Analysis of Pedal Operated Wheel Brake System of a Helicopter Using Adams Software

Yadavalli Basavaraj[1], Pavan Kumar B. K[2], Gourishankar Hiremath[3]

[1]Professor & Head, Department of Mechanical Engineering.
Ballari Institute of Technology and Management, Bellary. Karnataka. India

[2]Assistant Professor, Department of Mechanical Engineering.
Ballari Institute of Technology and Management, Bellary. Karnataka. India

[3]M.Tech Student, Department of Mechanical Engineering.
Ballari Institute of Technology and Management, Bellary, Karnataka, India

Abstract: ***In wheel type of landing gear helicopters landing gear wheels and tyres are used for ground maneuvering. So for smooth ground maneuvering, run on take off, run on landing and for helicopter spot turning a brake system is mandatory for wheel type landing gear helicopters. The objective of this paper is to give a simple, basic and generalized design procedure to design a wheel brake system of a wheel type landing gear helicopters, the design should meet INDUSTRY standard requirements and analyzing the kinematic behavior of wheel brake pedal system using ADAMS software. The pedal system is modeled in ADAMS software by using joints of the pedal system as definition points and individual part characteristics. After simulating the model for 20 degrees of pedal travel the characteristics of Brake Master Cylinder axial load and Pedal torque data are acquired from ADAMS postprocessor.***

Keywords: Brake system, ADAMS, INDUSTRY standards, Master cylinder, helicopter

1. Introduction

Aircraft is provided with a power brake system (type III in INDUSTRY std) to operate the main wheel brakes. The pressure is manually generated in slave control units (Brake Master Cylinders), which in turn operates a main control unit (Brake Control Valve) which meters fluid from a pressure generating system. The power brake system operates at a system pressure of 1000 psi (68 bars), 2000 psi (137bar) and 3000 psi (206bar), obtained by reducing aircraft hydraulic system pressure using a Pressure Reducing Valve. Brake Master Cylinders (BMC) are mounted below each rudder pedal in both front and rear cockpits. They are toe operated to generate hydraulic pressure outputs. The hydraulic pressure outputs from BMCs are connected to Brake Control valves (BCV). The BCV meters the brake system pressure in proportion to the outputs from the BMCs and sends to each brake. For each brake higher of two demands from both cockpits controls the metering.

Advantages of braking other than stopping the aircraft are Steering of the aircraft on ground**,** restriction of forward speed when taxying, residual thrust from the engines often being applicable**,** holding the aircraft stationary against full thrust when the engines are run up for testing purposes and Parking.

2. Literature Survey

Marc A.stelmack et al [1] paper presents A Multidisciplinary Design Optimization framework called Concurrent Subspace design (CSD) has been applied to the design of an aircraft brake assembly. This application entailed an interactive implementation of CSD in which design information was obtained using existing industrial analysis software. The optimization problem statement in this study included a number of performance requirements associated with a brake that has been produced for a commercial aircraft. The results indicated that the CSD framework was able to efficiently identify improved designs which met all the constraints imposed on the problem

H. T. E. Hertzberg and Francis e Burkel et al [2] paper presents Anyone who does work with his muscles knows that effort and fatigue can be minimized by finding and using the position of optimal mechanical advantage of the limbs for any given task. A shoveler, for instance, quickly learns the best grip location to minimize the effort of continued work. But when the worker on a fixed machine must conform to the situation built in by the machine designer, he may be at a considerable muscular disadvantage and consequently suffer undue fatigue. This is the condition encountered in some airplane brake pedals, and not infrequently in other types of pedals. Although rudder-and-brake controls have to be generally siIndustryar in location and adjustability, the design variation in angle of brake-pedal face among different airplanes is often a source of complaint among pilots.

S.K. Chaturvedi*, V.K. Patidar [3] paper presents A typical aircraft braking system uses links and cables that port some of the aircraft hydraulic pressure to the brakes after going through a valve that meters the amount of pressure. Operation of the brakes has evolved from a single lever applying all brakes symmetrically, to heel operated pedals, to toe operated brake controls incorporated into the rudder pedals. The foot operated controls has resulted in the ability to apply left or right brakes independently allowing use of differential braking system to steer the aircraft during ground operations and to maintain directional control during that portion of the takeoff or landing roll when the airspeed is too low for the aerodynamic controls to be effective.

Kapseong Ro and Haechang Lee [4] paper presents the theoretical derivation of equations of motion of the landing gear system based on the physical principle. Developed model is structured in sense that undercarriage system is regarded as an assembly of strut, tire, and wheel, where each component is modeled by a separate module. These modules are linked with two external modules-the aircraft and the runway characteristics- to carry out dynamic analysis and numerical simulation of the aircraft motion on the ground.

3. Objectives

Industry standard requirements for brake system are as follows:

a) A foot force of 66.7 to 88.9 N at the tip of the pedal shall cause initial metering through the brake control valve.
b) A foot force of between 289.1 to 378 N at the tip of the pedal shall develop the maximum brake pressure.
c) The travel of the pedals shall be in the range of 15 and 25 degrees to produce the maximum brake pressure.

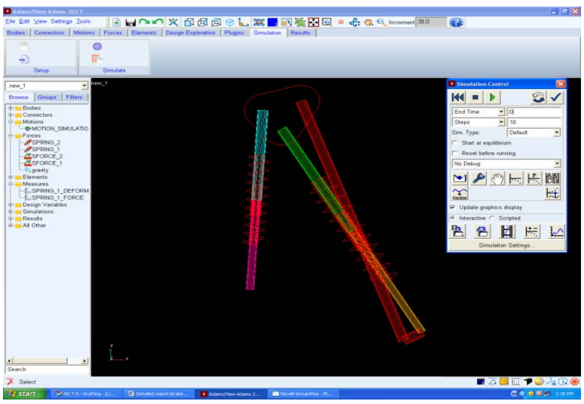
4. Methodology

- Based on design data of the aircraft and INDUSTRY standard requirements hydraulic parameters will be generated.
- Using hydraulic data characteristics of brake master cylinder will be obtained
- As per INDUSTRY requirement pedal kinematics will be finalized
- Using all the above data a model will be generated in ADAMS software
- Using ADAMS software the desired parameters will be plotted for the model and compare with the INDUSTRY requirements.

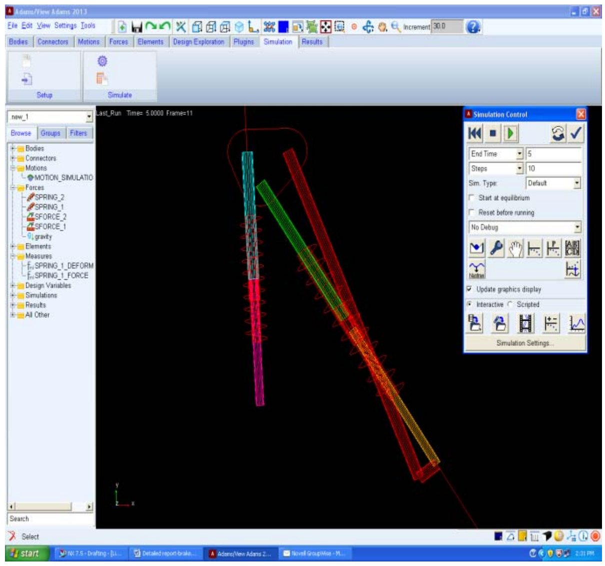
INPUT data for ADAMS analysis:
Pedal geometry:

Joint	x	y
pedal to base	0	0
pedal to spring box	17.55	6.63
spring box to link	-109.49	187.37
pedal to link	-102.19	215.92
bmc to link	-130.04	200.55
bmc to base	-112.6	31.3

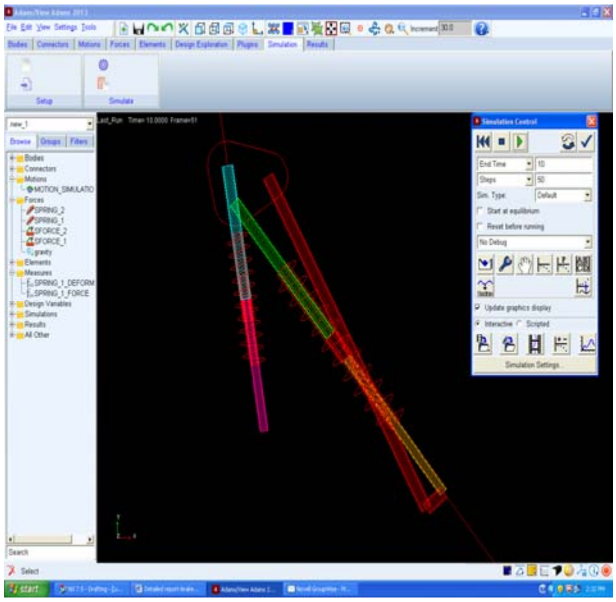
5. Brake Pedal Operation Simulation



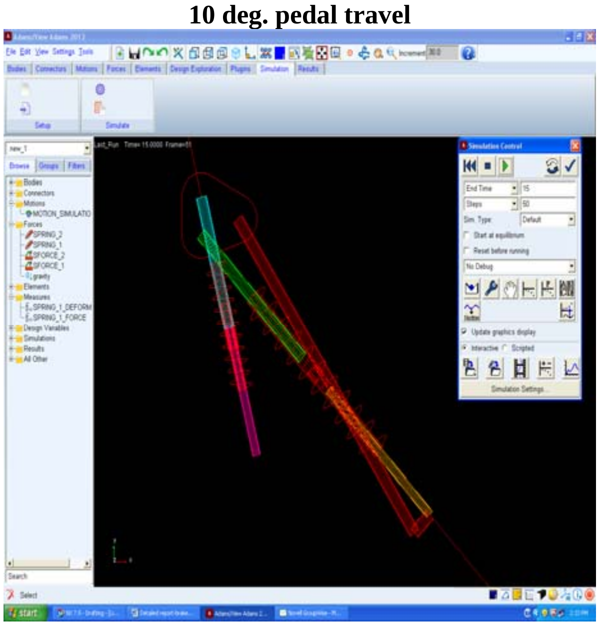
0 deg. pedal travel



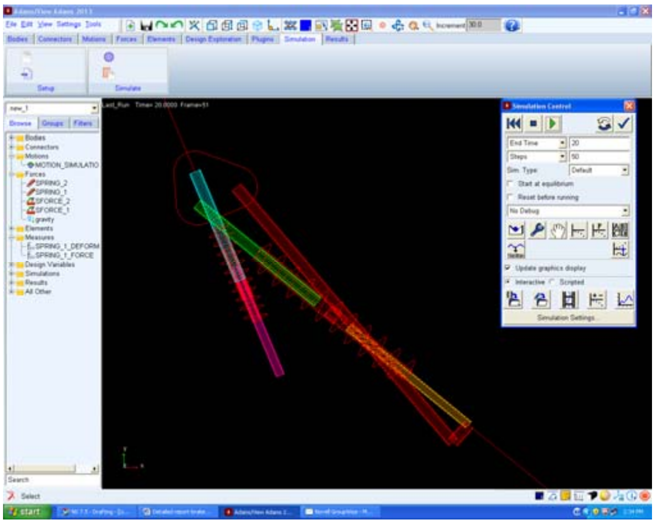
5 deg. pedal travel



10 deg. pedal travel



15 deg. pedal travel



20 deg. pedal travel

6. Summary and Conclusions

Comparison of INDUSTRY requirement and achieved ADAMS results:

Condition	*Industry requirement*	*Achieved*
Initial metering pedal force	6.8 to 9 kgf	8.97 kgf
Pedal force at maximum pressure	20 to 39 kgf	20.07 kgf *
Total pedal travel	15 to 25 deg	16.08 deg.

After analyzing the behavior of toe operated type pedal system using ADAMS software it is concluding that the results are closely matching with the INDUSTRY standard requirement in terms of brake pedal force at initial metering, force at maximum pressure and pedal travel. This kind of basic design procedure can be adapted to any Helicopter wheel brake system design. This kind of simplified analysis prior to manufacturing stage reduces cost of modifications and reduces number of ground tests to evaluate the results.

7. Scope of Future Work

There is a scope to extend this work with regard to modifications. Any kind of modification can be incorporated in to the model and can be analyzed similar way as mentioned in the analysis. In current project the work carried out for helicopters. The basic design procedure and analysis work can be extended to any Aircraft wheel brake system design and Automobile brake system (hydraulically operated) with some modifications.

References

[1] Marc A. Stelmack, Stephen M. Batill, Design of an Aircraft Brake Component Using an Interactive Multidisciplinary Design Optimization Framework, American Institute of Aeronautics and Astronautics.
[2] H. T. E. Hertzberg and Francis e. Burkel, Foot Forces Exerted at Various Aircraft Brake-Pedal Angles, HUMAN FACTORS, 1971, 13(5), 445-456
[3] S.K. Chaturvedi*, V.K. Patidar, Preliminary Study of Aircraft Braking System with Emphasis on Fail-safe Technology, Department of Aerospace Engineering University of Petroleum & Energy Studies,Dehradun-248007, Uttrakhand, India. Advances in Aerospace Science and Applications. ISSN 2277-3223 Volume 3, Number 3 (2013), pp. 191-198
[4] Kapseong Ro and Haechang Lee, Modeling and Simulation of Aircraft Motion on the Ground: part I. Derivation of equations of motion, Aircraft Division Korea Aerospace Research Institute, International Journal. Vol.2, No. 1, May 2001
[5] Hunsicker, P.A. Arm strength at selected degrees of elbow flexion. (WADC TR 54-548).USAF: Aerospace medical Research Laboratoy, Wright Air Development Center, Wright-Patterson air force base, Ohio, 1955.
[6] Lay, W.E. and Fisher, L.C. Riding comfort and cushions. Society of Automotive Engineers journals transactions), 1940, 47, 480-496.
[7] Industryitary specifications. "Design of Brake Systems, Wheel, Aircraft" (INDUSTRY-B-8584B). May 29, 1963. (Supersedes previous editions.)