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Study of Patents Filed in India in Mechanical Engineering Sector

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In the present study, an attempt has been made to identify the trends of patenting activity in mechanical engineering in India using data from value added databases. It is a first time full data compilation of patent filing and granted data at Indian Patent Office from year 1961 and patent filing data in the different areas of inventions from 1986. Further for this study a separate search was conducted using patent information databases with focus (IPC based) on mechanical engineering sector to understand and identify the companies working in this area. More than 10,000 patent applications and grants exclusively related to mechanical engineering have been considered for analysis. The study indicates focus of research of different organizations/industries in specific areas of mechanical engineering, R&D collaboration between the companies. The paper also addresses various trends and discusses the R&D partnership observed in Indian organizations and foreign organizations. The study further highlights the important directions for future path of R&D.

Keywords: Mechanical engineering, patent trend, automobile, auto component, R&D collaboration, Indian industry, foreign industry

Mechanical engineering[1] is a diverse subject that derives its breadth from the need to design and manufacture everything from small individual parts and devices to large systems. The role of a mechanical engineer is to take a product from an idea to the marketplace. In order to accomplish this, a broad range of skills are needed. Mechanical engineering plays fundamental role in many industries such as manufacturing, automobile, computers and electronics, medical diagnostic systems, energy conservation, automation, etc. To put it in simple words, mechanical engineering deals with everything that moves.

Importance of Patent

Now a days, research community is well aware and awakened on intellectual property rights (IPR) and mainly on patents. A patent[2] is granted as an exclusive right by the Government for an invention, for a limited period of time in consideration of disclosure of the invention by an applicant. A patentee enjoys exclusive right to prevent the third party from unauthorized act of making, using, offering for sale, selling or importing the patented product or process within the country during the term of the patent. A patented invention becomes free for public use after expiry of the term of the patent or when the patent ceases to have effect, by non-payment of any renewal fee.

Patent literature is essential and rich source of technical information available worldwide often published first in the patent document and any one (researchers working in R&D institutes, SMEs, government organisations, private industrial organisations, business planners, patent attorneys, research scholars, inventors and licensors, venture capitalists, etc.) can refer this through databases to understand what is going on in particular area/sector of science and technology. As on today there are about 80 million patent documents available.

Patents are the main source of technical information however it has been observed that they are not properly used; if it is used properly, it would have accomplished the needs of R&D, business planning and the business strategies.

Patent searches are important in the process of initiating, developing and marketing a new product or process. They are useful because:

a) Patents are valuable sources of technical and scientific information in the world
b) More than 80 million patent documents
c) Majority are first and only publication
d) Disclose the invention and how it can be worked out
e) Provide the most current information on technology

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f) Identifying companies which are end-users of a particular product or equipment
g) Analysis of the patent holdings of specific inventors within a narrow research area can be used as an aid to recruitment, since it can identify a major player in the field, whose services could then be sought.

Patent Filing Scenario at Indian Patent Office

Before discussing on Indian patenting scenario, we will review the world patent scenario (source: - WIPO statistical database 2013).[3] Fig. 1 shows in year 2012, there were approximate 24 lakh patents filed in different patent offices worldwide and it shows 9.2 % increase over previous year. Fig. 2 shows in year 2012, there were 43,955 patent applications filed in India and out of which approximate 78% applications were filed by foreign companies/individuals. Fig. 3 shows in year 2012, there were 4,328 patents granted in India and out of which approximate 83% patents are granted to foreign companies/individuals.

The data from Indian Patent Office[4] (Table 1 & Fig. 4) shows that from year 1961, non-resident (foreign) patent applications are more in numbers compared to resident (Indian) patent filing at Indian Patent Office. Also, it can be seen that the number of total applications by non-residents was limited to 50,00 up to year 1993-94, in period 95-99 the foreign filing increased to more than 8,000 applications, however, it went down to 2,600 applications in 1999-2000; after 2001, the foreign patent applications are constantly increasing and it reached 33,763 in year 2012-13; whereas, resident patent applications are constant i.e. approximately 1,000 applications per year up to 1990-91, further, average of 9% increase is seen in patent filing by Indian applicants from 1992 onwards and it reached 9,911 applications in year 2012-13.

Looking, at this filing trend in Fig. 5, it can be estimated, that from year 1961 there is 26% resident (Indian) patent filing and 74% non-resident (foreign) patent filing at Indian Patent office.

Table 2 & Fig. 6, shows there is a constant increase in number of applications under mechanical field of

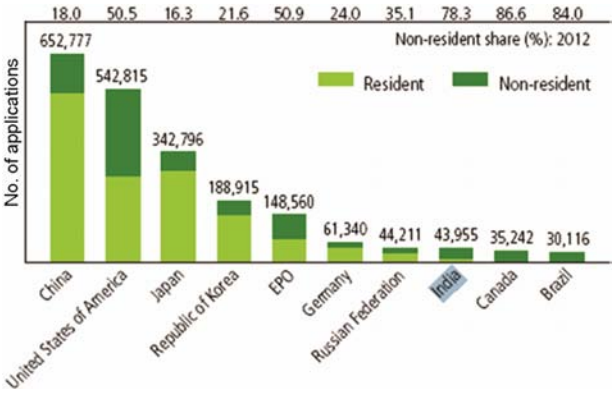

Fig. 2 shows in year 2012, there were 43,955 patent applications filed in India and out of which approximate 78% applications were filed by foreign companies/individuals

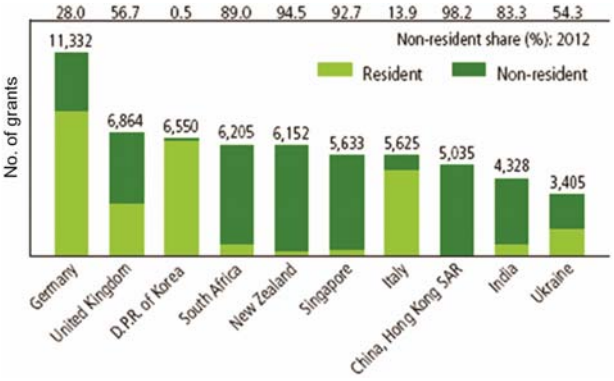

Fig. 3 shows in year 2012, there were 4,328 patents granted in India and out of which approximate 83% patents are granted to foreign companies/individuals

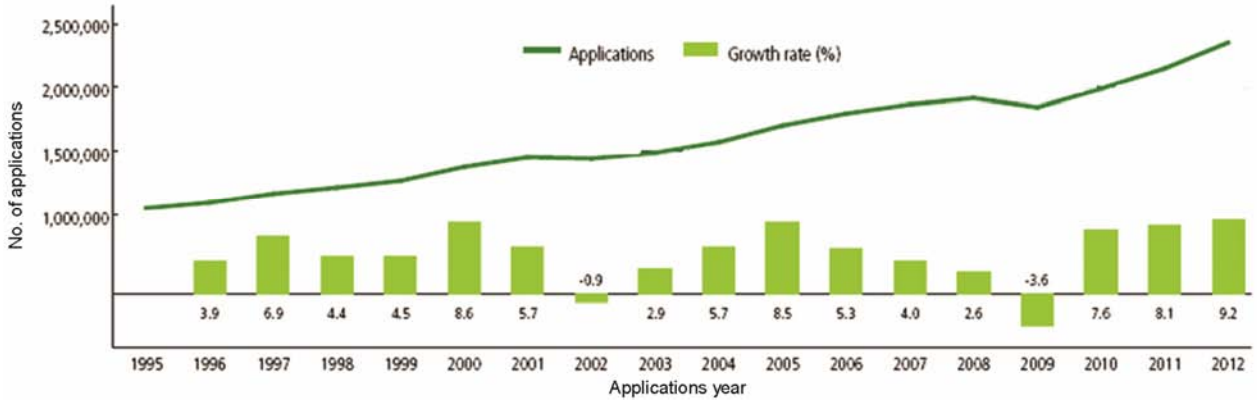

Fig. 1 - World patent applications scenario

Table 1– Applications filed by residents and non-residents through various routes for last 50 years

S No	Year	Indian	Foreign	Total	S no	Year	Indian	Foreign	Total	S No	Year	Indian	Foreign	Total
1	1961	706	4583	5289	18	1978-79	1124	1808	2932	35	1995-96	1606	5430	7036
2	1962	738	5075	5813	19	1979-80	1055	1925	2980	36	1996-97	1661	6901	8562
3	1963	754	4922	5676	20	1980-81	1159	1795	2954	37	1997-98	1926	8229	10155
4	1964	824	4881	5705	21	1981-82	1093	1896	2989	38	1998-99	2247	6707	8954
5	1965	878	5124	6002	22	1982-83	1135	1950	3085	39	1999-2000	2206	2618	4824
6	1966	894	4535	5429	23	1983-84	1055	2090	3145	40	2000-01	2179	6324	8503
7	1967	1026	4164	5190	24	1984-85	1001	2318	3319	41	2001-02	2371	8221	10592
8	1968	1110	4248	5358	25	1985-86	999	2527	3526	42	2002-03	2693	8772	11465
9	1969	1120	4326	5446	26	1986-87	983	2506	3489	43	2003-04	3218	9395	12613
10	1970	1116	4026	5142	27	1987-88	930	2527	3457	44	2004-05	3630	13836	17466
11	1971	-	-	-	28	1988-89	1077	2521	3598	45	2005-06	4521	19984	24505
12	1972-73	1143	2496	3639	29	1989-90	1039	2622	3661	46	2006-07	5314	24430	29744
13	1973-74	976	2515	3491	30	1990-91	1180	2584	3764	47	2007-08	6040	29178	35218
14	1974-75	1148	2258	3406	31	1991-92	1293	2559	3852	48	2008-09	6161	30651	36812
15	1975-76	1129	1876	3005	32	1992-93	1228	2239	3467	49	2009-10	7044	27243	34287
16	1976-77	1342	1762	3104	33	1993-94	1266	2603	3869	50	2010-11	8312	31088	39400
17	1977-78	1097	1773	2870	34	1994-95	1741	3589	5330	51	2011-12	8921	34276	43197
-	-	-	-	-	-	-	-	-	-	52	2012-13	9911	33763	43674

Source: The data compiled from Annual Reports published by Controller General of Patents, Designs and Trademarks; Kardam K S, Annual reports and patenting activities in India: An overview, *Journal of Intellectual Property Rights*, 2 (3) (1997) 113-123.

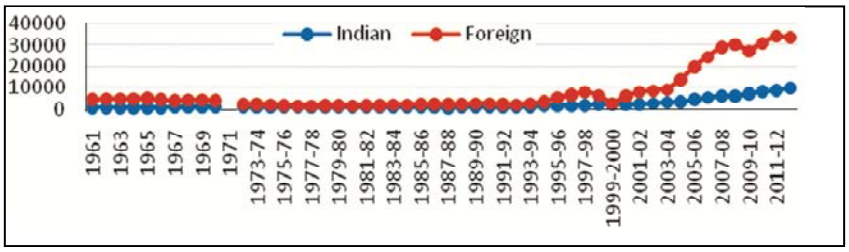

Fig. 4- Patent filing trend during 1961-2012 by Indian and foreign applicants

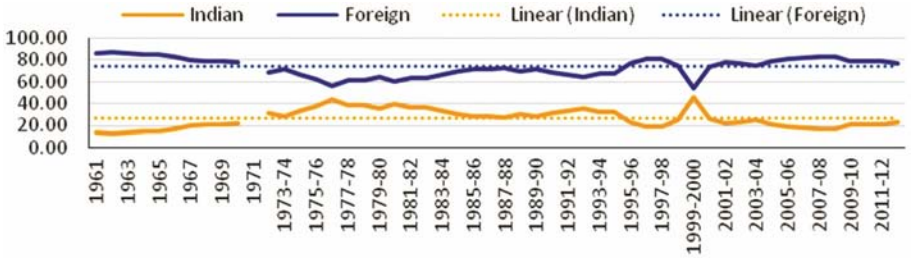

Fig. 5- Percentage of patent filing contribution by Indian and foreign applicants during1961-2012

invention from year 2002-03 onwards, however, it is more particularly observed (Fig. 9) during 2008 to 2013 when compared with other fields of invention. Table 3 & Fig. 7 shows the number of patents granted during 1986-2013 under various fields of invention. It is observed that there is tremendous increase in number of patent applications filed by foreign companies in India. India as a developing and upcoming nation has to really look into this trend of patent filing from outside countries and also should find the driving force behind it. Table 4 shows the data for inventions related to "mechanical engineering" field. It can be seen that there is a constant increase in this field of invention from the year 2008 (Fig. 8).

Data Collection

This study is based on the data from Indian Patent Office showing the increasing trend in mechanical section therefore it was decided to further drill down into the mechanical engineering patents filed/granted at Indian patent Office. The value added patent database Thomson Innovation (TI) with time limit 2008 to 2013 was used to find the patents under this

Table 2 – Number of patent applications filed during 1986-2013 under various fields of inventions

S No	Year	Chemical	Drugs	Food	Electrical	Mechanical	Computer/ Electronics	Biotechnology	General	Other fields	Total
1	1986-1987	1112	214	34	577	972	-	-	579	-	3488
2	1987-1988	1020	198	39	563	847	-	-	790	-	3457
3	1988-1989	1191	221	21	419	974	-	-	772	-	3598
4	1989-1990	1225	216	13	454	932	-	-	821	-	3661
5	1990-1991	1297	258	41	492	1173	-	-	503	-	3764
6	1991-1992	1185	323	38	468	994	-	-	544	-	3552
7	1992-1993	1138	234	29	461	946	-	-	659	-	3467
8	1993-1994	1122	273	82	426	859	-	-	1071	-	3833
9	1994-1995	-	-	-	-	-	-	-	-	-	-
10	1995-1996	-	-	-	-	-	-	-	-	-	-
11	1996-1997	-	-	-	-	-	-	-	-	-	-
12	1997-1998	2221	1481	112	2264	1760	-		2317	-	10155
13	1998-1999	2023	1555	140	1778	2125	-	3	1333	-	8957
14	1999-2000	840	1000	107	877	1187	-	9	544	-	4564
15	2000-2001	787	883	96	921	1106	-	4	546	-	4343
16	2001-2002	778	879	110	731	1174	-	2	569	-	4243
17	2002-2003	776	966	119	690	1257	-	46	562	-	4416
18	2003-2004	2952	2525	123	2125	2717	-	23	2148	-	12613
19	2004-2005	3916	2316	190	1079	3304	2787	1214	-	2659	17465
20	2005-2006	5810	2211	101	1274	4734	5700	1525	-	3150	24505
21	2006-2007	6354	3239	1223	2371	5536	5822	2774	-	1621	28940
22	2007-2008	6375	4267	233	2210	6424	4842	1950	-	7110	33411
23	2008-2009	5884	3672	340	2319	6360	7063	1844	2946	6384	36812
24	2009-2010	6014	3070	276	2376	6775	7646	1303	885	5942	34287
25	2010-2011	6911	3526	315	2719	7782	9594	1497	1017	6039	39400
26	2011-2012	6698	2762	294	4160	9716	4225	788	822	13732	43197
27	2012-2013	6812	2954	452	3568	10198	4424	832	1561	12873	43674

Source: The data compiled from Annual Reports published by Controller General of Patents, Designs and Trademarks; Kardam K S, Annual reports and patenting activities in India: An overview, *Journal of Intellectual Property Rights*, 2 (3) (1997) 113-123.

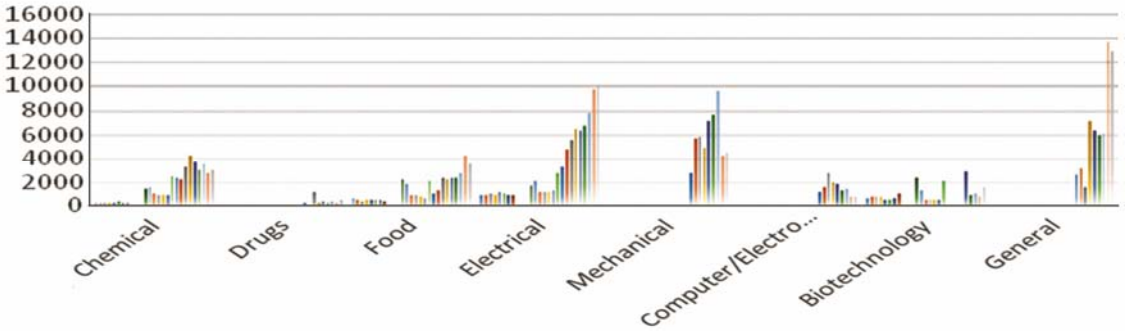

Fig. 6 – No. of patent applications in various fields of inventions during 1986-2013

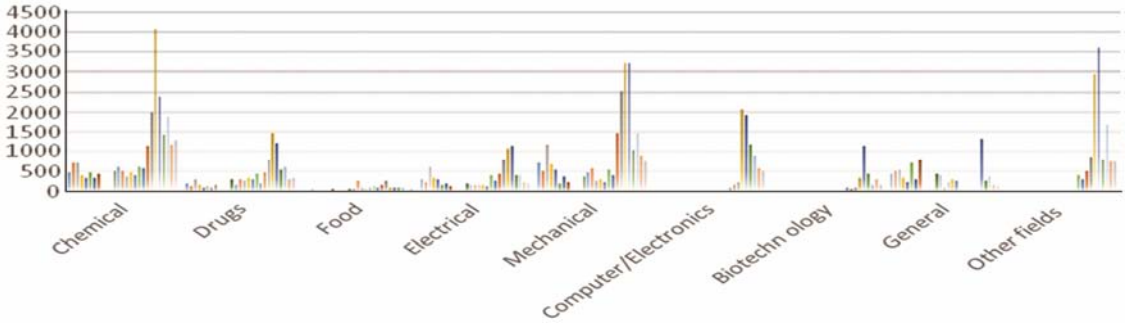

Fig. 7–No. of patents granted in various fields of inventions during 1986-2013

Table 3 – Number of patents granted during 1986-2013 under various fields of inventions

S No	Year	Chemical	Drugs	Food	Electrical	Mechanical	Computer/ Electronics	Biotechnology	General	Other fields	Total
1	1986-1987	474	185	21	293	705	-	-	448	-	2126
2	1987-1988	731	124	15	228	489	-	-	517	-	2104
3	1988-1989	704	300	44	608	1183	-	-	541	-	3380
4	1989-1990	389	146	20	322	692	-	-	321	-	1890
5	1990-1991	339	87	10	285	535	-	-	235	-	1491
6	1991-1992	474	118	10	167	181	-	-	726	-	1676
7	1992-1993	318	94	12	194	372	-	-	282	-	1272
8	1993-1994	436	145	30	132	215	-	-	788	-	1746
9	1994-1995	-	-	-	-	-	-	-	-	-	-
10	1995-1996	-	-	-	-	-	-	-	-	-	-
11	1996-1997	-	-	-	-	-	-	-	-	-	-
12	1997-1998	503	291	58	177	381	-	-	434	-	1844
13	1998-1999	609	150	35	138	462	-	-	406	-	1800
14	1999-2000	516	307	250	147	569	-	-	92	-	1881
15	2000-2001	353	276	72	142	254	-	-	221	-	1318
16	2001-2002	483	320	36	139	311	-	-	302	-	1591
17	2002-2003	399	312	67	118	228	-	-	255	-	1379
18	2003-2004	609	419	110	396	539	-	-	-	401	2474
19	2004-2005	573	192	67	245	414	71	71	-	278	1911
20	2005-2006	1140	457	140	451	1448	136	51	-	497	4320
21	2006-2007	1989	798	244	787	2526	237	89	-	869	7539
22	2007-2008	4071	1469	88	1078	3230	2052	314	-	2959	15261
23	2008-2009	2376	1207	97	1140	3242	1913	1157	1318	3611	16061
24	2009-2010	1420	530	72	404	1024	1195	449	273	801	6168
25	2010-2011	1899	596	84	394	1458	892	165	350	1668	7506
26	2011-2012	1168	282	21	228	888	584	309	153	748	4381
27	2012-2013	1289	344	37	188	749	510	144	121	744	4126

Source: The data compiled from Annual Reports published by Controller General of Patents, Designs and Trademarks; Kardam K S, Annual reports and patenting activities in India: An overview, *Journal of Intellectual Property Rights*, 2 (3) (1997) 113-123.

category. Further, database was searched for patents using selected keywords in their IPC field. The following search query was used-

CC = (IN) AND (PY> = (2008) AND PY<= (2013)) AND CC = (IN) NOT ICR (IPC Current) = (A OR B OR C OR D OR E OR G OR H) ---->resulting into 10808 Hits

The search was restricted by IPC as F denotes "Mechanical Engineering"; lighting; heating; weapons; blasting engines or pumps to consider the patents under mechanical engineering sector only.

(The difference in number (between search result and Indian Patent Office (IPO) Annual Report data) under mechanical section may occur because of the base of categorization done by IPO is not known). The dataset was further cleaned and analysed to find out yearly breakup, application and granted patents, assignee, assignee type, country of origin, inventor, IPC, R&D partnership, use, etc.

Analysis and Discussion

The time frame considered for study is for the years 2008 to 2013.

Yearly Breakup

Table 5 & Fig. 10 shows number of patent applications and grants during 2008 to 2013, there are total 10,808 patents (including applications and grants) under IPC = F.

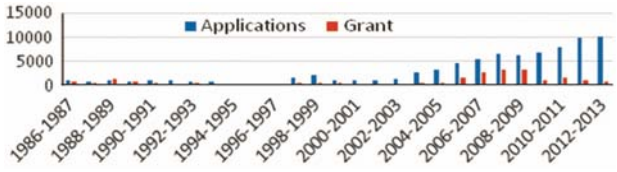

Fig. 8–No. of patent applications and patents granted in mechanical field of invention during1986-2013

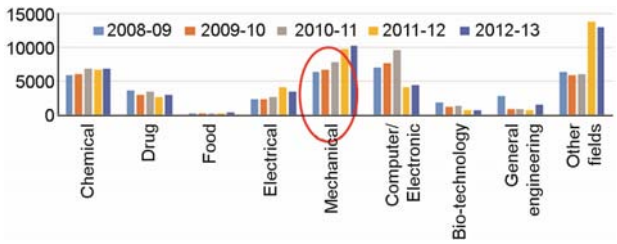

Fig. 9–No. of patent applications under various fields of inventions during 2008-2013

Table 4 – Number of patent applications filed and granted during 1986-2013 under mechanical field of inventions

S No.	Year	Applications	Grant
1	1986-1987	972	705
2	1987-1988	847	489
3	1988-1989	974	1183
4	1989-1990	932	692
5	1990-1991	1173	535
6	1991-1992	994	181
7	1992-1993	946	372
8	1993-1994	859	215
9	1994-1995	-	-
10	1995-1996	-	-
11	1996-1997	-	-
12	1997-1998	1760	381
13	1998-1999	2125	462
14	1999-2000	1187	569
15	2000-2001	1106	254
16	2001-2002	1174	311
17	2002-2003	1257	228
18	2003-2004	2717	539
19	2004-2005	3304	414
20	2005-2006	4734	1448
21	2006-2007	5536	2526
22	2007-2008	6424	3230
23	2008-2009	6360	3242
24	2009-2010	6775	1024
25	2010-2011	7782	1458
26	2011-2012	9716	888
27	2012-2013	10198	749

Source: The data compiled from Annual Reports published by Controller General of Patents, Designs and Trademarks; Kardam K S, Annual reports and patenting activities in India: An overview, *Journal of Intellectual Property Rights*, 2 (3) (1997) 113-123.

Table 5 – Number of Patent applications and grants from under IPC = F

Year	Applications (A)	Granted (B)
2008	1211	672
2009	1957	528
2010	1413	329
2011	1059	226
2012	1437	228
2013	1732	16
Total	8809	1999

(A+B)Total = 10808

It is observed that there is some downfall in patent applications between 2010 and 2011 however, the filing trend again increased from 2012 onwards.

Top Assignees

Top 30 assignees who are active in this area are found [company name, number of records] such as, Robert Bosch GMBH–419, GM Global Technology Operations Inc., US - 507, Honda Motor Co Ltd., JP- 306, Bharat Heavy Electricals Limited, IN - 254, TVS Motor Company Limited - 152, Siemens Aktiengesellschaft - 179, General Electric Company, CA - 154, Mitsubishi Heavy Industries Ltd. - 121, Borgwarner Inc., US - 104, Tata Motors Limited - 119, Altsom - 77, LG Electronics Inc., KR - 82, Crompton Greaves Limited - 84, Toyo Roki Seizo Kabushiki Kaisha, JP - 73, BSH Bosch Und Siemens Hausgerate GMBH, DE - 78, Eaton Corporation, US - 67, Vestas Wind Systems A/S - 58, Daikin Industries Ltd. - 48, Federal-Mogul Burscheid GMBH - 56, Mahindra and Mahindra Limited - 50, Danfoss AS, DK - 35, Praxair Technology Inc, US - 50, Carrier Corporation, US - 49, Council of Scientific and Industrial Research, IN - 47, Sanyang Industry Co. Ltd. - 36, Steel Authority of India Limited - 41, Thermax Limited - 43, Indian Institute of Technology, IN - 35, Knorr-Bremse Systeme Fur Nutzfahrzeuge GMBH, DE - 39, Alfa-Laval AB – 36.

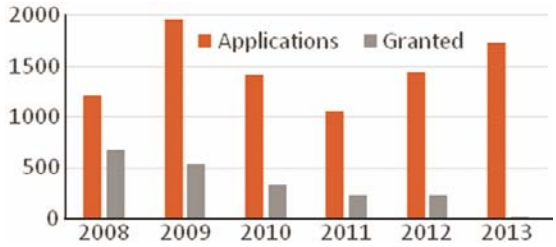

Fig. 10 – Yearly breakup of patent applications and grants

Country of Origin

Table 6 shows the country of origin of invention who have filed the patent applications in India; approximately there are 65% patent applications from foreign countries, in which USA is at top with 2,124 followed by Germany 1,269, Japan 1,082, and so on. There are also applications through PCT route.[5]

The assignment to countries of origin is important aspect. In this study a patent is assigned to the country based on the office of the priority application (derived from the legal background). The priority filing is the first application of a specific patent; in many cases the first application is filed at the patent office of the country where the invention originated.[6] This justification is used for the priority country as the country of origin.

Top Inventor

Table 7 shows the top 30 inventors and their organizations

Further this data of 10,808 patent applications and grants were categorized between foreign companies (Foreign Comp) 2117, Indian companies (Indian

Table 6 – Number of patent applications filed and granted from different countries

S No	Country	Applications filed	Granted	Total
1	IN	3099	685	3784
2	US	1740	384	2124
3	DE	1086	183	1269
4	JP	766	316	1082
5	EP	339	27	366
6	FR	235	59	294
7	GB	213	56	269
8	WO	239	27	266
9	IT	159	35	194
10	KR	129	59	188
11	CN	143	13	156
12	AU	97	30	127
13	SE	95	22	117
14	DK	91	5	96
15	AT	43	9	52
16	NO	35	4	39
17	NL	33	4	37
18	TW	31		31
19	BR	24	5	29
20	CA	12	14	26
21	FI	22	4	26
22	ES	24	1	25
23	IL	18	7	25
24	BE	19	5	24
25	ZA	14	10	24
26	CH	18	3	21
27	UK		16	16
28	RU	11	3	14
29	NZ	11	2	13
30	CZ	5	2	7
31	TR	6	1	7
32	GR	6		6
33	MY	4	1	5
34	TH	5		5
35	AR	4		4
36	CL	4		4
37	LU	2	2	4
38	HU	2	1	3
39	IE	3		3
40	PL	2	1	3
41	RS	3		3
42	KZ	2		2
43	SG	1	1	2
44	AZ	1		1
45	BG		1	1
46	CO	1		1
47	HK	1		1
48	ID		1	1
49	IS	1		1
50	JM	1		1
51	KP	1		1
52	LT	1		1
53	MX	1		1
54	PK	1		1
55	PT	1		1
56	RO	1		1
57	UA	1		1
58	UY	1		1
59	VN	1		1
Total				10808

Comp) 472, foreign individuals (ForgIndiv) 754 and Indian individuals (IndIndiv) 1566. Table 8 shows the International Patent Classification [area of invention they are focusing] by category and area of invention.

Fig. 11 shows the invention activity of different categories of applicants filing patents in India. Further, this data is drilled down to find out which Indian and foreign companies are actively pursuing the invention, as depicted in the tables (Table 9 shows top 20 IPCs in which Indian companies are working; Table 10 shows top 20 IPCs in which foreign companies are working).

Foreign Companies

Foreign companies are mainly working in the area of gearing, supplying combustible mixtures to combustion engines, controlling of combustion engines, couplings for transmitting rotation, combustion engines, wind motors, positive-displacement machines, valves, devices for venting, pipe joints or fittings, exhaust apparatus for machines, rotary-piston, refrigeration machines, non-positive-displacement pumps, cyclically operating valves, flexible shafts for transmitting, pistons; cylinders; pressure vessels, heat-exchange apparatus, devices for fastening or securing constructional elements, air-conditioning, springs and shock-absorbers.

Indian companies more or less are similar in working on the inventions like foreign companies however their filing is less in this area and in addition they are also working on functional features of lighting devices or systems and structural combinations of lighting devices with other articles; lubricating of machines or engines in general; lubricating internal-combustion engines and crankcase ventilating. However, Indian companies are less active in the area of fluid-pressure actuators, springs; shock-absorbers; means for damping vibration, pistons; cylinders; pressure vessels, wind motors, refrigeration machines and controlling of combustion engines.

Also it has been seen from the data that there are approximate 1566 Indian individual applicants, active in filing the patents in the area of wind motor, positive-displacement engine, and producing mechanical power from heat, internal combustion engines, mechanical power producing devices, gearing, air-conditioning; and 754 foreign individual applicants working in the area of wind motors, positive displacement engine, internal combustion engine, devices for venting or aerating, gearing, joints

Table 7– Inventor and their organizations

S No	Inventor	Organisation	No. of records
1	M Hart James	GM Global Technology Operations Inc, US	183
2	H Wittkopp Scott	GM Global Technology Operations Inc, US	182
3	W Phillips Andrew	GM Global Technology Operations Inc, US	161
4	E Carey Clinton	GM Global Technology Operations Inc, US	159
5	Raghavan Madhusudan	GM Global Technology Operations Inc, US	57
6	Krishna Mohan Raju Dommaraju	Individual	27
7	Nagaraja Krishnabhatta	TVS Motor Company Limited	21
8	Friedrich Boecking	Robert Bosch GMBH	21
9	Holger Rapp	Robert Bosch GMBH	19
10	Chandak, Ajay, Girdharilal	Individual	19
11	Ryo Kubota	Honda Motor Co Ltd, JP	17
12	Weijun Xu	Shanghai Boiler Works Ltd, CN	17
13	Volker Joergl	BorgwarnerInc, US	16
14	Joachim Franke	Siemens Aktiengesellschaft	16
15	Hui Huang	Shanghai Boiler Works Ltd, CN	16
16	Yamanishi Teruhide	Honda Motor Co Ltd, JP	16
17	Subramoniam Chithambaram	TVS Motor Company Limited	15
18	Samraj Jabez Dhinagar	TVS Motor Company Limited	15
19	Valagam Rajagopal Raghunathan	Individual	15
20	Yang Tai-Her	Individual	15
21	Yalamuru Ramachandra Babu	TVS Motor Company Limited	14
22	Sivaraman Gopalakrishnan	TVS Motor Company Limited	14
23	Joseph Abraham	Bajaj Auto Limited	14
24	Yoshio Imanishi	Honda Motor Co Ltd, JP	14
25	Prasad Karri	Bharat Heavy Electricals Limited, IN	14
26	LakshminarasimhanVaradha Iyengar	TVS Motor Company Limited	13
27	Santosh Arvind Pradhan	Individual	12
28	Rengarajan Babu	TVS Motor Company Limited	12
29	Harne Vinay Chandrakant	TVS Motor Company Limited	12
30	Srinivasa Rao Kandregula	TVS Motor Company Limited	9

Table 8 – Category of patent applications and area of invention

IPC Category	Foreign Companies	IPC Category	Indian Companies	IPC Category	Indian Individual	IPC Category	Foreign Individual
F16H	662	F16H	109	F03D	131	F03D	44
F02M	501	F16D	101	F03B	128	F03B	44
F02D	369	F02M	94	F24J	88	F02B	36
F16D	334	F01D	72	F02B	74	F16K	28
F02B	307	F16K	69	F03G	55	F16H	27
F03D	293	F02D	60	F16H	50	F16L	19
F04B	285	F02B	56	F24F	48	F24J	18
F16K	255	F16C	54	F02M	37	F04B	14
F16L	212	F04D	49	F04B	35	F04D	11
F01N	196	F01N	48	F16K	34	F03G	10
F04C	184	F21V	43	F25B	32	F24F	10
F25B	160	F16L	39	F02D	30	F02M	10
F04D	160	F03D	36	F16C	26	F01C	10
F01L	149	F24F	36	F04D	24	F16D	10
F25D	134	F03B	35	F16D	23	F16B	9
F16C	125	F25D	34	F01D	23	F28D	8
F01D	122	F04B	31	F24C	21	F21S	8
F16J	114	F01L	30	F21V	20	F23D	8
F28D	92	F16B	30	F15B	19	F17C	7
F16B	91	F24J	30	F01N	18	F01K	7
F24F	87	F01M	27	F16L	18	F01B	6
F24J	87	F23C	26	F25D	17	F24C	6
F28F	84	F27B	26	F24H	17	F01N	6
F16F	83	F25B	24	F26B	16	F16C	5
F15B	79	F28F	24	F28D	16	F21V	5

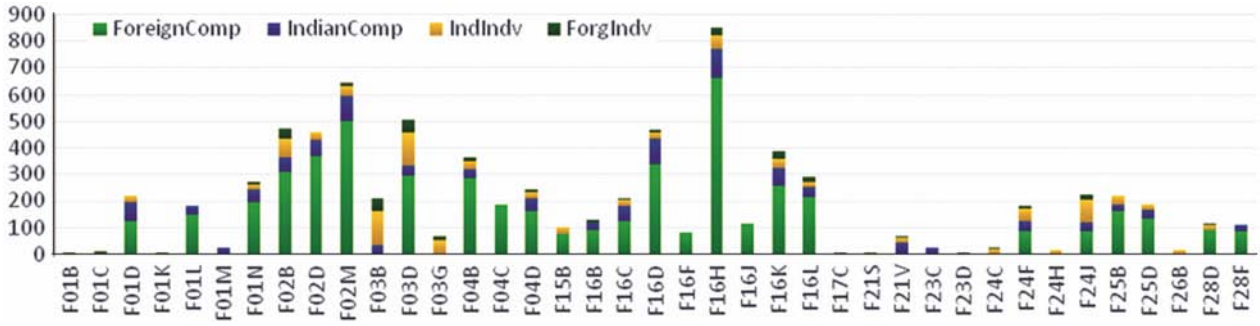

Fig. 11 – Category of patent applications and area of invention

or fittings for pipes, engines or other mechanisms for producing mechanical power from heat.

Usage

Apart from IPC code based categorization of patents, titles of the patents were also scrutinized to understand the nature of invention, and these inventions are mainly applied in the areas such as internal combustion engine, motor vehicle engine, wind turbine, diesel engine, refrigerator, compressor, gas turbine, two-wheeled motor vehicle, air conditioner, pump, heat exchanger, steam turbine, truck, transmission, motorcycle, automobile, fuel injection system, multi-speed transmission, hybrid vehicle, scroll compressor, power plant, automatic transmission, cooling system, passenger vehicle, exhaust system, generator, petrol engine, variable transmission, gearbox, wind power plant.

R&D Partnership

Indian companies are working in various areas under mechanical engineering, there are some interesting findings. Many small scale and big industries are taking efforts in R&D and are coming up with new inventions. For these inventions they have either filed applications or have granted patents in their name. For example, invention in the area of vehicle jack assembly has been filed (1885/DEL/2011)[7] by Rasandik Engineering Industries India Ltd. Patent Application No. 373/MUM/2012[8] is for system for controlling ignition timing of spark-ignited in internal combustion engine, by Sedemac Mechatronics Pvt Ltd and 4338/CHE/2012[9] Application is for lever shifter cable control assembly for controlling operation of e.g. single-lever throttle cable, in different equipment by Suprajit Engineering Ltd.

Building upon the Honey Bee Network Philosophy, the National Innovation Foundation, India[10] (NIF), started functioning in March 2000 as India's national initiative to strengthen the grassroots technological innovations and outstanding traditional knowledge. Its mission is to help India become a creative and knowledge based society by expanding policy and institutional space for grassroots technological innovators. Patent No. IN222780B[11] (Inventor - Ram Naresh Yadav from Kanpur, Uttar Pradesh) for double cylinder reciprocating fluid pump capable of being driven independent of the nature of the driving source, whether electrically, on fossil fuels or mechanically, without loss of performance and with significant savings in terms of power requirement has been granted to NIF, India. This shows how the individual inventors under the umbrella of NIF are taking advantage of IP protection and the developed technology that can be used for society with proper IP protection and recognition to individual inventor.

Application No. 2427/MUM/2010[12] is for float valve cap tray for mixing vapor with liquid discharged from down-comer distillation column by Desmet Ballestra India Pvt Ltd. (controlled by Financière DSBG, a holding company based in Paris, France). Application No. 1713/MUM/2010[13] is for rotating mechanical seal element for use as single/double/balanced/unbalanced/pusher/non-pusher seal element for sealing gap between rotary and stationary elements by Eagleburgmann India Pvt Ltd. (part of the German Freudenberg and Japanese EKK group). It is interesting to know that Application No. 787/MUMNP/2012[14] is for modular heat exchanger used in ocean thermal energy conversion (OTEC) power generation system, filed by Lockheed Martin Corporation.

Yeda Research and Development Company Ltd. Israel[15], is the Technology Transfer Company of the Weizmann Institute of Science, Israel. Yeda markets and commercializes intellectual property created at the Weizmann Institute laboratories. They have filed Indian Patent Application (740/KOLNP/2011)[16] in the

area of solar receiver for use in solar energy system, a solar radiation absorber located within chamber surrounding portion of window to absorb radiation and heating of working fluid.

It is also observed that the different companies are working together either in pre-research/pre-development stage and have joint patent application in the inventions area or the granted patent is reassigned to them.

Table 9 – Top 20 IPC categories in which Indian companies are working

Assignee/IPC category	F16H	F02M	F03D	F02B	F16D	F02D	F16K	F04B	F16L	F03B	F01D	F04D	F25B	F01N	F24J	F16C	F04C	F25D	F24F	F01L
Bharat Heavy Electricals Limited	5	3	12	4	6	2	9	3	7	17	37	10	2	4	4	4		2	1	2
TVS Motor Company Limited	26	27		16	34	11	4	1			1	6		10		11	1			12
Tata Motors Limited	16	20		9	15	12	3	1	2		2		1	11		4	1		2	3
Crompton Greaves Limited	2	1	3		2		1	4			2	13	1	2	2	7	1		7	
Mahindra and Mahindra Limited	9	7		3	6	3	3					2		6		4	1			
Council of Scientific and Industrial Research				3		1		1	2	1	2		1		2	2		1	1	2
Steel Authority of India Limited	1	1	1								1	1				1		1		1
Indian Institute of Technology		3	6			1		2		3	5		2		1	1		1	1	
Larsen & Toubro Limited	8	1			1	1	1	2	1		2	1	1			2				
Tata Steel Limited	1				1		2	1			1	2				2				
Ashok Leyland Limited	1	2		4		6			1					6						2
Bajaj Auto Limited	5	3				8								2		1				
Maruti Suzuki India Limited	2	3		2		4														
Audco India Limited	3						13													1
Godrej & Boyce Mfg Co Ltd																		11		
Blue Star Limited								1	1				4						2	
High Technology Transmission Systems Pvt Ltd				1	8											1				
Triveni Engineering & Industries Ltd (Turbine Business Group)							1				8									
Department of Space Indian Space Research Organization (ISRO)							3					1	1							
Department of Science and Technology				4													1			

Indian Share

Mahindra and Mahindra Limited and M.N. Ramarao & Company hold a Patent No. IN249076B[17], in the area of improved air filter system for railway locomotive. Council of Scientific and Industrial Research, in association with Gas Authority of India Limited, Encon Thermal Engineers (Pvt) Ltd and National Research Development Corporation hold a granted patent (IN220134B)[18] in the area of improved industrial gas burner. Also, Council of Scientific and Industrial Research, India in association with Central Power Research Institute, National

Table 10 – Top 20 IPC categories in which foreign companies are working

Assignee/IPC Category	F16H	F02M	F03D	F02B	F16D	F02D	F16K	F04B	F16L	F03B	F01D	F04D	F25B	F01N	F24J	F16C	F04C	F25D	F24F	F01L
Robert Bosch GMBH	10	217		14	10	96	16	44	1		1	10	12	32	5	2	13	3		2
GM Global Technology Operations Inc,US	229	33	1	28	29	46	4	7	3		4			40		1	3			24
Honda Motor Co Ltd,JP	37	37		25	18	49		4	1			3		13		10	3			32
General Electric Company,CA	3	4	45	1	2	6	3	2	1	1	32	8	1	3	1	1	3	1		
Mitsubishi Heavy Industries Ltd.	4	14	20	2	2	2	5	8	1		20	12	3		4	5	10		3	4
BorgWarner Inc,US	19	7		73	5		5	1			7	6		4						4
LG Electronics Inc,KR								17	1			2	5				4	38	3	
BSH Bosch und Siemens Hausgerate GMBH,DE								6				4	8					38		
Toyo Roki Seizo Kabushiki Kaisha,JP	7	7		7		36								8		2				7
Eaton Corporation, US	17			1	14	3	8	2	3			1		1			5			1
Vestas Wind Systems A/S	2		64			1		1			1		1							
Daikin Industries Ltd								3				2	12				22		19	
Federal-Mogul BurscheidGMBH		3		1	4											11				
Danfoss AS,DK							6	13			1	1	11			1	16	2		
Praxair Technology Inc,US												3	2					4		
Carrier Corporation, US	1							4	1			3	19				2	5	5	
Sanyang Industry Co. LTD.	4	4		3		5						1		2		1				9
Knorr-BremseSysteme Fur Nutzfahrzeuge GMBH,DE	1			3	23	2	1	8						1			1			
Alfa-Laval AB							2	1	1			1								
Man Diesel AS,DK		5		2		5					1	5		3						4

Hydro Power Corporation Limited and Satluj Jal Vidyut Nigam Limited have patent application (2653/DEL/2011)[19] in the area of composition for erosion resistance steel. Steel Authority of India Limited in association with Petroleum Conservation Research Association has patent application no (136/KOL/2008)[20] in the area of aerodynamic design for high produce tunnel kiln in industrial application.

TVS Motor Company Limited and Indian Institute of Science, have applications (671/CHE/2011[21], 4026/CHE/2010[22], 594/CHE/2011[23]) in the area of internal combust engine, two-stroke internal combustion engine. TVS Motor Company Limited and Pinnacle Engines Inc. has application (8612/CHENP/2012)[24] in the area of improving the compression ratio between the pistons and prevent the lubricating oil from undergoing combustion during operation of the engine and thus reducing the pollution. Bajaj Auto Limited in association with Indian Institute of Technology has patent application (970/MUM/2006)[25] in the area of variable valve timing assembly for 4-stroke internal combustion engine.

Foreign Share

Honda Motor Co. Ltd., JP and Keihin Corporation, JP has patent applications (4983/CHENP/2010[26] 4039/CHENP/2010,[27] 5404/CHENP/2009,[28]5007/ CHENP/2007,[29]1606/CHENP/2008)[30] in the area of fuel supply module engine injection valve for two wheel motor vehicle; inlet manifold for multi cylinder internal combust engine; fuel feed system for two wheel motor vehicle; pressure regulated engine fuel supply system respectively.

Mitsuba Corporation has patent applications (619/CHENP/2008,[31] 618/CHENP/2008,[32] 5007/ CHENP/2007,[29] 1606/CHENP/2008)[30] in the area of fuel feed pump for two wheel motor, fuel pump suction unit suck discharge arrange lower portion cylinder yoke. Hitachi Co Ltd, JP has patent applications (2106/CHENP/2011,[33] 7905/CHENP/2011)[34] in the area of silent chain power transmission device for internal combustion engine.

Daikin Industries Ltd has patent application (1553/KOLNP/2012)[35] in the area of transmission oil seal for vehicles. Tokai Rubber Industries Ltd, JP has a granted patent (IN229059B)[36] in the area of connector for fuel conveying resin tubes. Mahle Filter Systems Japan Corporation has patent applications (8581/CHENP/2013)[37] in the area of seal element for plug tube structure engine base section. Exedy Corporation, JP has granted patent (IN242302B)[38] in the area of clutch apparatus for motorcycle fin with integral clip guided for lubrication.

Nissin Kogyo Co Ltd, JP has granted patent (IN218019B)[39] in the area of Disc brake for vehicle. Shindengen Electric Manufacturing Co. Ltd has granted patent (IN194906B)[40] in the area of ignition device capacitor for two wheel motor vehicle control operated based voltage terminal zener diode key switch. Arai Seisakusho Co. Ltd has granted patent (IN216976B)[41] in the area of reed valve vibration suppress member. Keihin Corporation has patent application (1132/CHE/2012)[42] in the area of Inlet manifold internal combust engine vehicle pipe circulate fluid held hold space branch parallel.

Siemens Aktiengesellschaft and Delavan Inc. has granted patent (IN252009B)[43] – in the area of burner gas turbine combust quench air inlet radial orient outlet direct cooling pilot product exhaust. Mitsubishi Heavy Industries Ltd (MHI) and Electric Power Development Co Ltd, JP has granted patent (IN228456B)[44] in the area of liquefy natural gas turbine combination cycle power plant heat medium evaporation and suction cooling device. Hitachi Construction Machinery Co Ltd, JP has patent application (4613/DELNP/2010)[45] in the area of super-charger that can be started or stopped smoothly and surging of super-charger can be prevented. BorgWarner Inc, US and Bayerische Motoren Werke Aktiengesellschaft, DE has patent application (722/KOLNP/2011)[46] in the area of exhaust gas turbocharge internal combust engine in vehicle manifold.

Emitecgesellschaft Fur Emissionstechnologie GmbH, DE has Indian patent application (390/DELNP/2010)[47] in the area of exhaust gas secondary treatment system for clean diesel engine passenger motor vehicle. Daikin Industries Ltd and Honda Motor Co Ltd, JP has Indian patent application (1553/KOLNP/2012)[35] in the area of transmission oil seal vehicle elastic component. Toyo Roki Seizo Kabushiki Kaisha, JP and Nippon Gasket Co Ltd, JP has patent application (10736/DELNP/2008)[48] in the area of high sealing performance of the cylinder head gasket. Aisin Seiki Kabushiki Kaisha and Toyota Jidoshokki Kabushiki Kaisha has patent application (3871/CHENP/2012)[49] in the area of engine stop determine apparatus for hybrid vehicle on the basis coolant temperature detection.

Aisan Kogyo Kabushiki Kaisha and Toyota Jidosha Kabushiki Kaishahas patent application (7420/DELNP/2012)[50] in the area of idle rotation speed control device for a bifuel engine. Fujitsu Ten Limited and Toyota Jidosha Kabushiki Kaisha has patent application (7502/DELNP/2011)[51] in the area of controller for an internal combustion engine. Pacific Industrial Co. Ltd. and Toyota Jidosha Kabushiki Kaisha has patent application (169/MUMNP/2013)[52] in the area of oil pan inner tank valve structure for vehicle. Emerson Climate Technologies Inc, US and Whirlpool Corporation have patent application (10655/DELNP/2012)[53] in the area of suction arrangement for refrigerate compressor inlet nozzle. The arrangement can eliminate the risk of interior liquid-refrigerant fluid returning to the interior of compression chamber and can prevent the loss of energetic efficiency effectively.

Future Path

There is lot of growth opportunities in engineering sectors like automobile, automobile component, power transmission and distribution, material handling equipment, machine tools etc. which has now connected with Government of India's "Make in India Plan". Make in India is a major new national programme of the Government of India designed to facilitate investment, foster innovation, enhance skill development, protect intellectual property and build best in class manufacturing infrastructure in the country.

Statistics of Automobile Component Sector[54]

- Turnover of USD 39.7 billion in 2012–13.
- Growth expected to reach USD 115 billion by 2020-21.
- Market estimated to become the third largest in the world by 2016, accounting for more than 5% of global vehicle sales.
- Expected to become the fourth largest automobiles producer globally by 2020 after China, US and Japan.
- Exports of auto components increased at a Compound Annual Growth Rate (CAGR) of 17% during 2008-13, reaching USD 9.7 billion in 2012-13.

Engineering is a diverse and largest industry with various segments in India. The foreign direct investment (FDI) inflows into India's miscellaneous mechanical and engineering industries during April 2000 to September 2014 stood at around US$ 2.64 billion, as per data released by the Department of Industries Policy and Promotion (DIPP).[55] The engineering sector is a growing market. Current spending on engineering services is projected to increase to US$ 1.1 trillion by 2020.

Conclusion

This paper discussed about patents and the patenting trend in the area of mechanical engineering at Indian Patent Office. It is a first time full data compilation of patent filing and granted data at Indian Patent Office from the year 1961 and patent filing data in the area of particular invention from 1986. Further, for this study separate search was conducted using value added patent information databases with focus (IPC based) on mechanical engineering sector to understand and find out the companies working in this area. The paper also addressed the various trends and discussed the R&D partnership observed among Indian organisations and also at foreign organisations level. From the patent filing trends from 1961, it can be concluded that almost 74% of the patent applications are filed by foreign applicants and 26% are by Indian applicants. The filing trend has been constant and has increased after 2005 by foreign companies; this may be due to globalization effect and also it will attract more filing in future as Indian market is opening for Foreign Direct Investment (FDI).

It has been observed that the Indian companies are not that aggressive like foreign companies in patenting activity and their R&D collaborations are less compared to foreign companies. There is also development in allied sectors of engineering fields such as automobile, auto component, together with skilled technical human resources available in India. Indian engineering sector is expected to grow faster with quality and quantity and recognize in the world. Considering the growth in engineering sector in India, it is highly recommended that the Indian industries to compete with the international market in the intellectual property (IP) scenario, all the Indian engineering companies may come forward and take the advantage of patent system.

However, it is not only important to file the patent applications but also to use the patent information in the R&D planning of engineering companies, with their business plan, and it is equally important to come up with the new innovative products. This will help Indian companies to showcase their potential and

join hands in R&D with their competitors. The joint collaboration will result in a major innovative product development in the engineering sector, which in turn will help them to protect their IP and this IP can be further used while marketing and exporting the product within country and in other countries and leverage to make financial return on it. During study it was also felt that a separate study of Indian companies working in mechanical engineering sector, who have filed patent applications/having granted patents in foreign countries, will focus more light on IP awareness/protection and the use of patent in the business strategy of Indian companies.

References

1 http://me.columbia.edu/what-mechanical-engineering (accessed on 24 February 2015)

2 Manual of Patent Practice & Procedure, Controller General of Patents, Designs & Trade Marks, India. Third Edition – 2008.

3 www.wipo.int/freepublications/en/intproperty/.../wipo_pub_941_2013.pdf (accessed on 10 January 2015).

4 http://ipindia.gov.in/cgpdtm/AnnualReport_English_2012_2013.pdf (accessed on 28 January 2015).

5 Patent Cooperation Treaty (PCT) System - The PCT system offers inventors and industry a better route for obtaining patent protection internationally as by filing one international patent application protection for an invention can be simultaneously sought in 117 countries, which are signatories to the PCT. This system is advantageous both to the applicants and patent offices of the PCT member countries as there is certain uniformity in the formality requirements, the international search and preliminary examination reports and the centralized international publication provided by the PCT system.

6 Handbook of Quantitative Science and Technology Research, *The Use of Publication and Patent Statistics in Studies of S&T Systems*, Editors: Henk F Moed, Wolfgang Glänzel & Ulrich Schmoch, ISBN: 978-1-4020-2702-4 (Print) p. 220.

7 Kumar A *et al.*, *Vehicle Jack Assembly*, *India,* Application No. 1885/DEL/2011 (Rasandik Engineering Industries India Ltd.), 2011.

8 Dixit A *et al*., *A System And Method For Controlling Ignition Timing of an Internal Combustion Engine , India*, Application No. 373/MUM/2012 (Sedemac Mechatronics Pvt. Ltd.), 2013.

9 Rao SN *et al*., *Lever Shifter Control Cable Assembly, India,* Application No. 4338/CHE/2012 (Suprajit Engineering Ltd.), 2014.

10 http://nif.org.in/aboutnif (21 January 2015).

11 Yadav RN, *Power Saving Double Cylinder Reciprocating Fluid Pump , India,* Patent No. IN222780B (National Innovation Foundation, India), 2008.

12 Jayawant RB, *A Float Valve Cap Tray for a Distillation Column, India,* Application No. 2427/MUM/2010 (Desmet Ballestra India Pvt. Ltd.), 2013.

13 Kulkarni SV, *Self Lubricating Mechanical Seal*, *India,* Application No. 1713/MUM/2010 (Eagleburgmann India Pvt. Ltd.), 2013.

14 Nagurny NJ *et al.*, *Modular Heat Exchanger, India,* Application No. 787/MUMNP/2012 (Lockheed Martin Corporation), 2013.

15 http://www.yedarnd.com (accessed on 10 March 2015).

16 Karni J, *Solar Receiver System, India,* Application No. 740/KOLNP/2011 (Yeda Research and Development Co. Ltd.), 2011.

17 Prakash RM *et al.*, *An Apparatus For Cleaning Air Used By An Engine Of Railway Locomotives , India,* Patent No. IN249076B (Mahindra & Mahindra Ltd., M.N. Ramarao & Company), 2011.

18 Madan HK *et al.*, *An Industrial Gas Burner Having Improved Gas and Air Mixing Means, India,* Patent No. IN220134B (National Research Development Corporation, IN; Encon Thermal Engineers (Pvt) Ltd, IN; Gas Authority of India Limited, IN; Council of Scientific and Industrial Research, IN), 2008.

19 Chowdhury SG *et al.*, *An Erosion Resistant Steel for Underwater Components of Turbine Hydrogenerators and Process for Producing the Same*, *India*, Application No. 2653/DEL/2011 (Council of Scientific & Industrial Research; Central Power Research Institute; National Hydro Power Corporation Limited; Satluj Jal Vidyut Nigam Limited), 2013.

20 Pandey KN *et al.*, *An Improved Design for Aerodynamics and Higher Productivity for Tunnel Kiln used in White Ware Industry, India*, Application No. 136/KOL/2008 (Steel Authority of India Limited, IN; Petroleum Conservation Research Association, IN), 2009.

21 Melkote VN *et al.*, *Internal Combustion Engine, India*, Application No. 671/CHE/2011 (TVS Motor Company Limited, IN; Indian Institute of Science, IN), 2011.

22 Melkote VN *et al.*, *Two-Stroke Internal Combustion Engine, India*, Application No. 4026/CHE/2010 (TVS Motor Company Limited, IN; Indian Institute of Science, IN), 2011.

23 Melkote VN *et al.*, *Two-Stroke Internal Combustion Engine, India,* Application No. 594/CHE/2011 (TVS Motor Company Limited, IN; Indian Institute of Science, IN), 2011.

24 Babu JVV *et al.*, *Opposed Piston Engine With Non-Collinear Axes of Translation, India,* Application No. 8612/CHENP/2012 (Pinnacle Engines Inc.; TVS Motor Company Limited), 2014.

25 Sheth NR *et al.*, *Variable Valve Timing Assembly for a 4-Stroke Internal Combustion Engine, India,* Application No. 970/MUM/2006 (Indian Institute of Technology Madras, IN; Bajaj Auto Ltd., IN), 2008.

26 Torikai M *et al.*, *Fuel Supply Module, India*, Application No. 4983/CHENP/2010 (Keihin Corporation, JP; Honda Motor Co. Ltd., JP), 2011.

27 Naito T *et al., Fuel Supply Module, India,* Application No. 4039/CHENP/2010 (Keihin Corporation, JP; Honda Motor Co. Ltd., JP), 2010.

28 Taira T *et al., Intake Manifold for Multiple-Cylinder Internal Combustion Engine, India*, Application No. 5404/CHENP/2009 (Keihin Corporation, JP; Honda Motor Co. Ltd., JP), 2009.

29 Honma B *et al.*, *Fuel Supply Apparatus*, *India*, Application No. 5007/CHENP/2007 (Mitsuba Corporation, JP; Honda Motor Co. Ltd., JP; Keihin Corporation, JP), 2008.

30 Shimogawa M *et al.*, *Pressure Control Device, India,* Application No. 1606/CHENP/2008 (Honda Motor Co. Ltd., JP; Mitsuba Corporation, JP; Keihin Corporation, JP), 2008.

31 Ikarugi T *et al.*, *Fuel Pump, India*, Application No. 619/CHENP/2008 (Mitsuba Corporation, JP; Honda Giken Kogyo Kabushiki Kaisha, JP), 2008.

32 Ikarugi T *et al.*, *Fuel Pump, India*, Application No. 618/CHENP/2008 (Mitsuba Corporation, JP; Honda Giken Kogyo Kabushiki Kaisha, JP), 2008.

33 Fujiwara A *et al.*, *Silent Chain Power Transmitting Device, India*, Application No. 2106/CHENP/2011 (Honda Motor Co. Ltd.; Hitachi Powdered Metals Co. Ltd.), 2011.

34 Fujiwara A *et al.*, *Silent Chain Transmission, India*, Application No. 7905/CHENP/2011 (Honda Motor Co. Ltd., JP; Hitachi Powdered Metals Co. Ltd., JP), 2012.

35 Ogishi H *et al.*, *Vehicle Transmission Oil Seal, India*, Application No. 1553/KOLNP/2012 (Honda Motor Co. Ltd.; Daikin Industries Ltd.), 2013.

36 Yagisawa K *et al.*, *Resin Tube-Equipped Quick Connector, India*, Patent No. IN229059B (Honda Motor Co Ltd., JP; Tokai Rubber Industries Ltd., JP), 2009.

37 Akiyama Y *et al.*, *Seal Member and Plug Tube Seal Structure for Engine, India,* Application No. 8581/CHENP/2013 (Mahle Filter Systems Japan Corporation; Honda Motor Co. Ltd.), 2014.

38 Imanishi Y *et al.*, *Motorcycle Clutch Device, India,* Patent No. IN242302B (Exedy Corporation, JP; Honda Motor Co. Ltd., JP), 2010.

39 Keiichi T *et al.*, *Mechanical Disc Brake for Vehicles, India,* Patent No. IN218019B (Nissin Kogyo Co. Ltd., JP; Honda Giken Kogyo Kabushiki Kaisha, JP), 2008.

40 Masami K *et al.*, *Ignition Device of Capacitor Charging and Discharging Type, India*, Patent No. IN194906B (Honda Giken Kogyo Kabushiki Kaisha; Shindengen Electric Manufacturinc Co. Ltd.), 2009.

41 Hiroshi O *et al.*, *Reed Valve, India*, Patent No. IN216976B (Honda Giken Kogyo Kabushiki Kaisha; Arai Seisakusho Co. Ltd), 2008.

42 Fukuda S *et al.*, *Intake Manifold For Internal Combustion Engine, India*, Application No. 1132/CHE/2012 (Keihin Corporation; Honda Motor Co. Ltd.), 2013.

43 Cornwell M *et al.*, *A Burner for a Gas Turbine Combustor, India,* Patent No. IN252009B (Siemens Aktiengesellschaft; Delavan Inc), 2012.

44 Hideto W *et al.*, *Vaporizing Apparatus of LNG As Fuel for a Natural Gas Firing Gas Turbine Combined Cycle Power Station, India*, Patent No. IN228456B (Chubu Electric Power Company Incorporated, JP; Mitsubishi Jukogyo Kabushiki Kaisha, JP), 2009.

45 Shiraishi K *et al.*, *Marine Diesel Engine, India*, Application No. 4613/DELNP/2010 (Mitsubishi Heavy Industries Ltd.; Tsuneishi Holdings Corporation; Hitachi Zosen Corporation), 2011.

46 Lingenauber R *et al.*, *Exhaust-Gas Turbocharger, India,* Application No. 722/KOLNP/2011 (BorgwarnerInc, US; Bayerische Motoren Werke Aktiengesellschaft, De), 2011.

47 Brock R *et al.*, *Exhaust-Gas Secondary Treatment Preceding A Turbocharger, India*, Application No. 390/DELNP/2010 (Borg Warner Inc, US; Emitecgesellschaft Fur Emissionstechnologie Mbh, De), 2010.

48 Yoshijima K *et al.*, *Cylinder Head Gasket, India,* Application No. 10736/DELNP/2008 (Toyota Jidosha Kabushiki Kaisha, JP; Nippon Gasket Co Ltd., JP), 2009.

49 Yumisashi N *et al.*, *Engine Stop Determination Device and Engine Stop Determination Method, India,* Application No. 3871/CHENP/2012 (Aisin Seiki Kabushiki Kaisha, Toyota Jidosha Kabushiki Kaisha), 2013.

50 Shirasawa H *et al.*, *Idle Rotation Speed Control Device for Bifuel Engine, India,* Application No. 7420/DELNP/2012 (Toyota Jidosha Kabushiki Kaisha, Aisan Kogyo Kabushiki Kaisha), 2014.

51 Ide K *et al.*, *Controller for Internal Combustion Engine, India*, Application No. 7502/DELNP/2011 (Toyota Jidosha Kabushiki Kaisha, Fujitsu Ten Limited), 2012.

52 Inoue T *et al.*, *Oil Pan Inner Tank Valve Structure, India,* Application No. 169/MUMNP/2013 (Toyota Jidosha Kabushiki Kaisha, Kabushiki Kaisha Toyota Jidoshokki, Pacific Industrial Co. Ltd.), 2014.

53 Silveira M *et al.*, *Suction Arrangement for A Refrigeration Compressor, India,* Application No. 10655/DELNP/2012 (Emerson Climate Technologies Inc., Whirlpool S.A.), 2014.

54 http://www.makeinindia.com/sector/automobile-components/ (accessed on 23 March 2015).

55 http://indiainbusiness.nic.in/newdesign/index.php?param=industryservices_landing/399/1 (accessed on 8 April 2015).