



Technology

टैक्नोलॉजी फोकस



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Military Aviation Tyres and Tubes

In order to achieve self-reliance and sufficiency in Indian defence requirements there is a need to adapt modern technology and master the process of indigenisation. India needs to change from being the biggest recipient, to highest level of self-sufficiency before joining the list of highest suppliers. The Indian government reinforced a policy of self-reliance in defence and is advancing the concept of *Make in India*. A fruitful realisation of this goal will also free the country from dependency on foreign supplies.





From the Desk of Guest Editor



P Jayapal

Chief Executive
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Centre for Military Airworthiness and Certification (CEMILAC), Bengaluru, with its 14 Regional Centres of Military Airworthiness (RCMAs), each with a specific core competence, carries out airworthiness certification of military aircraft, aero-engines and airborne stores being designed and developed by DRDO laboratories, ordinance factories, public sectors units such as HAL, BEL, MIDHANI, etc., and many private sectors. CEMILAC has been given the responsibility of type approving system and equipment for aerospace use. It has been seen that there are many small scale private industries that are capable of producing quality hardware and software for military aerospace application. Understanding the magnitude of advantages of indigenisation, CEMILAC has gone all out to support indigenous programmes. CEMILAC has successfully contributed towards certification of indigenous airborne stores of national importance with its well laid down procedures and expertise gained during the process of design and development of these programs across the years.

Having assessed the capability of private industry who were suppliers of raw material and components in the past, CEMILAC has now driven them as partners in design and development. Private sectors can today harness available expertise of management, scientific and technological skills and also raise resources for investments in R&D activities towards achieving the goal of self-reliance. As a major player in Public-Private-Partnership (PPP) model, for the first time, CEMILAC initiated and certified the indigenous tyres and tubes for the varied military aero platforms. CEMILAC initiated development plan with user and manufacturers and has successfully developed requisite technology, methodology of testing, ground and flight evaluation criteria right from the raw materials preparation to the finished product. It is expected that, the use of indigenously developed tyres for entire fleet-life of aircraft would fetch a phenomenal financial exchequer (FE) saving. Moreover, it is estimated that by 2017/18, India will achieve self-reliance in aviation tyres/ tubes and will be in a position to export tyres to other countries. M/s MRF Chennai came forward nobly with initial investment for development and testing of tyres. Today other companies like JK Tyre, ARL and Triton have also joined the tyre bandwagon. The development marks one of the significant steps in defence's indigenisation programme. CEMILAC feels that the synergy between the user, the developer, the manufacturer and the certifying agency with suitable coordination by the Ministry of Defence will pave the way for indigenisation of defence products. This will bring out enormous FE savings to the nation besides creating opportunities and self-reliance in the aviation sector.

CEMILAC is extremely grateful to Dr. K Tamilmani, Distinguished Scientist, Director General (Aeronautics Systems), DRDO for inspiring us to take up the initiative to make India self-reliant in the field of military aviation tyres and tubes.

India is a leading manufacturer of tyres and tubes in the automobile industry. However, for military aviation tyres, the defence services are dependent on foreign countries. In order to achieve self-reliance in military aviation tyres in the country, CEMILAC, one of the establishment of DRDO, initiated development plan with users and manufacturers and has successfully developed requisite technology, methodology of testing, ground and flight evaluation criteria right from the raw materials preparation to the finished product. CEMILAC helped in identifying vendor/s, the requisite test facility for static tests and for conducting 'Dynamometer Test' in-house. Further, it also finalised the technical specifications, Qualification Test Schedules (QTS) and flight testing parameters for the same. M/s MRF Chennai came forward with initial investment for development and testing of tyres.

Fighter Aircraft Tyres

As a first step, development of main wheel tyres of Su-30MKI was initiated keeping in mind that this aircraft will form the backbone of the IAF and will be operated for the next two decades. DRDO in

consultation with HAL, IAF and private industries like MRF evolved the process for material selection, tyre build up and manufacture. DRDO initiated the process of manufacture of main wheel tyres of Su-30 based on study carried out on samples of Russian tyres from the IAF. Details such as type of construction, dimensions, materials, speeds and loads are not available in the country. Aviation tyres are usually tested using ground test facilities due to the expense and hazards associated with testing on aircraft. The facilities for testing and validation are not available in the country. Aircraft tyre test facility are available with developed countries such as US, France, Germany, Japan, Russia, etc., As most of these countries possessing the testing technology, are also large scale manufactures of aviation tyres, they do not want competition from the Indian market and thereby refuse testing of tyres on dynamometers. As on date only China has accepted to test our tyres.

After initial development, a prototype tyre underwent in-house testing. Various tests as per international qualification norms and our users requirement were designed by the DRDO through destructive testing of OEM tyres to obtain comparative



Su-30 MKI Aircraft : The Backbone of IAF



THE BEST ON LAND NOW CONQUERS THE AIR.



MRF, India's leading tyre manufacturer, adds another first. MRF's **Aero Muscle**, the only Indian tyre approved by CEMILAC, has been chosen for the main wheels of the legendary fighter jet - **Sukhoi 30 MKI**. And it's this same commitment to excellence that also empowers you on the road.

MRF AERO MUSCLE

Adding Muscle to the Nation's Security.



Main Wheel Tyre of Fighter Aircraft

static and dynamic test values. The indigenously developed main wheel tyre was subject to various other static tests such as leak, burst, bottoming out, on site assessment of wear & tear, ply & cord fraying/

separation, etc. For dynamically proving the tyre in all speed and load combinations the tyres undergo dynamic testing on a tyre dynamometer (at M/s Lanyu, China) where the tyre is subject to cycles simulating taxi, take-off, landing and rejected take-off. The tyres were also tested for high altitude conditions thereby permitting landing of fighter aircraft at high altitude airfields like Leh and Thoise.

The dynamometer test simulating the landing and take-off stages of the tyres under different speed and loads is a mandatory process of tyre qualifications. Strategically, it is very important for India to develop technology to produce aircraft tyres and to create facility for testing, validation and certification. Since the requirements and testing of aero tyres is very costly, many tyre manufacturers do not venture in development of aero tyres. Towards setting up of test facility, DRDO convinced M/s MRF to procure the same and set it up in India so that the defence services can also utilise the same for defect investigations. After successful ground testing on dynamometer, flight trials were conducted on MRF tyres to ascertain the suitability, performance and life in terms of number of landings. During the process, the tyre was tested for speeds as high as 420 Km/h and loads up to 37 tons to ensure operation of the tyre at all altitudes. Flight

clearance was accorded by DRDO for ground and flight evaluation. After satisfactory completion of flight testing, RCMA (Nasik), DRDO accorded provisional clearance for these indigenous tyres for production. The tyres have since been supplied and are in use by the IAF. Buoyed by the success, indigenisation of tyres for all fighter aircraft in the inventory of the IAF was initiated through Air HQ. Stringent certification test based on available international standards (TSO C62e), followed by rigorous field and flight trials (420 Km/h, 37 tons load) established the efficacy of the tyre. The tyre aptly named *Aero Muscle* was inducted into Service and as on date more than 1000 tyres have been supplied to the IAF. Buoyed by the success of the main wheel tyre of Su-30 aircraft and driven by the critical shortage of Russian origin tyres causing AOGs (Aircraft on Ground) in the IAF, DRDO with the help of private industries fast tracked the indigenisation of other fighter aircraft tyres like Su-30 Nose Wheel, LCA, MiG-29K (Indian Navy), MiG-29 UPG, Jaguar and FGFA.

and static tests on these tyres will commence shortly. Israel Aircraft Industries (IAI) the OEM of the UAVs has expressed intention to buy these tyres from these agencies, which is a shot in the arm for Indian aviation tyre industry.

Helicopters/UAV Tyres

Simultaneously success was also achieved on indigenisation of helicopters tyres of Chetak and Cheetah by M/s MRF and presently more than 1400 tyres have already been supplied. This propelled the development of tyres for Advanced Light Helicopter (ALH) and Light Combat Helicopter (LCH), and provisional clearance for use of the same has since been issued. Indian Navy has approached DRDO to develop tyres for seaking helicopter. The tyres have been developed and qualification test schedule for testing these tyres are being formulated presently. The tyres will subsequently undergo static and dynamic tests before it is tested in the field for all loads and speeds.

The process of indigenisation of western fleet fighter aircraft, Boeing P8i (Indian Navy) and UAVs (Heron and Searcher) has also been initiated parallelly. Heron tyres have undergone fitment trials and are in advanced stage of design and prototype production. Test schedules for these tyres have been formulated



ALH : Helicopter Tyres

Tyre Design Parameters and Specifications

Every tyre designed in India and certified by DRDO is a re-engineering in true terms. As the aviation technology did not exist, a process of trial and error to arrive at the correct kind of material to ensure strength and rigidity of the tyre overdesign for the speed and load at which it is to be used. Aviation experts will agree that the tyre needs to be the soft cushion at the time of landing, lest it destroys the undercarriage or the airframe itself. Hence the rated speed and load a tyre and its factor of safety are crucial factors which need to be arrived at before deciding the specifications of the tyre and also the process of its testing. Qualification Test Schedules (QTS) for each tyre needs to consider the following aspects:

- ✧ The wheel must be fitted with a suitable tyre of proper fit with a speed rating approved by



the certification agency that is not exceeded under critical conditions and with a load rating approved by is not exceeded under.

- ✘ The loads on the main wheel tyre, corresponding to the most critical combination of airplane weight (up to maximum weight) and centre of gravity position.
- ✘ The loads corresponding to the ground reactions on the nose wheel tyre. The applicable ground reactions for nose wheel tyres are the static ground reaction for the tyre corresponding to the most critical combination of airplane weight (up to maximum ramp weight) and centre of gravity position with a force of 1.0 g acting downward at the centre of gravity. This load may not exceed the load rating of the tyre.
- ✘ The reactions in this case must be distributed to the nose and main wheels by the principles of statics with a drag reaction corresponding to the vertical load at each wheel with brakes capable of producing this ground reaction.

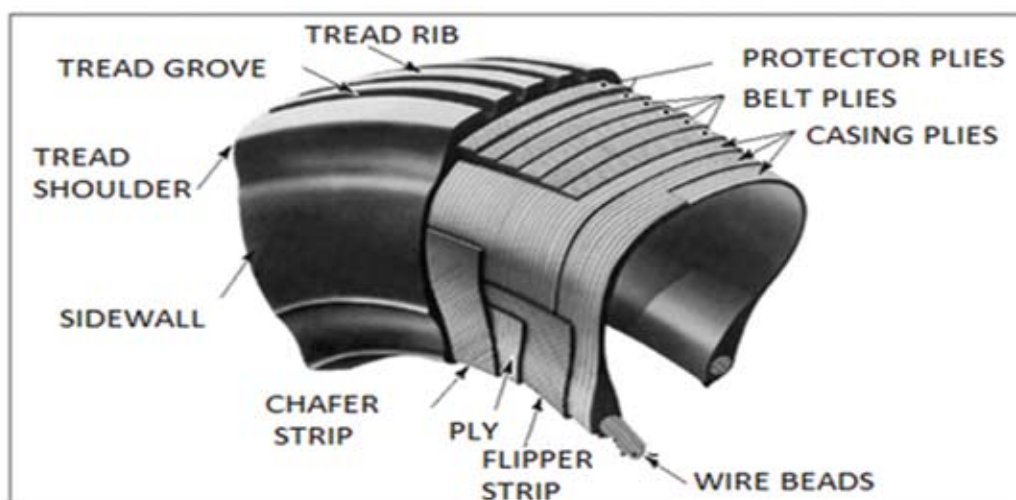
Similar criteria needs to be followed when a landing gear axle is fitted with more than one wheel and tyre assembly, such as dual or dual-tandem, each

wheel must be fitted with a suitable tyre of proper fit with a speed rating approved by the certification agency that is not exceeded under critical conditions, and with a load rating approved by the DRDO with conditions similar to those specified above except for a few technical deviations in the parameters.

Qualification Test Schedule

QTS are developed by DRDO for both static and dynamic testing of tyres in order to meet the end requirements of the platform on which it is to be fitted. These test requirements must cater to the conditions specified above and also ensure that the tyre is usable in the entire envelop of the aircraft. The aircraft lands at high altitude runways wherein loads are low and speeds very high compared to other runways where loads are high and speeds moderate. This envelop is a challenge to any certification agency which designs the QTS. Also these conditions are unique to India as runways at high altitudes are not available anywhere else in the world other than in China probably.

Qualification testing tyres shall be subjected to qualification testing according to the requirements specified in MIL-T-5041J-H and TSO-C62e based on test schedules coordinated by the Indian Airworthiness Authority (CEMILAC).



Cross-section of a Typical Aviation Tyre



Tyre Pressure Test Under Progress

Classification of Tests

Pre-production/Qualification tests and acceptance tests consisting of visual examination of product, balance, weight, sampling test to ensure dimensions and air retention tests. The tyres also undergoes destructive testing in the form of burst pressure test using water as the medium to check its pressure bearing capacity. This test is carried out such that the tyre sustains atleast four times the rated pressure. This is further followed by user and flight trials after necessary batch clearance by DGAQA.

Identification Product/Specimen

Each of the tyres including qualification test specimen shall be suitably identified by engraving/ embossing the information as per the international norms and standards which include ply rating, date of manufacture, material country, etc.

Quality Assurance and Reports

After completion of the pre-production, an inspector from DGAQA who is independent of CEMILAC, matches the Qualification Test Report (QTR) with the specifications of the tyres and prepares a compliance matrix, which forms the basis for acceptance of the tyres into service.

The manufacturer is responsible for meeting all inspection requirements of DGAQA as laid down

in the specifications and corresponding universal standards. The inspecting officer from DGAQA may at this discretion repeat any of the tests to satisfy himself on the performance and quality of the product. Independent test reports generated by the manufacture at each stage of the manufacturing process are cross checked by the inspecting officer before the tyre is cleared for dispatch to the user.

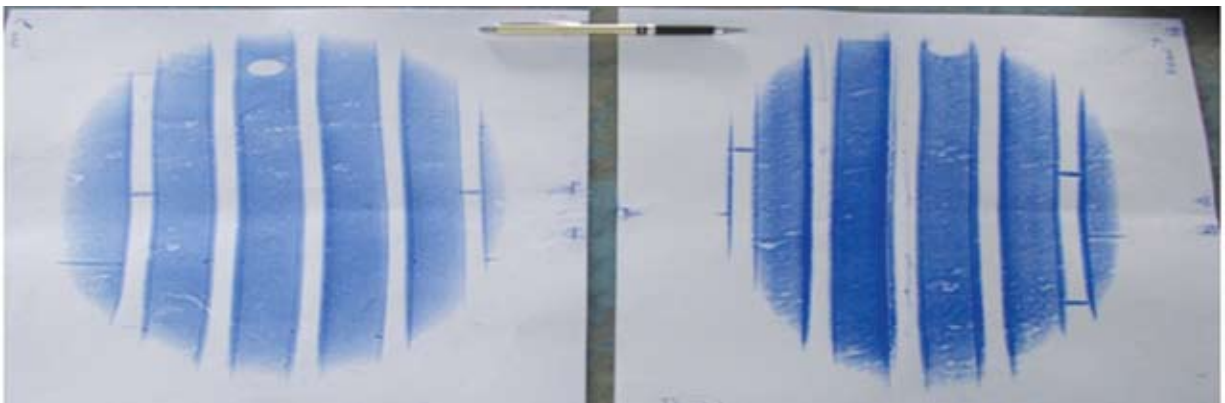
Static Tests on Prototype Tyre

The quality control sheet is to be completed with the results of the tyre examination. Based on this information, the tyre is declared accepted or rejected. Tyres which fail this examination may be used for destructive qualification tests, by which influence of the observed defects on test results may be verified.

Footprint

Footprints of the tyre as per standard indicating the actual shape, total gross contact and net contact area in square inches of the tyre at rated static load and inflation shall be prepared and submitted. The prints shall include data at rated load and also at increments of approximately 15, 30 and 45 per cent above rated load and at increments of approximately 15, 30, 45 and 60 per cent below rated load.

At 100 per cent rated load, the tyre foot print should be comparable to the OEM tyre for the same rated inflation pressure.



Footprint of the Tyres

Dynamic Testing

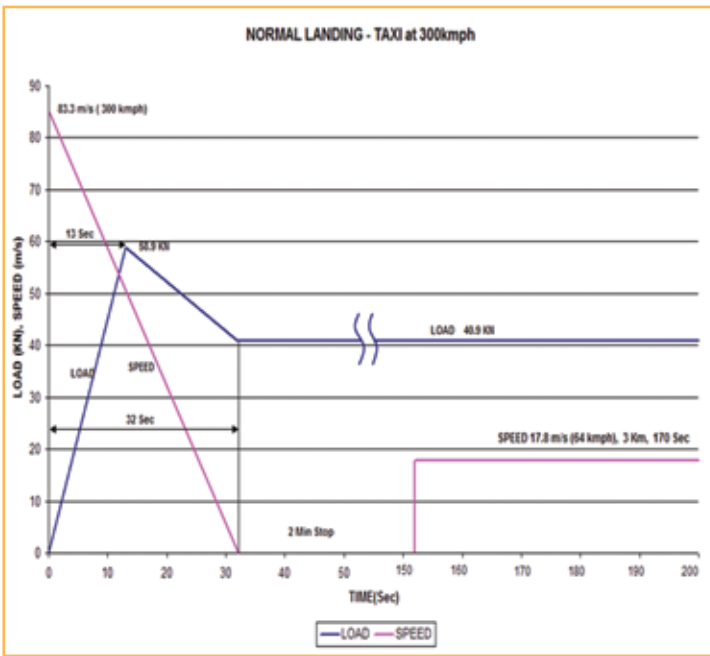
Tyre shall be tested on a suitable dynamometer to withstand simulated cycles of takeoff-landing, taxi cycles, overload cycles and one Rejected Take Off (RTO) as per TSO-C62e. Measurement of SLR new, SLR grown and grown tyre dimensions shall be performed during the dynamometer test. Load speed diagrams are drawn for each case of the dynamometer test. The dynamometer is then programmed to run as per the schedule specified in the drawn diagrams. The graph here depicts a typical dynamometer cycle for a landing followed by taxi. These graphs are drawn for the worst case scenario of highest loads and speeds both at time of takeoff & at landing. The graph above depicts a typical impact load of 58.9 tons when the aircraft touches down which reduces after a few

seconds to 40.9 tons as the nose wheel is lowered to the ground, thereby ensuring distribution of the load and reduction of load on main wheel tyres.

The red line on the right extreme depicts the taxi load, distance and time. Similarly load speed diagrams like this are drawn for different conditions of taxi followed by take-off, landing followed by taxi to tarmac, high speed taxi and take off and high altitude takeoff-taxi. The graphs are arrived at after the basic calculations using the 'Equations of Motions'. The



Typical Tyre Dynamometer for Aviation Requirements



Normal Landing- Taxi at 300 Kmph



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data represented in the graphs are translated into the cycles of the dynamometer test so that the tyre qualifies for the entire profile under which the aircraft operates including high altitude airports.

After completion of the tests a compliance matrix covering all the test parameters is drawn to ascertain the pass/fail criteria.

Retreading of Tyres

Civil and commercial airliners having bogie type tyres all over the world use retreaded tyres. Some of the tyre retreaders, carry out 12 retreads on each tyre. Hence, an effort was initiated to retread tyres of IL-76/78 aircraft. M/s Elgi Coimbatore, a private automobile tyre industry and DRDO carried out extensive studies for retreading followed by stringent qualification ground testing, taxi/flight trials to prove the tyre in the field conditions. The retreaded tyres gave higher number of landings as compared to the new foreign tyre (132 landings compared to 80 landings). This significant achievement has translated

into supply of retreaded tyres to the IAF. Process of flight trials after second retread is already in progress at an IAF base. Aviation Research Centre (ARC) has been apprised of the success of retreaded tyres, so that the same can be used on IL-76 operated by them. The proven technology is now being used to retread main and nose wheel tyres of other transport fleets like An-32 aircraft.

Aircraft Tubes

In order to ensure correct matching of tyre and tube, DRDO hastened indigenisation of IL-76/78 tubes. M/s Agrawal Rubbers Limited (ARL), Medak came forward for development and testing of aircraft tubes. A private industry in Mysore, M/s Triton, manufacturing automobile inflation valves was identified to develop inflation valves for aviation tubes. The tubes have since been developed, ground and flight tested and cleared for use.

M/s ARL has developed tubes for Chetak, Cheetah, ALH, LCH and IL-76/78, An-32 and UAVs (HERON, Searcher). M/s ARL has now the capability to produce aviation tubes for the entire range of fleet starting from Chetak helicopter (2.5 T) to IL-76/78 (210 T). The tubes used in aviation have been named as Aero Maruti.

The joint efforts of the private industry coupled with the initiative and technical guidance from CEMILAC (DRDO) has put India on a road for self-sufficiency in aviation military tyres and tubes. With the setting up of



First Retread of IL- 76 Transport Aircraft Tyre



IL- 76/ 78 Inflated Tube (M/s ARL)



Inflation Valve- (M/s Triton)

an exclusive private aviation tyre manufacturing unit by MRF at Medak and Dynamometer Testing Facility at Chennai, aviation tyre industry in the country is now a reality. DRDO focus on *Make in India* and sustained follow up has put India on the road to self-reliance in aviation tyres.

By 2017-18 India will be in a position to export military aviation tyres to other friendly foreign countries. MRF's supply is to result in significant savings as its tyres will be priced 30-40 per cent lower than the tyres the IAF used to procure from outside the country.

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DRDO Monograph series

Investment Casting: A Treasure Trove AM Sriramamurthy, 2015



This monograph attempts to provide a comprehensive description of this highly specialised technology developed indigenously in Defence Metallurgical Research Laboratory (DMRL), through the research efforts of numerous scientists over a period of three decades. The

monograph covers some of the innovations that led to the indigenous design and fabrication of major/critical tools and equipments, thus making the technologies developed comprehensive and helping achieve a high level of self-reliance.

Price: ₹1300/\$60/£40

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