets law. Companies are required to make strict secrecy management of know-how to have protection. However, it's not easy to keep it as secrecy, and in the real business situation there are many disputes according to information leakage by the mobilization of human resources. Originally, know-how is controlled as a secret in companies, and it is invisible for outsiders. However, if we specify technical field in which know-how is hidden in patent specification without disclosure, it is useful for leading companies to keep its secrecy and upgrade the strategies of managing know-how. On the other hand, it helps following companies to make decisions which technical field they should concentrate on the development effort of such secrecy area. This research is a challenge to specify technical field in which know-how is hidden in patent specification, by making analysis on patent specification, in the field of aramid textile as one of the example of this research field. We believe that this research outcome contributes to management of technology in chemical companies in aramid textile field, also give the possibility to use the same methodology to find out know-how area from patent specification of the other industry field in the future.**

I. INTRODUCTION

Under the current globalized competitive environment, the increase of mobility of human resource is getting very critical business risk together with leakage of information of intellectual property. Accordingly, the number of legal disputes of the leakage of technologically information is getting increased nowadays, resulting in the big loss of business for the company. The subject of information leakage is basically related with know-how, which is difficult for the company to manage it in-house.

In general, know-how and trade secret are the same in concept, but differ in concept in several ways. The trade secret has four requirements[1].

- A "trade secret" must consist of information; technical information , business information.
- The information must derive economic value (actual or potential) from the fact that it is secret.
- The information cannot be generally known (either by the public, or, more importantly, by other persons in the industry).
- The information must be treated as a secret, and be the subject of reasonable efforts to maintain its secrecy.

On the other hand, it is not necessarily always required treatment as a secret in know-how, and it is not cared even if know-how is generally known. Accumulation of known information is not trade secret, but it is valuable economically as know-how. In the manufacturing process of products, we can found a lot of know-how.

To protect our technology, we have two alternatives; patent application for the technology and keeping it as know-how. However, we must comply with the rule of trade secret if we choose the latter case. I. Daizadeh *et al.* show the algorism of selecting patent application or trade secrets[2].

In this paper, we focused on aramid fiber industry, belonging to the chemical industry. Characteristic of the chemical industry on intellectual property is as follows.

- Process product
- Products are protected by small number of patents
- It is large capital investment and time-consuming from development to commercialization
- It is difficult to access to plants
- In the many case, products are not released in consumer market because of B to B market
- It is difficult to acquire a competitor's product
- Reverse engineering is difficult; identifying some experimental conditions from products
- Purpose of patent application is their implementation

These features are summarized as Fig. 1. Therefore, it is easier to utilize know-how strategically in the chemical industry.

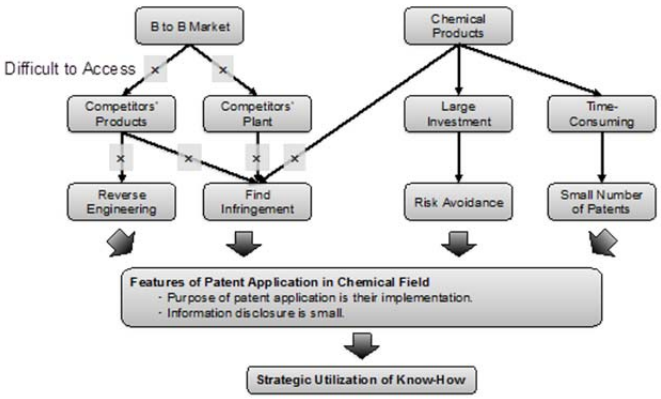

Fig. 1. Feature of Intellectual Property in Chemical Field.

Aramid fiber is polyamide fibers in which the molecular structure contains aromatic rings, classified into para-aramid fibers and meta-aramid fibers roughly as shown in Fig. 2 [3]. It is para-aramid; benzene rings are bounded straightly by an

amide bond represented by-NHOC, and meta-aramid; benzene rings are bounded by an amide bond to make 120 ° with each other. Any fibers of aramid having a durability and high heat resistance, especially, para-aramid fibers are specializing in high strength and high modulus and meta-aramid fibers are specializing in flame-retardant.

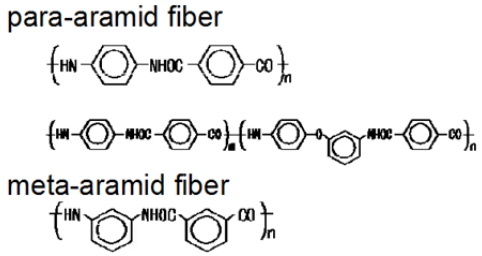

Fig. 2. Aramid Fibers.

The intellectual property litigations are often held in aramid fiber industry. As I mentioned above, aramid fiber is product added-value because of special properties regard with strength, and several companies enter the market recently. In general, following companies are required to catch up with leading company in technical field, providing products at a low price because the power of brand are lacking. Aramid fiber industry is the same. We focus on four companies in this paper; Du Pont, Kolon, Teijin, AKZO. Du Pont and Teijin are leading companies in this field. AKZO is a pioneer company in aramid industry, but the business was sold to Teijin now. On the other hand, Kolon is a following company.

The first big litigation in intellectural property was held in 1976 between Du Pond and AKZO. The object in this litigation was the timing of patents applied in same technology and the credibility of citing patents. This litigation had continued for 12 years, gotten over a quarrel.

Another litigation, the theme of which was technology leakage, was held between Du Pont and Kolon in 2009[4]. Kolon has a problem with the quality of aramid fiber. Kolon contracted the technology consulting agreement between the retirees of Du Pont to solve the technical problem, and they obtained information; competitive information, financial records, production capacity, the denier type. According to the case precedent, Federal District Court of the United States has ordered Kolon that the manufacture and sale of aramid fiber 'Heracron' are prohibited in 2012.

II. PURPOSE OF RESEARCH

The way of preventing leakage of trade secrets or know-how by the retiree is possible NDA at retirement, trade secret management and litigation based on the Unfair Competition Prevention Act, however, if the know-how is flowed out actually, it is difficult to identify the evidence or source of leakage because of the lack of information. Therefore, the purpose of research is to identify the technology area with high risk of leakage of know-how in this study, we made a research questions such as the following.

- RQ1) Can we specify the technical field with high risk of technology leakage in advance?
- RQ2) Can we specify the technical field containing know-how by intellectual property portfolio analysis?
- RQ3) Can we propose a strategy to estimation, is not able to propose each company should take a strategy, if we can estimate such a field?

And if it is possible to propose a method of extracting from patent information technology area that know-how is hidden, it is possible to identify the technology area with high leakage risk for the leading companies, and the company might take some actions. On the other hand, it is possible to identify a blank area in which preceding companies are not filed, which means that it might shows the technical field in which following companies should concentrate the resource.

III. METHODOLOGY

In this research, we focused on finding the technical fields which know-how is hidden with patent portfolio matrix. The axes of matrix are shown as below.

- Horizontal axis: Processes of aramid fiber.
- Vertical axis: Categories of keywords relating to know-how or units of physical quantities.

Scheme of the methodology is shown in Fig.3. First of all, we focused on USP because the intellectual property litigation as I mentioned before were held in the United States. In addition, the United States is one of the central markets until now after the war, that a patent application of important technology is expected. And it is expected that the gap of timing between the development and the application is small, because of first-to-invent principle until 2013/3. Further, as application of the U.S. policy, 'duty of candour' is required.

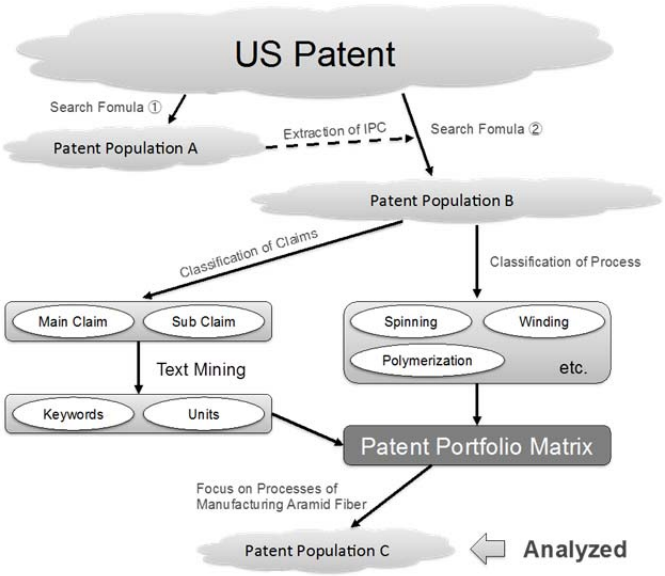

Fig. 3. Scheme of the methodology in this research

That is, it is regarded the applicant who didn't describe citing information intentionally not to refuse his application as 'lack integrity', which can be the reason for refusal. Sampat et al. reported that this increases the reliability of the invention's citation; it becomes easier to track the flow of technology [5]. That is, considered that it sources the art is clear as compared to the patents filed in other countries many of the patents filed to the U.S. is expected to be relevance surveyed.

Secondly, we picked up the intended patents by searching flow in Fig. 4. We used Patent SQUARE made by Panasonic as a searching tool. In the first step, we have searched IPCs used in aramid fiber field by search formula ①; searching 'aramid' or 'aromatic*amide' used in abstract, and we have picked up 75 IPCs on subclass level in patent population A. In the next step, we have expanded the scope from title and extract to full text, and narrowed the search to patents including process claims by formula ②. We have searched 'aramid', '[aromatic * amide] W1', '[aromatic * polyamide] W1', in full text of patents related to the 75 IPCs. Here W1 means sequence between two words; aromatic and amide. Since it is considered that the industry of interest is an aramid fiber industry, it is the multiplication of the 'fiber'. In addition, description relating to know-how might be found in method claims, 'process', 'method', 'art' are multiplied. As a result, we have extracted patent population B as the targeting patents as patent **b** shown in Table 1.

Thirdly, we have classified patents in patent population B according to manufacturing process in aramid fiber. The process was described in the technical literature that has been authored by employees of Du Pont and Teijin, there are some differences depending on the companies and each grades, however, the manufacturing process were roughly divided into 8 categories as shown in Fig. 5; 'synthesis of monomers', 'polymerization', 'dissolution', 'spinning', 'winding', 'processed', 'usage' and 'other fibers' [6][7].

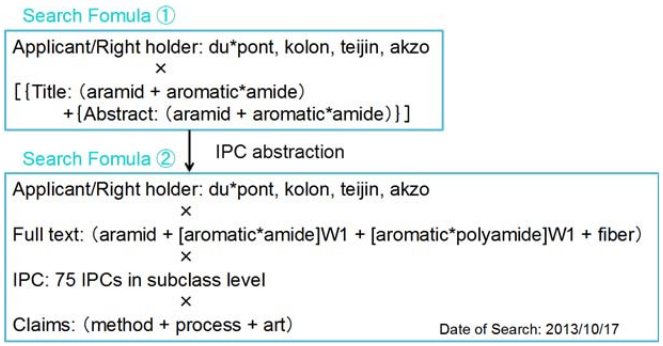

Figure 4. Searching Flow

We have classified the manufacturing process of aramid fibers by reading 'titles', 'abstracts' and 'claims' of the targeting patents. Since it is claimed as a series of processes in many cases at this time, "from spinning step to neutralization step" and "from heat treatment step to winding step", they were combined together to spinning process and the winding process respectively. Most of the filed patents were related to additional techniques after the winding process, the use of aramid fibers, aramid resin, and other fibers, classified respectively in Table 2. These process were used as horizontal axis of the portfolio matrix.

TABLE 1. THE NUMBERS OF PATENT APPLICATION FROM EACH COMPANY.

	Du Pont	Kolon	Teijin	AKZO
The number of patents in aramid fiber **a**[1]	1238	42	288	70
The number of patents containing method claims **b**[2]	772	28	168	45
b/a (%)	62.4	66.7	58.3	64.3

[1]**a** is the number of patents without searching 'method', 'process', 'art'.

[2]**b** is the number of patents with searching 'method', 'process', 'art'.

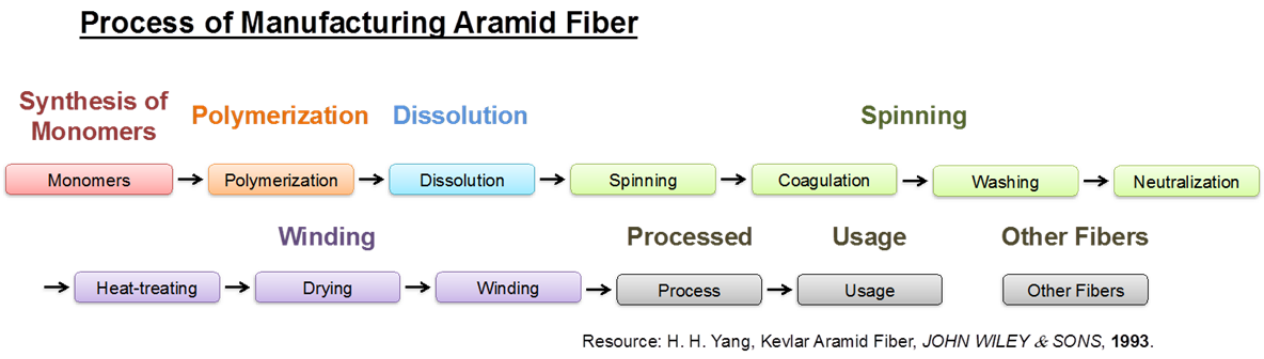

Fig. 5. Process of Manufacturing Aramid Fiber.

TABLE 2. CLASSIFICATION OF PROCESSES OF ARAMID FIBERS.

Categories	Du Pont		Kolon		Teijin		AKZO	
	count	ratio (%)	count	ratio (%)	count	ratio (%)	count	ratio (%)
Synthesis of Monomers	1	0.1	1	3.6	0	0.0	0	0.0
Polymerization	19	2.5	6	21.4	6	3.6	2	4.4
Polymerization ~ Dissolution	0	0.0	1	3.6	0	0.0	0	0.0
Dissolution	8	1	2	7.1	10	6.0	0	0.0
Dissolution ~ Spinning	4	0.5	1	3.6	1	0.6	0	0.0
Spinning	42	5	4	14.3	16	9.5	5	11.1
Spininng ~ Winding	3	0.4	1	3.6	0	0.0	0	0.0
Winding	24	3	4	14.3	5	3.0	1	2.2
Processed	97	12.6	2	7.1	24	14.3	5	11.1
Usage	312	40	3	10.7	54	32.1	18	40.0
Processed of Moldings	20	2.6	0	0.0	4	2.4	0	0.0
Other Fibers	241	31	3	10.7	48	28.6	14	31.1

Additionally, we have extracted technical keywords and physical units from process claims in patent population B with free text mining tool, ttm-mac (Tiny Text Miner β version). We have mined them from independent claim and dependent claim respectively.

In general, a large amount of information is described in the patent; technical contents related invention, the inventor's profile. We think that it is possible to extract the hidden information that does not appear in the wording by using text mining. Applicants might not select words in a conscious way the text mining in creating a specification, especially, before spread of mining technology. We thought that it might be able to link know-how to keywords which authors had used unintentionally by using text mining. Also, the software gives us the results automatically so that it is also useful to exclude our arbitrary decisions. Therefore, we used text mining here to extract the keywords for vertical axis of the portfolio matrix.

In the first step, we did text mining to abstract of the targeting patents. The extracted keywords were categorized into 8 types; technical field, purpose of patents, reagent, substance, usage of aramid, process, experimental condition and others. Since keywords classified into the 'condition' were related to experimental condition, temperature, ratio, pressure, tension, concentration etc., they might be related to know-how than keywords classified into elsewhere. We thought the frequency of these keywords in 'condition' category is important in the meaning of know-how. In the case of high frequency of keywords in claims, such patents might be improvement patent disclosing their know-how. On the other hand, in the case of low frequency, such patents might be cared about leakage of technological information.

Additionally, we also focused on 'units'. In the many cases of process patents, the experimental conditions are disclosed as numerical limitations patents with physical units and the scope of claims are narrowing as the order of claims decrease. We thought if we pay attention to the appearance frequency of units used in the claims, it might be seen the strategy of know-how in respective companies.

In the second step, we went to the text mining about description of the independent and dependent claims which are described in the patent of surveyed companies. It is considered that the description of know-how is described in method claims; therefore we went to text mining about the method of the patent claim. Pieces of keywords and units extracted by text mining are shown in Table 3.

There are policies of narrowing down keywords in extracting keywords; 1) keywords are noun because they appear as noun in claims, 2) keywords are not parameter given as experimental result but controllable factors as experimental conditions, because before-the-fact keywords are more strongly related than after-the fact in our opinion, 3) keywords related to 'heat' and 'cold' are eliminated, because controllable factors are included in temperature category and the units related to heat quantity such as 'kJ' or 'cal' didn't appear in the targeting patents.

Portfolio matrix analysis

In this study, we tried to find the technical field where know-how is hidden by analyzing intellectual property portfolio matrix. Patent portfolio matrixes against each company were prepared as shown in Fig. 6. The horizontal axis consists of manufacturing process of aramid fiber, and the vertical axis consists of keywords or units extracted by text mining. The portions filled in matrix in Fig. 6 are regions in which the keywords or units appeared in the claims, and white portions are regions in which they don't appear. By comparing these matrixes, we try to find application policies relating to know-how information. Here, there are much more patents from Du Pont than others in the scope of our research. Therefore we compared the matrixes between Du Pont and other companies.

The area indicated by circles in the Fig. 6 is a region in which the keywords or units has emerged in the other companies' patent matrixes, though has not emerged in Du Pont. Patents applied in such circle area might be related to essential technology in aramid fiber industry because all companies except Du Pont had applied. If it were not for the reasons for refusal in the patents applied to circle area from Kolon, Teijin, and AKZO, Du Pont might continue to protect as many years know-how is expected that technology in the area because the technology in the area had not been disclosed until the patents was applied. On the other hand, with the reasons for refusal, Du Pont might not conceal know-how in the area.

TABLE 3. KEYWORDS AND UNITS EXTRACTED BY TEXT MINING.

Categories	Keywords	Units	Categories	Keywords	Units
Mass	weight, mass	wt, grams	Phase	phase	resistance
Time	time	sec, minutes, h	Quantity	content, amount	stability
Velosity	velocity, speed	m/s, m/min	Humidity	humidity, moisture	water
Temperature	temperature	deg, degrees	Angle	angle	-
Pressure	pressure	bar, mpa, atom, psi	Solubility	solubility	polyamide
Fineness	diameter, orifices	dtex, denier, g/cm	Elongation	elongation, stretch	alkyl
Density	density	g/l	Distance	distance, length	microns, meters
Ratio	rate, ratio	percent, ppm	Frequency	frequency	paper
Acidity	pH, pKa	pH, pKa	Wavelength	wavelength	drying
Compatibility	hlb	hlb	Mole Number	-	mol, molar
Viscosity	viscosity	pa, pa・s	Number of Times	-	times
Orientation	orientation	heat	Periodicity	-	hz
Gap	gap	tension	Specific Volume	-	dl/g
Tension	tention	layer	Volume	-	ml
Concentration	concentration	copolymer	Elasticity	-	g/denier, cn/dtex
Dispersion	dispersion	-	Molecular Weight	-	gram/mole, g/mol
Force	-	cn	Number of Rotations	-	rpm
Conductance	-	ms/cm	Hardness	-	gpa
Twisted	-	/m			

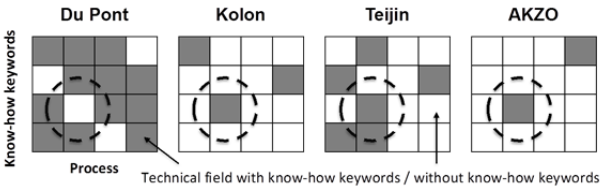

Fig. 6. Patent Portfolio Matrix Analysis

IV. RESULTS AND DISCUSSIONS

Analysis of Patent Application

As we shown in Table 1, the number of patent application related to aramid fiber is a large difference among each company. The area of bubble shows the number of patent application. Here, we analyzed the trend of patent applications with regard to the processes of aramid fiber as shown in Fig. 7. This figure was made by patent data until 2011, because of taking into account undisclosed time period of 18 months. As a result, Du Pont applied many patents around aramid fiber technologies. We predicted that Du Pont might control the number of patent application because of litigation based on Trade Secret law against Kolon, however, Du Pont applied patents in a positive way. This is why US is the Du Pont's home country and Du Pont might apply patents based on their clear policy; patent application or trade secret.

As shown in Fig. 7, in the case of Du Pont, two of application peaks have appeared around 1990 and after 2000 since commercialized aramid fiber in 1972. Patents applied around 1990 might be improvement patens to elongate their rights period, because the patents filed in early application was expired around 1990 and the number of applied patents decreased within five years. In addition, the patents were mainly applied to the peripheral aramid fiber technology domain such as processed and usage. On the other hand, patents applied after 2000 were increasing and mainly applied to usage and other fibers. Therefore, Du Pont might be developing for new fibers based on aramid fiber technology or have changed their application strategy against following companies.

In the case of Teijin, there are no peaks of application, however, it has been filed without leaving 20 years with respect to the process from polymerization to winding, which is considered that it is intended for the right term extension by improved patents. Since 2000, patent applications has been similar to Du Pont, it has been concentrated on usage and other fibers, which might be diversion against following companies.

As for Kolon, in spite of a following company, patents have been applied to upstream process influencing on the physical properties since 2006. Since the period of patent application overlaps with the time when Kolon has drained the technical information from Du Pont illegally, we investigated the citation information of patents filed from Kolon (Table 4). As a result, citation information has not been described in any patents applied before 2008 but not most of patents applied since 2008. It indicates that Kolon has applied patents based on leakage information from Du Pont since 2008. Also, focused on the registration status of these patents, only patents with citation source have been registered. This indicates that it is judged on 'duty of candour'.

Finally, in the case of AKZO, though AKZO is also a pioneer in the aramid fiber industry, patents applied in the early 1970s, the dawn of the aramid fiber, are nothing. This is

why we couldn't extract patents from AKZO, whose aramid business repeated to restructure such as Institure of Enka in Courtaulds, Accordis, Twaron BV and Teijin BV. This is a limitation of this research, and the data of AKZO in following discussion is fastened down.

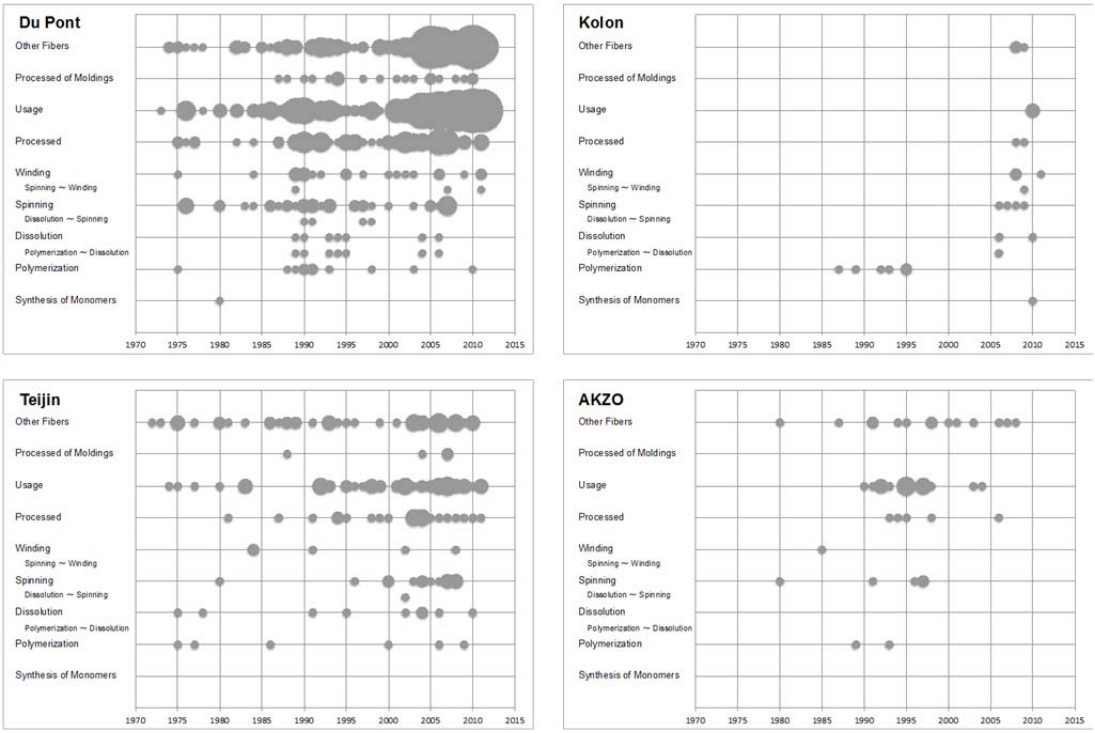

Fig. 7. Analysis of patent application among each company.

TABLE 4. CITATION INFORMATION OF PATENTS APPLIED FROM KOLON.

Application Year	Application Number	Resistration	Cited Companies
1987	24173	○	Kolon
1989	396880	○	Kolon
1992	875615	○	Kolon, Du Pont
1993	446730	○	Hoechst
1995	522103	○	Teijin
1995	718469	○	Kolon, Hoechst
2006	11/994641	○	Du Pont, Du Pont - Toray, AKZO, Teijin, Clemson University Research Foundation
2006	11/994642	○	Kolon, Du Pont, Air Products and Chemicals
2006	11/994643	○	Toyobo, G. E. Air Products and Chemicals, Hoechst, Sumitomo Cheical, Shell Oil, Du Pont Eastman Chemical, Basofil Fibers, Kansai Research Institute, Univation Technologies, Nippon Shokubai
2007	12/440334	○	Du Pont, Kansai Research Institute, Du Pont - Toray
2008	12/598998		-
2008	12/599129	○	Sokol, A & P Technology, Magnatech International, RJS Corporation, Northrop Grumman Systems
2008	12/663653		-
2008	12/663681		-
2008	12/674880	○	Asahi-Kasei, Du Pont, Coutaulds Limited, Acordis Lelheim GmbH, Lanxes, Weyerhaeuser, Kuraray, Invista North America, AKZO, Uni-Charm, Kaneka, Sante Biomaterials, Lapierre, Hyosung, Glassel David, Lenzing, Qinetiq Nanomaterials, Sappi Manufacturing
2008	12/741724	○	Nanosyntex
2009	12/551943	○	JP Morgan Chase Bank, Wifag, Bank of America, Whitebox Delphax, Seron, Solvay Advanced Fibers, Sumitomo Rubber
2009	12/935523		-
2009	12/935539		-
2009	12/990192		-
2010	13/258895		-
2010	13/264137		-
2010	13/265989		-
2010	13/519760		-
2010	12/792304	○	Du Pont
2011	13/290329	○	Du Pont, AKZO, Kolon
2011	13/821458		-
2012	13/655885		-

Macro Analysis by Text Mining Data

Next we defined the following parameters based on the text mining data to analyze application information.

x_i: the number of patent applications, including the know-how related keywords of a year *i*

$x(p)_i$: the number of patent applications, including method claims of a year *i*

c_{ij}: the number of claims described in a patent *j* filed in year *i*

$c(p)_{ij}$: the number of method claims described in a patent *j* filed in year *i*

$c_i(p)_{ij}$: those belonging to the independent claims of the $c(p)_{ij}$

$c_d(p)_{ij}$: those belonging to the dependent claims of the $c(p)_{ij}$

It is shown in Table 5 that the breakdown of patents filed in four companies. There is no significant difference in the ratio of method claims ($\Sigma x(p)_i/\Sigma x_i$) among four companies. Also, as far as we can see the ratio of method claims in total claims, independent claims, dependent claims ($\Sigma c(p)_{ij}/\Sigma c_{ij}$, $\Sigma c_i(p)_{ij}/\Sigma c_{ij}$, $\Sigma c_d(p)_{ij}/\Sigma c_{ij}$), there was no difference in the respective companies and application trend. Here, we defined additional parameters; y_{ij}, z_{ij}, and know-how density $\phi(y)_i$, $\phi(z)_i$.

y_{ij}: the number of keywords related know-how related keywords, which is appeared in a patent *j* of a year *i*

z_{ij}: the number of units appeared in a patent *j* of a year *i*

$$\phi(y)_i = \frac{\sum_j y_{ij}}{x_i}$$

$$\phi(z)_i = \frac{\sum_j z_{ij}}{x_i}$$

It is shown in Table 6 that comparison of know-how density.

There was no difference among four companies in the ratio such as $\Sigma x(p)_i/\Sigma x_i$, $\Sigma c(p)_{ij}/\Sigma c_{ij}$, $\Sigma c_i(p)_{ij}/\Sigma c_{ij}$, $\Sigma c_d(p)_{ij}/\Sigma c_{ij}$ in Table 5, but the frequency of use keywords in all the number of patent applications ($\Sigma y_{ij}/\Sigma x(p)_i$), and the frequency of use units in all the number of patent applications ($\Sigma z_{ij}/\Sigma x(p)_i$) were different tendency in Table 6. That is, only Du Pont was the opposite trend to the other companies; the keywords and units related know-how are frequently used in the independent claims than in the dependent claims in Du Pont. Also the keyword frequency in the claims $\Sigma y_{ij}/\Sigma c(p)_i$, $\Sigma z_{ij}/\Sigma c(p)_i$, and know-how density $\phi(y)_i$, $\phi(z)_i$ is also similar trend.

In general, the skeleton of the invention is often described in the independent claims, the description related to know-how such as experimental condition, which might be concealed in many cases, is often seen in the dependent claims. Considering the characteristics of the text mining as we mentioned at introduction, the fact that only one company has different feature from other three companies, which means that Du Pont changed the description of the applied claims deliberately. In other words, though Du Pont has filed a patent application classified in usage and improvement patents widely, its contents include only the skeleton of the invention and conceal information treated as know-how.

TABLE 5. COMPARISON OF BREAKDOWN OF APPLIED PATENTS.

	Du Pont	Kolon	Teijin	AKZO
Σx_i	771	28	168	45
$\Sigma x(p)_i$	677	25	149	40
$\Sigma x(p)_i/\Sigma x_i$	0.88	0.89	0.89	0.89
Σc_{ij}	11525	480	2539	889
$\Sigma c(p)_{ij}$	5562	256	1247	416
$\Sigma c(p)_{ij}/\Sigma c_{ij}$	0.48	0.53	0.49	0.47
$\Sigma c_i(p)_{ij}$	848	36	139	44
$\Sigma c_d(p)_{ij}$	4714	220	1108	372
$\Sigma c_i(p)_{ij}/\Sigma c_{ij}$	0.07	0.08	0.05	0.05
$\Sigma c_d(p)_{ij}/\Sigma c_{ij}$	0.41	0.46	0.44	0.42

Here, we plotted tendency of know-how density $\phi(y)_i$, $\phi(z)_i$ in Fig. 8. These plots are related to dependent claims because keywords related to know-how and units are often seen in dependent claims as we mentioned. Both plots were similar tendency in roughly decreasing of Kolon, Teijin, and AKZO, on the other hand, keeping low $\phi(y)_i$ and $\phi(z)_i$ of Du Pont. Du Pont applied much more patents than the three other companies such as 4,714, however, $\phi(y)_i$ converge in the range $1 < \phi(y)_i < 2$ regardless of the year, especially $\phi(z)_i \approx 1$. It is conceivable that Du Pont attempt not to flow know-how information in the patent applications in some way.

TABLE 6. COMPARISON OF KNOW-HOW DENSITY.

	Independent Claim				Dependent Claim			
	Du Pont	Kolon	Teijin	AKZO	Du Pont	Kolon	Teijin	AKZO
Σy_{ij}	1611	53	279	80	1166	80	418	97
$\Sigma y_{ij}/\Sigma x_i$	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$\Sigma y_{ij}/\Sigma x(p)_i$	0.89	0.92	0.73	0.75	0.91	0.96	0.93	0.98
$\Sigma y_{ij}/\Sigma c_i$	0.14	0.11	0.11	0.09	0.10	0.17	0.16	0.11
$\Sigma y_{ij}/\Sigma c(p)_i$	0.29	0.21	0.22	0.19	0.21	0.31	0.34	0.23
$\phi(y)_i$	2.67	2.30	2.56	2.67	1.90	3.33	3.03	2.49
Σz_{ij}	774	23	102	22	577	39	193	34
$\Sigma z_{ij}/\Sigma x_i$	1.00	0.82	0.61	0.49	0.75	1.39	1.15	0.76
$\Sigma z_{ij}/\Sigma x(p)_i$	1.14	0.92	0.68	0.55	0.85	1.56	1.30	0.85
$\Sigma z_{ij}/\Sigma c_i$	0.07	0.05	0.04	0.02	0.05	0.08	0.08	0.04
$\Sigma z_{ij}/\Sigma c(p)_i$	0.14	0.09	0.08	0.05	0.10	0.15	0.15	0.08
$\phi(z)_i$	1.28	1.00	0.94	0.73	0.94	1.63	1.40	0.87

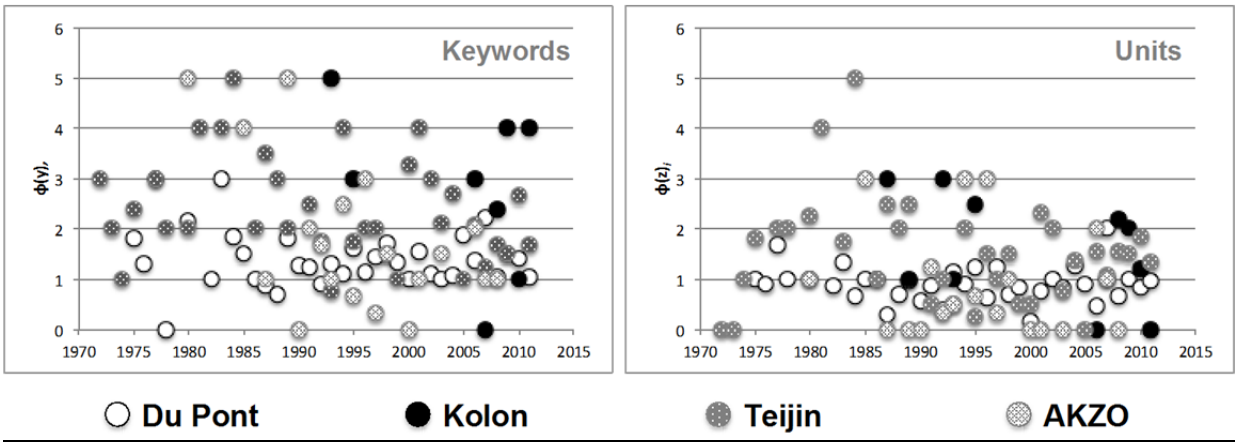

Fig. 8. Tendency of know-how density.

Patent Portfolio Matrix

We tried to identify the technical area where know-how was concealed by patent portfolio matrix, which was composed of manufacturing process of aramid fiber and keywords related to know-how or units. We classified process, and extracted keywords or units so far. Therefore patent portfolio matrix was prepared as shown in Fig. 9. Area of the bubble represents the number of times the keyword use. This is a piece of matrix; units in dependent claims. We selected it as an example, because keywords or units were seen more frequency in dependent claims and the number of appearance of units were better controlled as shown in Fig. 8. Despite of difference in the number of patent applications, Du Pont and AKZO used many units in the spinning process, and Teijin used many units in the melting and winding process. In the case of Kolon, though the number of target patents is small as shown in Table 1, Kolon used the units in the area that did not overlap with other companies.

Next, in order to identify the technical area where know-how is hidden, we focused on the technical area in which other companies are not filed against Du Pont, which applied the largest number of applications. As a result, as an area where two other companies are using regardless Du Pont is also not using the units; area of 'rotation number' in the spinning process has been extracted. We believe the rotation number in spinning process may be related to the screw rotation speed of the extruder. In general, a screw extruder extrudes resin, and extruded speed depends on the rotation number. Spinning speed is proportional to the extrusion rate. On the other hand, spinning speed influences the orientation of fibers, especially, aramid fibers because it is liquid crystals. Therefore 'rotation number' in the spinning process is an important parameter, the importance can be seen from the fact that Du Pont did not use the unit of 'rotational speed' or 'velocity' in spinning process. The number of patents filed from AKZO and Teijin in this area are same as 894,964. This patent was registered, therefore we extrapolate that Du Pont might conceal know-how in this area. In addition, we could extract the technical areas which know-how is concealed in as shown in Table 7. These technical areas hold high potential to contain Du Pont's know-how for aramid fiber.

V. CONCLUSIONS

We focused on the relationship between patents and know-how, and suggested a new methodology for identifying technical area which know-how was concealed by patent portfolio matrix. This methodology tells us that only Du Pont managed not to leak know-how information in aramid fiber industry, and enable to find technical area Du Pont might conceal know-how.

On the other hand, the fact Kolon used units in patent to avoid the duplication of technical area was shown by this methodology. i.e. Kolon might file strategically, which were helped by the engineer from Du Pont because most of patents filed in 2008 or later have no citation. That it was possible to identify areas such by the new methodology in this research, we consider that it might be a useful tool for following companies to file patents strategically.

TABLE 7. TECHNICAL AREA WHICH KNOW-HOW IS CONCEALED IN.

	Keywords	Units
Independent Claims	'viscosity' in polymerization 'viscosity' in spinning	'number of times' in dissolution 'velosity' in spinning
Dependent Claims	'temperature' in dissolution ～ spinning 'ratio' in dissolution ～ spinning 'length' in winding	'rotation number' in spinning

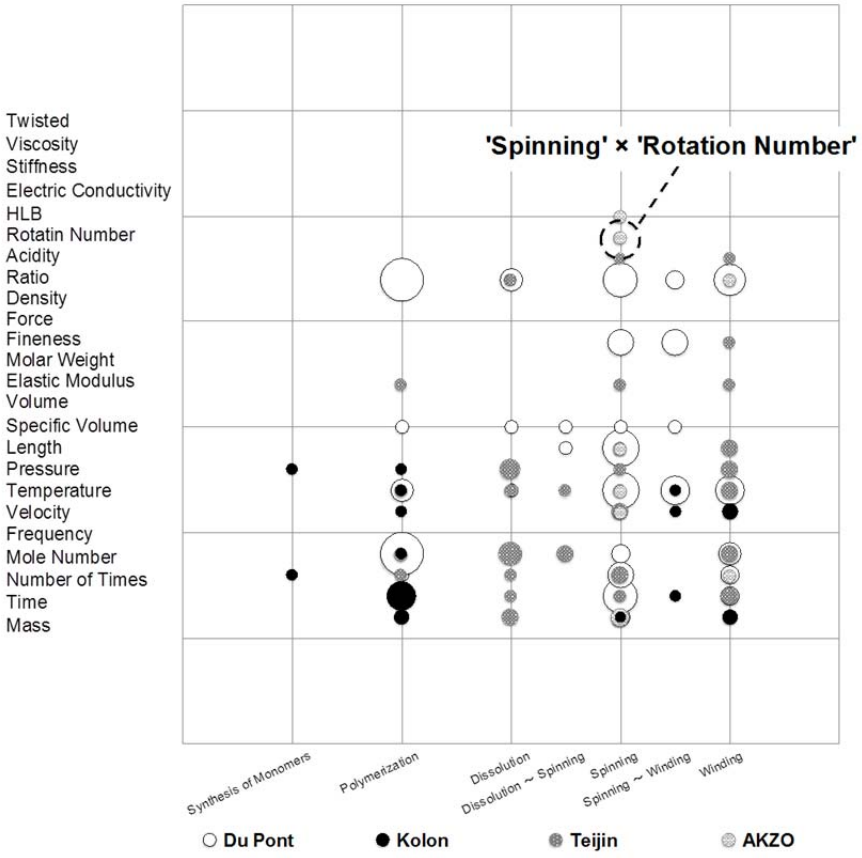

Fig. 9. Patent portfolio matrix.

VI. LIMITATION

The methodology introduced in this research helps to find technical area where know-how is hidden in patent specification in the field of aramid fiber industry. In this field we could find out such know-how area by making text mining method on patent specifications. As a next step, we need to expand the technical field whether the same methodology can be efficient to find out know-how area.

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