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Sahib, 140407, Punjab, India***ABSTRACT :**

*In the present study, output and citation analysis of research activities in engineering in the world are mapped during 2002-2016. The study aims to promote the awareness of the global research output in engineering. With this aim, Scimago Journal & Country Rank data (Scopus® database of Elsevier) has been accessed for obtaining the required scholarly publication data. An attempt for evaluation on different qualitative and quantitative parameters like number of publications, citation analysis, research output, and h-index has been done. With these indicators in the research, analysis and assessment of total 7252275 publications from engineering field were done. The results show that out of the total research output, China stands first with 22.22% share of the research and is followed by United States (17.78%) and Japan (6.04%). Outstanding countries in engineering research have significant impact and 68.93% of the total global engineering research has been done in 10 leading countries. During the period of study, the research output of engineering has improved considerably with an average annual growth of 6.88%.*

**Keywords:** Research Output, Citation Analysis, Engineering Research, Global Research.

**1. Introduction :**

Research in engineering plays a very important and vital role and indicators like number of articles, author, citations and impact factor etc are being used for measuring the research of the organization. The organization uses these indicators in various recruitment and promotion activities. Scopus, through its Journal Citations Report (JCR) indexes the specialist journals which helps the researchers in locating the required information of an interested subject. The diffusion of articles published in journals indexed in JCR is increased and the articles get more citations, in turn, increasing the impact factor and international recognition. The impact and quality of the research can be quantified by the tools which are provided by The SJR and are very useful in understanding and applying the concept for the researchers. The researchers can easily find out data for their researches, which are the leading countries and the analysis can be done with different angles. But in spite of the fact that a very valuable analysis can be done which can be of very help, no study has been done to analyze the global engineering research data.

The study is done with the aim of uncovering the status of engineering research in the world. The results of the study are focused on global engineering research and different valuable information can be extricated.

Valuable analysis can be done to reveal the status of research in engineering. The bibliometric indicators from the SCImago Journal & Country Rank database can be used as per the website statement. According to the website "The SCImago Journal & Country Rank is a publicly available portal that includes the journals and country scientific indicators developed from the information contained in the Scopus® database (Elsevier B.V.)." (SJR, 2017)

## 2. Review of Literature :

The present study tries to explore the research output and citations analysis within the field of engineering. For this, the analysis of literature review is done by the authors.

The recent study on analysis of mechanical engineering research showed that in the field of mechanical engineering Japan has more achievements as compared South Korea and India. (Pattanshetti, D M and Harinarayana, N S, 2017)

It is clear through quantitative analysis for 25 years of faculty publications of the physics department, SP Pune university that the growth in the research output is steady although the faculty members are very active in research (Nagarkar, S., & Kengar, M., 2017) Most of the studies related to emergy shows the availability of academic collaborations between the most dominant contributors like China, Italy and USA. (Chen, W., Liu, W., Geng, Y., Brown, M. T., Gao, C., & Wu, R., 2017). (Patra, S. K., & Muchie, M., 2017) mapped the scientific productivity of engineering research in African Union member countries. The used Scopus® database to map engineering publications data and analyzed that in spite of a tremendous growth in publications in the recent period, the engineering is not favorite area of research. They established that South Africa has more global and African collaborator countries in research in comparison Africa.

(Hussain, A., & Swain, D. K., 2011) inferred that, in the pinnacle of the research in Computer Science, major part is the collaborative research. Akyildiz, I. F (USA) is the most sought after author. Likewise, European Journal of Operational Research is the most sought after journal and Wireless sensor networks: a survey by Akyldiz; Su; Sankarasubramaniam; and Cayirci is the top paper with a record 3879 citations. USA is the top productive country and has the momentous impact in Computer Science field.

(Cañas-Guerrero, I., Mazarrón, F. R., Pou-Merina, A., Calleja-Perucho, C., & Suárez-Tejero, M. F., 2013) studied that structuration and complexity in research is increasing. 87% of the research is done in 30 countries and USA (2013) produces 27% of the total research followed by China, Germany, India, South Korea, Turkey, Spain, and Iran. They also established that 96.2% of the total publications is carried out in English language and is distantly followed by the German language (2.2%). The journals having higher IF have wide boundaries in terms of diffusion and internationalization of publications.

(Pandita, R., Singh, S., & Gaur, R. C., 2016) have noticed a steady growth (annual 58.90%) in medical sciences research publications in the country, with maximum research contribution from AIIMS.

(Pandita, R., & Singh, S., 2014) studied that research is disproportionate in oncology field in the world They also suggested that support efforts like creation of infrastructure for biomedical research and sustainability programmes should be provided to all the under-developed nations by the leading countries in oncology research like the United States, Japan, the United Kingdom, France, Germany, China, etc., which in turn will help in promotion of research in the field.

(Ravichandra Rao, I., & Suma, M., 1999) found in their analysis that of the Indian engineering literature only a few journals and some selected institutions were involved in research in engineering in India. However, research output in bioengineering, applied physics, information science and light and optics are increasing in India and at global level. (Kaur, H., & Gupta, B. M., 2009) in their study of microbiology and immunology publications during 1999-2008 analyzed the performance of India. They analyzed the publications on different parameters like annual average country growth rate, global rank and share of publications, international collaborative partners and their profiles, communication patterns journals both at national and international level and some common characteristics the most productive authors had. (Jesiek, B. K., Borrego, M., Beddoes,

K., Hurtado, M., Rajendran, P., & Sangam, D., 2011) analyzed the major global trends in engineering education and suggested for collaborations at cross-national levels also. They also suggested some steps through which global capacities can be built in engineering education. (Panat, R., 2014) found in his study that China in ahead in research output as compared to India. (Banshal, S K, Singh V K, Basu A & Muhuri, P K, 2017) found that top 5 engineering disciplines attract most of the decision makers in fund allocation and policy making and most of funds are allocated to these. The research output of the India's most prestigious engineering and technology institutions like IITs with international institutes like MIT-USA and NTU-Sin-gapore was compared in the study.

(Barrot, 2017), (Zou Y., & Laubichler, M. D., 2017), (Nobre, G. C., & Tavares, E., 2017) (Singh, V. K., Banshal, S. K., Singhal, K., & Uddin, A., 2015), (Hadagali, G. S., & Anandhalli, G., 2015), (Elango, B., Rajendran, P., & Bornmann, L., 2016), (Bhattacharya, S., Shilpa, & Bhati, M., 2012) (Gupta, B. M., Kshitij, A., & Verma, C., 2010) and (Sangam, S. L., & Keshava & Agadi, K. B., 2009) are of the studies done to access the growth of scientific research output .

### 3. **Problem Statement :**

The obsolesce of literature depends mainly on two facts. The first is if the research is being done at a very fast rate and at large scale, then the immediate past literature becomes obsolete. Also if the research is not done as per the future requirements, then also there are more chances of the literature obsolesce. In the modern era of information explosion, the first reason seems to be major cause of literature obsolesce because the research is being done at a very fast rate and the literature in engineering research is increasing day by day. Thereby, it is very difficult to know the growth rate of research output in engineering at global level.

### 4. **Objectives of the Study :**

After discussion over the literature survey and analytical framework, the study strives at following key research objectives:

- To measure the growth rate and overall status of research in engineering at global level.
- To know the most outstanding countries in the field of engineering reasech.
- To study the research output in engineering in 10 outstanding countries .
- To analyze the status of citations and self citations using different parameters at world level
- To know the status of citations per document in the field at world level

### 5. **Methodology :**

Keeping in mind the objectives of the study, the required data to measure the research output was retrieved from the website of SJR -SCImago Journal and Country Ranking” at the below link: <http://www.scimagojr.com/countryrank.php>

(The list of countries is given in Appendix A). To measure the output of research in engineering, the Scopus® database which is largest database for indexing and abstracting covering more than 28606 scholarly journals from various subject areas. The year wise data was revealed by entering subject area as engineering with all subject categories and all regions. The data for the period of 2002-2016 was exported in raw csv comma delimited MsExcel®.

### 6. **Data Analysis and Discussion**

Percentage has been drawn up to two decimal points and has not been rounded off. So at places, it may reflect a slight variation while computing data for 100% figure.

**Table 1: Ranking of the outstanding 10 countries during the period of study (2002-2016)**

| Country            | Rank | No. of Publications | Global Share % | CG%   |
|--------------------|------|---------------------|----------------|-------|
| China              | 1    | 1611732             | 22.22%         | 16.67 |
| United States      | 2    | 1290001             | 17.78          | 2.22  |
| Japan              | 3    | 438084              | 6.04           | 1.22  |
| Germany            | 4    | 332909              | 4.59           | 4.61  |
| United States      | 5    | 295116              | 04.06          | 4.63  |
| South Korea        | 6    | 239246              | 3.29           | 7.82  |
| India              | 7    | 233298              | 3.21           | 14.67 |
| France             | 8    | 173554              | 2.39           | 4.60  |
| Italy              | 9    | 192946              | 2.66           | 6.43  |
| Russian Federation | 10   | 130935              | 1.80           | 5.91  |

**Table 2: Year wise growth of engineering research in leading 10 countries**

| Country            | 2002  | 2003    | 2004   | 2005    | 2006    | 2007    | 2008    | 2009    | 2010   | 2011    | 2012    | 2013    | 2014    | 2015    | 2016    | (Share %)           |
|--------------------|-------|---------|--------|---------|---------|---------|---------|---------|--------|---------|---------|---------|---------|---------|---------|---------------------|
| China              | 21427 | 24817   | 42105  | 63792   | 71398   | 84430   | 100694  | 105791  | 123035 | 156788  | 162935  | 176286  | 186668  | 143258  | 148308  | 161732<br>(22.22%)  |
| CG%                |       | 15.821  | 69.662 | 51.507  | 11.923  | 18.253  | 19.263  | 5.0619  | 16.3   | 27.434  | 3.9206  | 8.1941  | 5.8893  | -23.255 | 3.5251  | 16.67%              |
| United States      | 65443 | 72273   | 88137  | 100210  | 89862   | 83212   | 83253   | 84980   | 89619  | 88539   | 87391   | 89919   | 92508   | 89521   | 85134   | 1290001<br>(17.78%) |
| CG%                |       | 10.437  | 21.95  | 13.698  | -10.326 | -7.4002 | 0.0493  | 2.0744  | 5.4589 | -12051  | -12966  | 2.8927  | 2.8793  | -3.2289 | -4.9005 | 2.22%               |
| Japan              | 22907 | 25948   | 27506  | 35533   | 34728   | 30925   | 29989   | 30406   | 30914  | 30122   | 29587   | 29246   | 28774   | 25900   | 25599   | 438084<br>(06.04%)  |
| CG%                |       | 13.275  | 6.0043 | 29.183  | -2.2655 | -10.951 | -3.0267 | 1.3905  | 1.6707 | -2.5619 | -1.7761 | -1.1525 | -1.6139 | -9.9882 | -1.1622 | 1.22%               |
| Germany            | 14224 | 16150   | 18954  | 22334   | 21358   | 21776   | 22065   | 22378   | 22745  | 23879   | 24627   | 24019   | 26769   | 25723   | 25908   | 332909<br>(4.59%)   |
| CG%                |       | 13.54   | 17.362 | 17.833  | -4.37   | 1.9571  | 1.3271  | 1.4185  | 1.64   | 4.9857  | 3.1325  | -2.4688 | 11.449  | -3.9075 | 0.7192  | 4.61%               |
| United Kingdom     | 12855 | 14039   | 17126  | 20165   | 19328   | 19628   | 19902   | 19961   | 20258  | 20623   | 20428   | 20847   | 23523   | 23007   | 23426   | 295116<br>(04.06%)  |
| CG%                |       | 9.2104  | 21.989 | 17.745  | -4.1508 | 1.5522  | 1.396   | 0.2965  | 1.4879 | 1.8018  | -0.9455 | 2.0511  | 12.836  | -2.1936 | 1.8212  | 4.63%               |
| India              | 4826  | 5282    | 6352   | 7492    | 9084    | 9975    | 11668   | 12517   | 13939  | 17447   | 19783   | 21612   | 28811   | 33024   | 34486   | 233298<br>(3.21%)   |
| CG%                |       | 9.4488  | 20.257 | 17.947  | 21.249  | 9.8085  | 16.972  | 7.2763  | 11.361 | 25.167  | 13.389  | 9.2453  | 33.31   | 14.623  | -4.6572 | 14.67%              |
| South Korea        | 7337  | 9044    | 10663  | 13049   | 14954   | 16198   | 15613   | 15410   | 17366  | 18416   | 19052   | 19777   | 21190   | 21059   | 20118   | 239246<br>(3.29%)   |
| CG%                |       | 23.27   | 17.9   | 22.38   | 14.6    | 8.319   | -3.612  | -1.3    | 12.69  | 6.046   | 3.454   | 3.805   | 7.145   | -0.618  | -4.468  | 7.82%               |
| France             | 9675  | 10127   | 12416  | 14241   | 15092   | 14934   | 16278   | 16533   | 16567  | 17494   | 17798   | 18155   | 19419   | 18767   | 17609   | 173554<br>(2.39%)   |
| CG%                |       | 4.6718  | 22.603 | 14.699  | 5.9757  | -10.469 | 8.9996  | 1.5665  | 0.2056 | 5.5955  | 1.7377  | 2.0058  | 6.9623  | -3.3575 | -6.1704 | 4.60%               |
| Italy              | 7384  | 8046    | 9601   | 10883   | 11274   | 11956   | 12287   | 12665   | 13233  | 13491   | 14270   | 15157   | 17597   | 17784   | 17318   | 192946<br>(2.66%)   |
| CG%                |       | 8.9653  | 19.326 | 13.353  | 3.5928  | 6.0493  | 2.7685  | 3.0764  | 4.4848 | 1.9497  | 5.7742  | 6.2158  | 16.098  | 10.627  | -2.6203 | 6.43%               |
| Russian Federation | 8453  | 7762    | 8182   | 8163    | 6388    | 6827    | 6604    | 6551    | 6747   | 7534    | 7496    | 8160    | 11736   | 13727   | 16605   | 130935<br>(1.80%)   |
| CG%                |       | -8.1746 | 5.411  | -0.2322 | -21.744 | 6.8723  | -3.2664 | -0.8025 | 2.9919 | 11.664  | -0.5044 | 8.8581  | 43.824  | 16.965  | 20.966  | 5.91%               |

\* CG % = Corresponding Growth Percentage, the formula for determining CG is:

Present year figures -previous year figures / previous year figures \* 100.

It is evident from the above tables 1 & 2 that during 2002-2016, total 4999372 articles were published by 10 leading engineering research countries. Out of these, the China has the highest publications share at global level with 32.23% (1611732 articles) share and is followed by United States (1290001, 25.80%) and Japan (438084, 8.76%) respectively. 332909 articles (6.65%) were published in Germany. Likewise, UK has a share of 5.90% with 295116 articles and India has 4.66% share with 233298 articles. South Korea has published 239246 articles

(4.78%), France 173554 (3.47%), Italy 192946 (3.85%) and Russian Federation has published 130935 articles (2.61%) during the period of study.

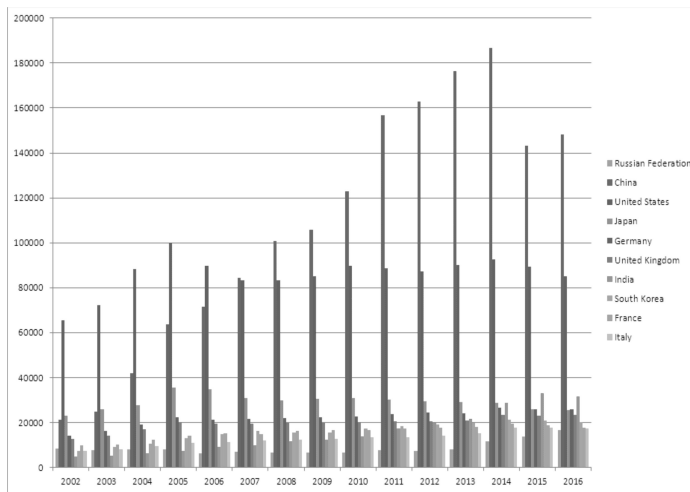
During the data analysis, it was revealed that the leading countries have a contribution of 68.93% (4999372) in the total publications during the study and the contribution of the rest of the world is (2252903, 31.07%). China has the highest Corresponding Growth Percentage (16.67%) and Japan has the least (1.22%) during the period of study.

During the study period the publications of the leading countries grew with an annual growth of 6.87%.. China has the highest growth and leading with 16.67% growth. India follows China with 14.67% and in turn is followed by South Korea 7.82% ,Italy 6.72% and Russian Federation with 5.91% annual growth. United Kingdom has 4.63% growth and is followed by Germany (4.61%) and France (4.60%). The average annual growth of USA is mere 2.22% and Japan has the least growth with only 1.22%.

### 6.1 No. of Citable Documents:

By citable documents we mean those research publications appeared in peer-reviewed or refereed journals.

The nature of journals can be either open access or commercial. There is no denial of the fact that in today’s technological era, the researchers can publish their researches in many forms like web portals, own blogs, websites and many more. However, articles in only peer reviewed and referred journals are considered more authentic, credible and are considered most for citations.



Graph 1: Shows that China has the highest growth rate.

Table 3 – Citable documents in leading countries

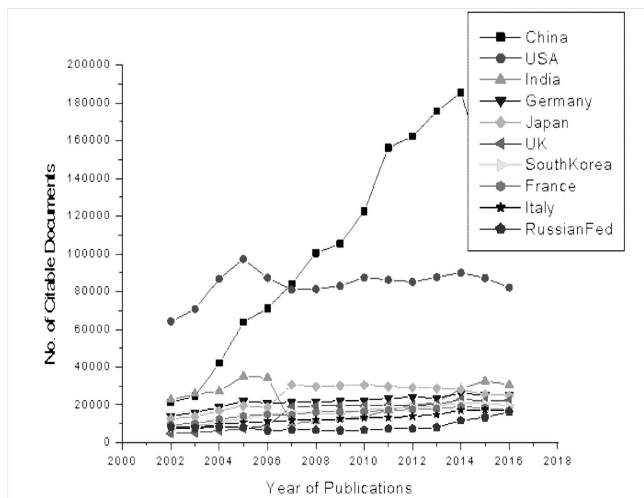
Out of the total 7255275 published articles during the study period, 98.43% (7141707) articles over the globe were citable. Once again, China leads the chart with 23.67% global share. US follows with 18.52%

| Country       | 2002  | 2003   | 2004   | 2005   | 2006   | 2007   | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | Total   | (Share |
|---------------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|--------|
| China         | 2368  | 24733  | 42017  | 63670  | 71244  | 84270  | 100461 | 105361 | 122657 | 166348 | 162327 | 175635 | 185586 | 142182 | 145738 | 1603597 | 23.67% |
| CG%           |       | 15.748 | 69.882 | 51.534 | 11.896 | 18.284 | 19.213 | 4.8775 | 16.416 | 27.468 | 3.8242 | 8.1983 | 5.6657 | -23.39 | 2.501  | 16.57%  |        |
| United States | 6424  | 70742  | 86839  | 97366  | 87351  | 81074  | 81334  | 83112  | 87462  | 86295  | 85167  | 87700  | 90110  | 87250  | 82232  | 1258248 | 18.52% |
| CG%           |       | 10.166 | 22.755 | 12.122 | -10.29 | -7.186 | 0.3207 | 2.186  | 5.2339 | -1.334 | -1.307 | 2.9742 | 2.748  | -3.174 | -5.751 | 2.10%   |        |
| India         | 22716 | 25781  | 27232  | 35177  | 34415  | 9860   | 1552   | 12387  | 13796  | 17265  | 19636  | 21382  | 28441  | 32679  | 30703  | 343022  | 5.06%  |
| CG%           |       | 13.493 | 5.6282 | 29.175 | -2.166 | -7.135 | 17.16  | 7.2282 | 11375  | 25.145 | 13.733 | 8.8918 | 33.014 | 14.901 | -6.047 | 7.15%   |        |
| Germany       | 14075 | 15984  | 18769  | 21990  | 20973  | 21376  | 21703  | 22020  | 22333  | 23434  | 24111  | 23526  | 26197  | 25160  | 25196  | 326847  | 4.82%  |
| CG%           |       | 13.563 | 17.424 | 17.161 | -4.625 | 1.9215 | 15.298 | 1.4606 | 1.4214 | 4.9299 | 2.889  | -2.426 | 11.353 | -3.958 | 0.1431 | 4.48%   |        |
| Japan         | 12618 | 13738  | 16854  | 19547  | 18800  | 30657  | 29681  | 30061  | 30547  | 29705  | 29156  | 28798  | 28234  | 25409  | 24963  | 368768  | 5.44%  |
| CG%           |       | 8.8762 | 22.682 | 15.978 | -3.822 | 63.069 | -3.184 | 1.2803 | 1.6167 | -2.756 | -1.848 | -1.228 | -1.958 | -10.01 | -1.755 | 6.21%   |        |
| United Kingd  | 4751  | 5201   | 6288   | 7398   | 8968   | 10048  | 13359  | 14227  | 16675  | 19991  | 19777  | 20220  | 22828  | 22249  | 22453  | 237633  | 3.50%  |
| CG%           |       | 9.4717 | 20.9   | 17.653 | 21.222 | 12.4   | 1.6327 | 0.3513 | 1.2766 | 1.6061 | -1.07  | 2.24   | 12.898 | -2.536 | 0.9169 | 14.21%  |        |
| South Korea   | 7211  | 8895   | 10592  | 12976  | 14862  | 16115  | 15496  | 15246  | 17216  | 18281  | 18808  | 19501  | 20831  | 20666  | 19588  | 236284  | 3.48%  |
| CG%           |       | 23.353 | 19.078 | 22.508 | 14.535 | 8.4309 | -3.841 | -1.613 | 12.921 | 6.1861 | 2.8828 | 3.6846 | 6.8202 | -0.792 | -5.216 | 7.78%   |        |
| France        | 9589  | 10050  | 12328  | 14089  | 14910  | 14769  | 16082  | 16314  | 16322  | 17241  | 17500  | 17901  | 19056  | 18352  | 17144  | 231647  | 3.41%  |
| CG%           |       | 4.8076 | 22.667 | 14.285 | 5.8272 | -0.946 | 8.8902 | 1.4426 | 0.049  | 5.6304 | 1.5022 | 2.2914 | 6.4522 | -3.694 | -6.582 | 4.47%   |        |
| Italy         | 7306  | 7938   | 9503   | 10709  | 11083  | 11762  | 12061  | 12444  | 12986  | 13235  | 13960  | 14812  | 17217  | 17386  | 16730  | 189132  | 2.79%  |
| CG%           |       | 8.6504 | 19.715 | 12.691 | 3.4924 | 6.1265 | 2.5421 | 3.1755 | 4.3555 | 1.9174 | 5.4779 | 6.1032 | 16.237 | 0.9816 | -3.773 | 6.26%   |        |
| Russian Fede  | 8428  | 7738   | 8157   | 8139   | 6359   | 6800   | 6586   | 6510   | 6660   | 7382   | 7226   | 8092   | 11649  | 13504  | 16162  | 129392  | 1.90%  |
| CG%           |       | -8.187 | 5.4148 | -0.221 | -2.187 | 6.9351 | -3.147 | -1.154 | 2.3041 | 10.841 | -2.113 | 11.985 | 43.957 | 16.924 | 19.683 | 5.7394  |        |

and is followed by Japan (5.44%), India (5.06%) and Germany (4.82%). UK shares 3.5%, France 3.41%, Italy 2.79% and Russian Federation has 1.9% share at global level.

Graph 2: No. of citable documents

The citable documents have the annual growth of 7.20% at global level during the study period. Leading ten countries have produced 68.95 % of the total citable documents. The rest of the world has 31.05% share of the total citable documents in the area of engineering research.



## 6.2 No of Citations

Citation means the way to tell the readers that some certain material has come from another source. The necessary information regarding the material source is also provided to the readers like the author, title, link of the source etc. Table 4: Number of citations in outstanding countries

The total numbers of citations during the study period were 55322605 and the average annual growth of citations per document was 7.20%. It is evident that the maximum citations 3913312 (12.89%) were received in the year 2006. United States leads with 13814656 citations and has 27.90% share at global level. Russian Federation has the least contribution with 0.83% share only. The outstanding ten countries have the 66.48% share and rest countries of the world have 33.52% of the total citations.

Graph 3: No. of citations in leading countries

It is evident from the graph given above that average numbers of citations have decreased continuously from 2002 to 2016. China has the maximum growth between 2009-2013 but has also decreased 2013 onwards. USA has the maximum citations during 2004-05 but decreased the citations in 2016.

## 6.3 Self Citations

Giving reference of own article from the same journal is called self citation. It is very helpful for the researcher to increase the visibility and awareness of the research among his peers.

Table 5: No. of Self-Citations

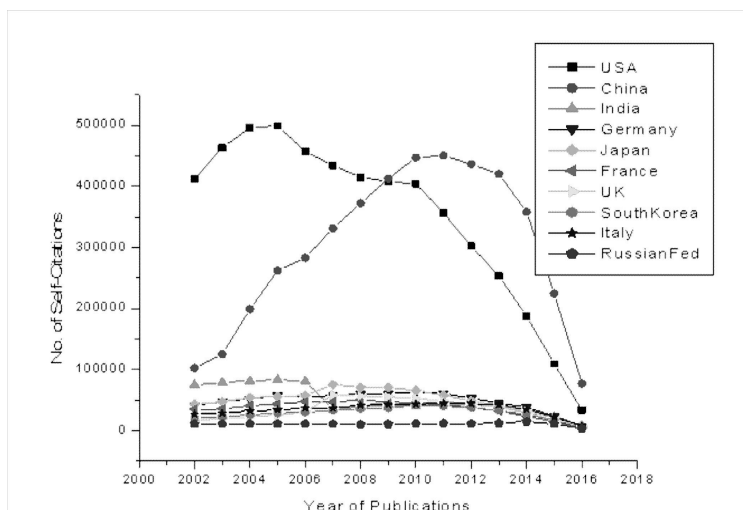
The United States leads the world with (5233721, 29.02%) global self citations and is followed by China

| Country       | 2002   | 2003   | 2004   | 2005   | 2006   | 2007   | 2008   | 2009   | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | Total (Share%)    |
|---------------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|-------------------|
| China         | 175879 | 219442 | 321941 | 410321 | 443574 | 519143 | 583469 | 639416 | 693001 | 687316 | 653023 | 614705 | 519673 | 320586 | 108734 | 6910223 (13.95%)  |
| United States | 1E+06  | 1E+06  | 1E+06  | 1E+06  | 1E+06  | 1E+06  | 1E+06  | 1E+06  | 1E+06  | 909561 | 751875 | 611735 | 449046 | 249642 | 71642  | 13814656 (27.90%) |
| India         | 240200 | 247592 | 257359 | 265183 | 255184 | 113233 | 123310 | 127367 | 120818 | 121288 | 111854 | 101437 | 81222  | 52259  | 18100  | 2236406 (4.57%)   |
| Germany       | 188696 | 220669 | 228328 | 241416 | 227447 | 236295 | 232728 | 227056 | 232267 | 213635 | 176426 | 142813 | 117681 | 67479  | 20648  | 2773584 (5.60%)   |
| Japan         | 217711 | 221786 | 264852 | 272921 | 269155 | 234364 | 214482 | 211562 | 195633 | 169554 | 135884 | 104598 | 79250  | 44032  | 14194  | 2649978 (5.35%)   |
| United Kingd  | 57420  | 68313  | 75084  | 86174  | 102550 | 294500 | 260852 | 246329 | 230613 | 206281 | 178533 | 154838 | 122234 | 71950  | 22993  | 2178664 (4.40%)   |
| South Korea   | 105126 | 117741 | 132297 | 142854 | 147840 | 158782 | 156152 | 159995 | 174414 | 162207 | 148492 | 121658 | 91147  | 54792  | 16113  | 1889610 (3.81%)   |
| France        | 144013 | 152495 | 164866 | 184700 | 188030 | 180493 | 196504 | 179523 | 169304 | 159680 | 132281 | 112219 | 78427  | 46084  | 14009  | 2102628 (4.24%)   |
| Italy         | 119559 | 123500 | 134976 | 146286 | 149644 | 146066 | 153659 | 152839 | 151516 | 139492 | 127852 | 112250 | 90557  | 55591  | 17779  | 1820566 (3.67%)   |
| Russian Fed   | 30501  | 35142  | 32331  | 32330  | 34581  | 32626  | 28714  | 27364  | 28221  | 25661  | 23257  | 23233  | 24427  | 18085  | 6394   | 402867 (0.83%)    |

(24.97%) which is in turn, followed distantly by India (4.16%), Germany(4.02%), Japan (4.1%) and France

(3.04%). Some outstanding countries in the list are UK with 2.95%, South Korea with 2.42% Italy with 2.89% and Russian Federation with 0.92% global share of the total self citations in the area of engineering research during the period of study.

Graph 4: Self-Citations status



It is clear from the graph above that USA and China are the only giant with reference to self citations during the period. Yet there is a drastic decrease in the self citations. The trend has fallen during 2014-16 drastically both in USA and China, along with the whole world.

#### 6.4 Citations per Document

Citations per document mean average number of citations received by the journal during the period. It is calculated by dividing the total number of citations

from total number of articles.

Table 6: No. of citations per document

It is clear from the table above that USA leads with highest with 10.45 average citations per document. Surprisingly, Italy has also emerged as the second highest with 10.02 average citations. UK has 9.63 citations and is followed by France(9.21), Germany (8.48), South Korea(8.35) and Japan(7.53). India received 6.91 average citations per document and is followed by China with 5.02 and Russian Federations with 3.61 citations per document.

Graph 5: No. of citations per document

The graph above shows the radical decrease in citations per document at the global level. The citations per

| Country       | 2002  | 2003  | 2004  | 2005  | 2006  | 2007  | 2008  | 2009  | 2010  | 2011  | 2012 | 2013 | 2014 | 2015 | 2016 | Avg   |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|------|------|------|------|------|-------|
| United States | 17.44 | 17.89 | 15.48 | 13.53 | 13.7  | 13.99 | 13.33 | 12.54 | 11.67 | 10.27 | 8.6  | 6.8  | 4.85 | 2.79 | 0.84 | 10.45 |
| Italy         | 16.19 | 15.35 | 14.06 | 13.44 | 13.27 | 12.22 | 12.51 | 12.07 | 11.45 | 10.34 | 8.96 | 7.34 | 5.15 | 3.13 | 1.03 | 10.02 |
| United Kingd  | 11.9  | 12.93 | 11.82 | 11.5  | 11.29 | 15    | 13.11 | 12.34 | 11.38 | 10    | 8.74 | 7.43 | 5.2  | 3.13 | 0.98 | 9.63  |
| France        | 14.89 | 15.06 | 13.28 | 12.97 | 12.46 | 12.09 | 12.07 | 10.86 | 10.22 | 9.13  | 7.43 | 6.18 | 4.04 | 2.46 | 0.8  | 9.21  |
| Germany       | 13.27 | 13.66 | 12.05 | 10.81 | 10.65 | 10.85 | 10.55 | 10.15 | 10.21 | 8.95  | 7.16 | 5.95 | 4.4  | 2.62 | 0.8  | 8.48  |
| South Korea   | 14.33 | 13.02 | 12.41 | 10.95 | 9.89  | 9.8   | 10    | 10.38 | 10.04 | 8.81  | 7.79 | 6.15 | 4.3  | 2.6  | 0.8  | 8.35  |
| Japan         | 16.94 | 15.8  | 15.46 | 13.53 | 13.93 | 7.58  | 7.15  | 6.96  | 6.33  | 5.63  | 4.59 | 3.58 | 2.75 | 1.7  | 0.55 | 7.53  |
| India         | 10.49 | 9.54  | 9.36  | 7.46  | 7.35  | 11.35 | 10.57 | 10.18 | 8.67  | 6.95  | 5.65 | 4.69 | 2.82 | 1.58 | 0.57 | 6.91  |
| China         | 8.21  | 8.84  | 7.65  | 6.43  | 6.21  | 6.15  | 5.79  | 6.04  | 5.63  | 4.38  | 4.01 | 3.49 | 2.78 | 2.24 | 0.73 | 5.02  |
| Russian Fede  | 3.61  | 4.53  | 3.95  | 3.96  | 5.41  | 4.78  | 4.35  | 4.18  | 4.18  | 3.41  | 3.1  | 2.85 | 2.08 | 1.32 | 0.39 | 3.46  |

documents were decreased severely during 2014-16. It happened in all the countries, including the leading ones.

## 7. Conclusion

It is very clear from the research undertaken that the research output is disproportionate in the field of engineering at the global level. 68.93% of the total engineering research globally has been done in 10 leading countries and the rest of the world has only 31.07% share. It shows that research is being done only in some countries and the rest of

the world by any reason, don't have proper research environment. During the period of study, the research output of engineering has improved considerably with an average annual growth of 6.88%.

The need of the hour is to create an environment at global level so that the research in engineering can be encouraged in the under-developed countries through all possible means. The help by the leading countries like technical support, funds, human resource training should be provided to the unnoticeable nations. The engineering research in the deprived and poor countries can be increased to a considerable degree by promoting the research related activities. A great help is required by the leading countries like USA, China, UK, Germany, India etc to promote engineering research at global as well as regional level. These countries should provide all the possible support for the needy nations for promotion of the research. Also the developing countries should also establish some intuitions dedicated to engineering research.

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